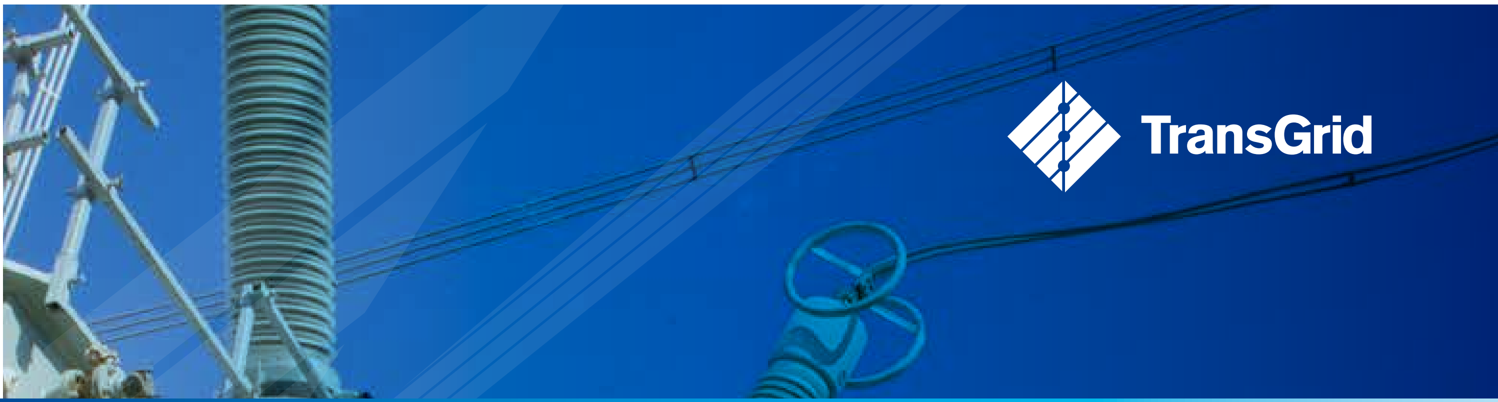

TransGrid

Network Management Plan 2013-2018

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Disclaimer

This Network Management Plan 2013-2018 has been prepared and made available solely for information purposes. Nothing in this document can be or should be taken as a recommendation in respect of any possible investment.

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Introduction

TransGrid is committed to providing safe, reliable and efficient transmission services to NSW, the ACT and the National Electricity Market. A safe and reliable electricity supply is essential to the wide range of activities undertaken in our communities, and is relied upon every day by industries, businesses and families. The efficient delivery of this electricity supply is paramount to the economic wellbeing of electricity customers in New South Wales.

There are many challenges we face to ensure that our electricity network meets the needs of our stakeholders in a sustainable and ongoing manner.

The safe operation of the electricity transmission network is TransGrid's highest priority. Our transmission lines exist on both private and public land, and are maintained in a condition that allows them to be operated safely at all times. Our substations and switchyards are designed with public safety as a central consideration.

TransGrid's network forms the backbone of the National Electricity Market (NEM), facilitating interstate trading and transfer of electricity. TransGrid works closely with the Australian Energy Market Operator (AEMO) to ensure that our central role in the NEM supports the operation of the market and upholds the NEM Objective. As the NEM evolves through developments and reviews, such as the Transmission Frameworks Review by the Australian Energy Market Commission (AEMC), TransGrid participates in these developments to seek the best outcome for our customers and market participants.

The Annual Planning Report 2012 forecasts that peak electricity demand in New South Wales will increase by 1.3 per cent each year on average for the next 10 years. This growth combined with the need to replace assets as they reach the end of their life is being met through an ongoing capital program to ensure that the New South Wales transmission network can meet the expectations of our customers. TransGrid is committed to meeting customer needs by adopting the most efficient options including investing and building infrastructure, and network support contracts. These are undertaken when they are needed and not before.

Minimising the impact of TransGrid's activities on the environment is also a key priority. This is supported by strategies targeted at preventing environmental incidents and fostering an environmental culture which integrates environmental management into everyday business activities. Through engagement with community and building partnerships TransGrid endeavours to balance the needs of our building program with the impacts on the wider community.

At a State level there has been a continuing focus by customers and stakeholders on the performance of transmission and distribution companies. In recent times network price increases have dominated the discourse emphasising the importance of efficient service delivery. However, it has also been recognised that the reliability – price trade-off needs to be addressed with care because of the central importance of electricity reliability to wider economic and social outcomes. It is in this context that the requirements of the New South Wales Electricity Supply (Safety & Network Management) Regulation 2008 need to be viewed. This includes the central requirement for Network Operators to develop Network Management Plans and report annually on the performance of the network.

To meet these requirements TransGrid has reviewed and updated its Network Management Plan to cover the period from 2013 to 2018 inclusive. The Plan includes chapters on network safety and reliability, customer installation safety, public electrical safety awareness and bush fire risk management as required by the Regulation. The Plan provides a focus for continually improving the management of the transmission system. It also provides a formal method for information dissemination to customers, stakeholders and regulators.

TransGrid's corporate objectives for electricity supply, safety, quality and the environment are achieved primarily through the strategies described in this Plan. The Plan articulates the model TransGrid uses to manage its assets and develop the asset management strategies through all phases of the asset life cycle – from initial planning to disposal. These strategies are integrated with non-asset strategies such as human resources, finance, information technology and procurement.

This Plan has been developed in parallel with the annual planning review conducted by TransGrid as the Jurisdictional Planning Body for New South Wales and therefore will by necessity be a living document that will change in response to feedback from customers and market participants.

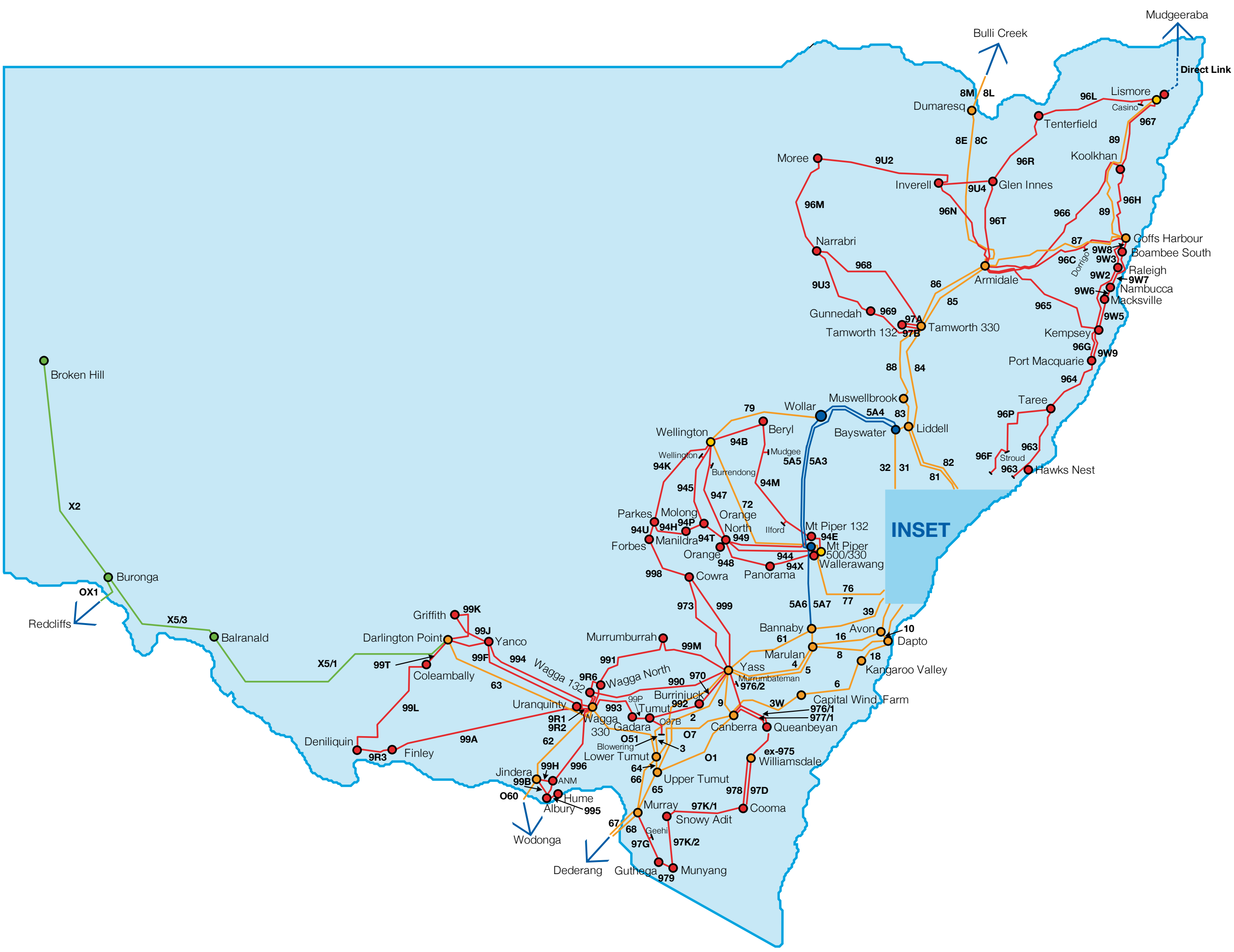
Feedback on the Network Management Plan is welcome as this will assist TransGrid to effectively meet the requirements of its customers and stakeholders.

Peter McIntyre
Managing Director
February 2013

About TransGrid

TransGrid is the owner, operator and manager of the high voltage transmission network in New South Wales. This network provides transmission capability between generators, distributors and major end use customers and is interconnected to Queensland and Victoria, providing a robust electricity system that facilitates interstate energy trading.

TransGrid, with 94 substations and over 12,700 kilometres of transmission lines, forms the backbone of Australia's National Electricity Market, one of the most extensive electricity systems in the world.



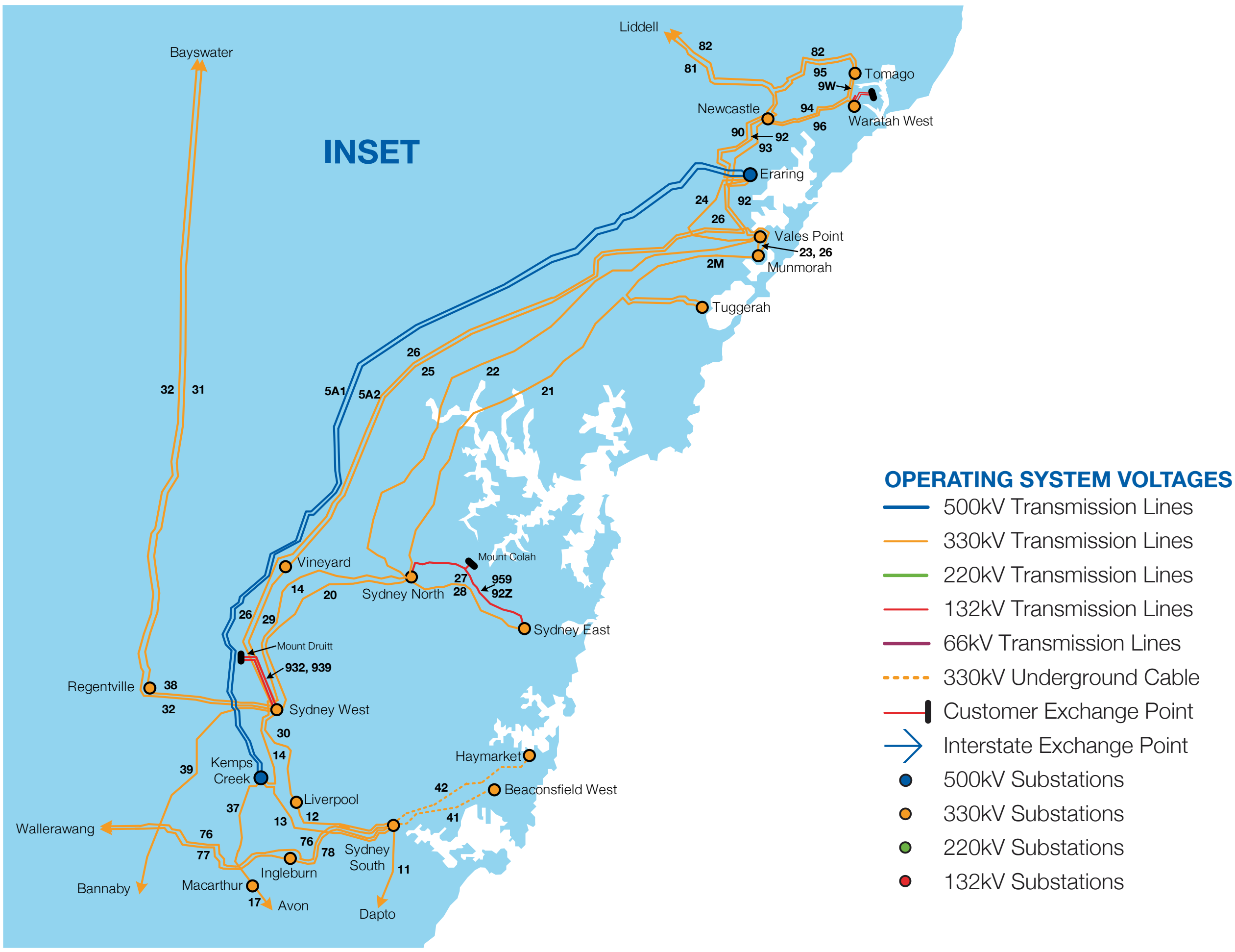
TransGrid is a State Owned Corporation (SOC) with its principal objectives stated in Section 6B of the Energy Services Corporations Act 1995 No 95. Its objectives are:

- to be a successful business;
- to exhibit a sense of social responsibility;
- to protect the environment;
- to exhibit a sense of responsibility towards regional development and decentralisation;
- to operate efficient, safe and reliable facilities for the transmission of electricity; and
- to promote effective access to those transmission facilities.

The system, which has a replacement value of over $10 billion, operates at voltage levels of 500, 330, 220 and 132 kV. The substations are normally located on land owned by TransGrid, with the transmission lines generally constructed on easements acquired across private or public land.

TransGrid has staff strategically based at locations throughout NSW in order to meet day to day operation and maintenance requirements as well as being able to provide emergency response. The head office is located at the corner of Park and Elizabeth Streets in Sydney. Field staff are co-ordinated from major depots located in Western Sydney, Newcastle, Tamworth, Orange, Wagga Wagga and Yass.

TransGrid has produced an Electricity Supply Network map showing locations of TransGrid Network assets. This map is shown below. The specific locations of individual sites may be requested from the appropriate Regional Offices.



Chapter 1: Network Safety and Reliability

Part 1: Network Management Plan Framework

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Part 1: Network Management Plan Framework

1.1 Introduction

The primary input to this Network Management Plan ("the Plan") is TransGrid's processes and procedures developed under its asset management model. The model reflects industry best practice in its approach to TransGrid's objectives relating to the high voltage transmission network. The model recognises that in a high voltage electricity transmission network, planning of the network in relation to system augmentations and capacity upgrades plays just as important a role as managing the existing assets.

It also ensures that from an organisational perspective, there is a corporate approach towards service standards as distinct from a primarily engineering approach towards managing individual assets or groups of assets.

The asset management model integrates all aspects of the asset management life cycle, these being Plan, Build, Operate, Maintain, Renew and Dispose. It has been prepared to demonstrate responsible management of TransGrid's assets on behalf of its stakeholders and customers.

The Plan covers the period 2013-2018, and includes some tentative or long-term activities which may extend beyond the period.

1.2 Customers, Stakeholders and Other Parties for which the Plan is prepared

TransGrid's customers are electricity distributors, retailers, generators, transmission network operators and directly connected end use customers.

TransGrid aims to provide all customers and end-use consumers a safe, adequate and reliable transmission service and to deliver this over the long term, at minimum cost.

TransGrid's shareholder is the NSW Government. The Government wishes to ensure, as the ultimate owner of the assets, that their financial capital is secure.

Other parties with a potential interest in this Plan include employees, contractors, members of the public through whose land the network is built, retailers and energy traders who use the network for trading and any of the regulatory bodies with which TransGrid liaises.

1.3 Structure of the Plan

This Plan is structured to meet all the requirements, for a Network Management Plan, of the Electricity Supply (Safety and Network Management) Regulation 2008, as stipulated in Clauses 9, 10, 11, 12 and Schedule 1 of the Regulation.

The Plan specifically describes and details the planning and service delivery strategies and standards and the resulting capital investment strategy.

It details TransGrid's asset management approach including the various associated policies, strategies and standards. It lists the programs for each of the asset categories detailing specific issues and the strategy for dealing with the issues. It also details the different measures used to determine the performance of the assets including technical performance assessments, quarterly asset performance reviews and benchmarking studies.

Asset disposal and waste strategies are also included in the Plan.

1.4 Assets

The Plan covers all assets comprising or relating to the network including:

- transmission lines and cables including easements and access tracks;
- substations and switching stations including all associated primary and secondary plant; and
- communications equipment and associated facilities.

The Plan does not cover non-network assets such as motor vehicles, furniture, non-system related land, buildings and equipment (e.g. corporate computers and business systems).

1.5 Working Assumptions of this Plan

The Plan was prepared on the following basis:

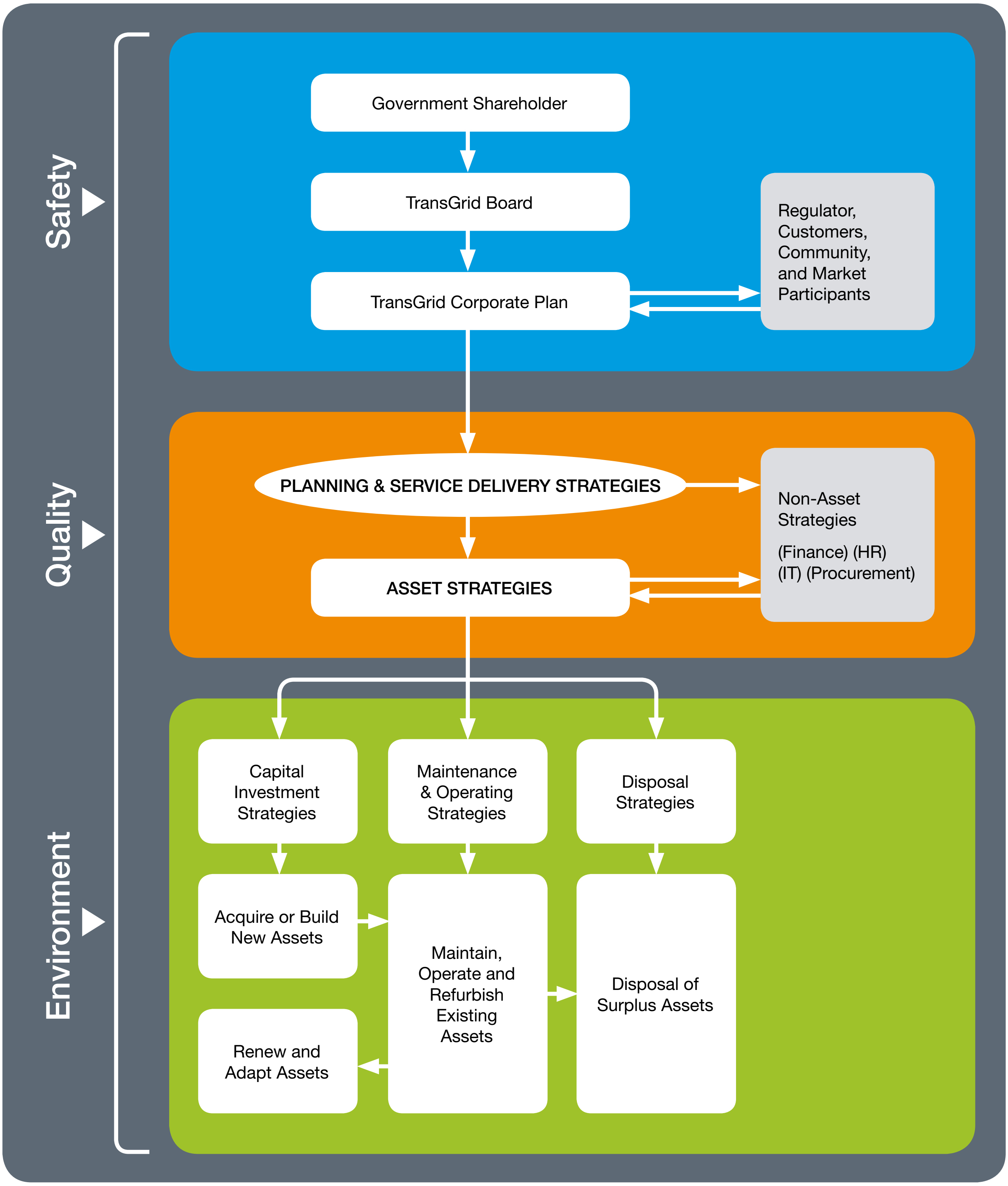
- It is an overview document that leads to the preparation of more detailed working documents identified in the Network Management Process. These include the Annual Planning Report, the Asset Management Strategies, the Maintenance Policies and the relevant capital and operating project governance documents.
- It does not represent an authorisation to commit expenditure, nor does it represent a commitment on the part of TransGrid to proceed with any specific projects or programs. Authorisation of expenditure will result from approval of the Annual Budget by the Board and from other specific expenditure, technical and environmental approvals.

1.6 TransGrid's Asset Management Model

The Model shown below provides a framework for the strategic planning and management of TransGrid's physical assets and is based on the NSW Government's Total Asset Management (TAM) Model.

The model shows the direct linkages between TransGrid's Corporate Plan, its Service Delivery Strategies and the Network Management Plan.

Asset Management Model



The following table illustrates the relationships and linkages between specific aspects of TransGrid's Network Management Plan, associated strategies and related performance indicators. These relationships serve as a framework for identifying why particular asset management activities are required.

Ultimately, TransGrid's performance is judged against community, customer and shareholder expectations and the key performance indicators shown below are the parameters by which this performance is assessed.

TRANSGRID'S CUSTOMER SERVICE DELIVERY STANDARDS, STATUTORY AND BUSINESS REQUIREMENTS			
Output Performance	Capital Investment Strategies	Asset Management Strategies	Asset Disposal Strategies
Key Drivers	System adequacy to meet service delivery, load growth, quality of supply and security criteria Efficient use of capital	System Reliability Efficient use of operating funds for maintenance and system operation activities	Community, legislative and Corporate responsibility requirements
Key Activities	Planning and development processes Consultation processes Construction of new assets Engaging Demand Management	Asset management strategies Maintenance policies Outage planning and coordination Condition monitoring Asset Health Indices	Asset equipment register to include materials such as PCBs Identification of surplus assets Waste management strategies
Key Performance Indicators	Satisfy customer service requirements Network reliability and availability Compliance with National Electricity Rules Completion of major CAPEX projects to program and budget Lack of safety and environmental incidents	Routine maintenance achievement Network reliability and availability Minimisation of market impact from TransGrid's activities Lack of safety and environmental incidents	Implementation of disposal plans Safe and cost effective disposal of surplus assets Lack of safety and environmental incidents

1.7 Schedule of Reports

TransGrid will, as required by notice in writing from the Director-General, lodge its Network Management Plan with the Director-General within such period as may be specified in the notice, to meet the requirements of Part 3 (Clause 8 [1]), Part 3 (Clause 9), Part 5 (Clause 20) and Schedule 1 of the Electricity Supply (Safety and Management) Regulation 2008.

TransGrid will, at times required by the Director-General, provide the Director-General with a report from a nominated auditor to meet the requirements of Part 4 (Clause 15, 16, 17 18 and 19) of the Regulation.

TransGrid will measure its performance against the Network Management Plan and an annual report will be provided to the Director-General as set out in Part 5 (Clause 21) of the Regulation. The annual report will be in the form of the Electricity Network Performance Report submitted annually to the Department of Trade and Investment NSW.

TransGrid will publish its Electricity Network Performance Report in accordance with Part 5 (Clause 21 [2 & 3]).

Chapter 1: Network Safety and Reliability

Part 2: Management Support Systems

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Part 2: Management Support Systems

The key network deliverable for TransGrid is to manage its assets and resources in order to meet defined levels of performance in terms of cost, reliability, availability and quality. However, the achievement of these objectives will at all times be performed in line with TransGrid's corporate social responsibility.

TransGrid manages its corporate social responsibility through management plans and systems including Quality, Safety, Environmental and Emergency Management Systems.

TransGrid ensures confidence in the effective application of identical policies and practices across the network through maintaining its certification to AS/NZS ISO 9001 for Quality Management, AS/NZS 4801 for Occupational Health and Safety Management Systems and AS/NZS ISO 14001 for Environmental Management Systems. To achieve the maintenance of these certifications, TransGrid follows a 3 year cycle consisting of 6 monthly audits and a 3 yearly certification assessment by an appropriate Certification Body.

This section of the Plan describes these systems.

2.1 Quality System

2.1.1 TransGrid's Quality System

TransGrid's Quality System lays a firm foundation for TransGrid to achieve its objectives of providing a safe, reliable, environmentally effective and economic bulk electricity network service to TransGrid's customers and the community.

The Quality System underpins all of TransGrid's activities, facilitating consistency in commercial rigour, technical excellence and environmental sensitivity.

2.1.2 Quality Certification

TransGrid demonstrates its ongoing commitment to quality through its compliance with, and continuing external certification to ISO 9001.

2.1.3 Quality System Organisational Structure

The Managing Director is ultimately accountable for the Quality System within TransGrid, while direct overall responsibility for the implementation and maintenance of the system is delegated to the Executive General Manager/People, Strategy & Corporate Services, reporting directly to the Managing Director.

Ensuring the flow through all levels of the organisation, managers throughout the organisation have responsibility for the implementation of quality practices within their part of the business and the quality of products and services provided by contractors.

Further, team leaders at all levels are responsible for ensuring that those activities under their control are carried out in accordance with established procedures.

As a consequence, TransGrid has confidence in the consistent application of quality procedures across its geographically diverse workforce.

2.1.4 Structure of Quality System Documentation

The backbone of TransGrid's Quality System is its hierarchy of documentation. This documentation, under regular review to meet TransGrid's ongoing business activities, ensures that all the requirements of the elements of ISO 9001 are met. The document hierarchy is as follows:

Corporate Procedures

- → Procedures to control and implement activities so that business needs and the requirements of ISO 9001 are met.
- → Cross-functional, applicable across business units and groups.

Asset Management Standards

- → Set minimum requirements for the management of assets.

Business Unit Documents

- → Cover specific needs for TransGrid.
- → Includes business unit policies, procedures, work instructions, specifications, standards, manuals, forms and check sheets.

Project Specific Documents

- → Includes project plans, design plans and contract project plans.
- → Other documents for a specific project.

2.1.5 Overall Principles

TransGrid's quality approach provides its workforce with the tools and management support to:

- → consistently deliver quality products and services which satisfy the customer's needs;
- → improve organisation performance and eliminate waste by reforming work processes;
- → work towards continuous improvement on all fronts; and
- → deliver the right result the first time.

2.1.6 Standards and Procedures

2.1.6.1 Design and Construction Standards

TransGrid's network assets are designed in accordance with TransGrid's Engineering Design Instructions, series number 1/A/1 to 6/C/1. These Design Instructions are based on relevant Australian and International Standards and incorporate additional TransGrid requirements developed from experience in operating the transmission network. Construction is carried out in accordance with designs. Post-construction review meetings are held to provide feedback on the design and construction process.

All design and construction of equipment for use in TransGrid includes, as part of the specification, the requirements of TransGrid's Safety Rules and requirements as nominated in Grid Standards and Grid Asset Management Standards.

As applicable, relevant Australian Standards and Codes of Practices are used in designing, selecting and maintaining equipment. Particular codes taken into account and implemented are:

- *ENA DOC 001-2008 National Electricity Network Safety Code*
- *Code of Practice: Electricity transmission and distribution asset management – February 2009, except that:*
  - In relation to Clause 7.3.4, the *ESAA NENS 04 – 2006 National Guidelines for Safe Approach Distances to Electrical Apparatus* are applied as guidelines for the purposes of this clause.
- *Crossings of NSW Navigable Waters: Electricity Industry Code*

The following Codes of Practice and Guidelines have been taken into account but not implemented in the Network Management Plan as they are intended for application in distribution networks and are not applicable to TransGrid's activities:

- *Demand Management for Electricity Distributors: Code of Practice*
- *ISSC 33 Guideline for Network Configuration during High Bushfire Risk Days*
- *Electricity Service Standards: Code of Practice*
- *ISSC 31 Guidelines for the Management of Private Lines*
- *Contestable Works: Code of Practice*
- *Installation Safety Management: Code of Practice*
- *Service and Installation Rules: Code of Practice*
- *Service and Installation Rules for NSW.*

Design and construction standards are located on TransGrid's intranet, or in controlled local folders in the design office.

2.1.6.2 Maintenance Standards

TransGrid's assets are managed as directed in the Network Asset Management Procedure – GD AS G2 003. All maintenance work is carried out in accordance with the relevant Asset Management Standard or Grid Standards.

- Substation Maintenance Policy – GM AS S1 001
- Protection Maintenance Policy – GM AS P1 001
- Metering Maintenance Policy – GM AS M1 001
- Telecommunications Maintenance Policy – GM AS C1 001
- Control Systems Maintenance Policy – GM AS D1 001
- Transmission Lines Maintenance Policy – GM AS L1 001
- Easements and Access Track Maintenance Policy – GM AS L1 002
- Underground Cable Assets Maintenance Policy – GM AS S1 005
- Network Security Inspection and Maintenance Policy – GM AS S1 011

Maintenance standards are located on TransGrid's intranet and controlled local folders in the relevant offices.

2.1.6.3 Operation and Work Procedures

TransGrid's work procedures are based on a formal process of task analysis and risk assessment supported by the accumulated experience of the organisation and best practice work methods. All work carried out within TransGrid, whether by TransGrid employees or contractors, is carried out in accordance with these procedures. TransGrid's procedures comply with all relevant legislation, the ENA National Electricity Network Safety Code and other Codes of Practice and Guidelines, including those issued by WorkCover Authority of NSW and Safe Work Australia.

Operation and work procedures are contained in TransGrid's Power System Safety Rules which details the rules for safe work on the transmission system, and Operating Manuals which provide operation parameters for specific sites and operating practices and requirements to facilitate safe switching operations.

Work Procedures are contained in Grid and Asset Management Standards:

- Substation Procedures and Instructions – GM AS S2 – S3 series
- Lines Procedures and Instructions – GM AS L2 – L3 series
- Live Line Procedures and Instructions – GM LL L2 – L3 series
- Protection Procedures and Instructions – GM AS P2 – P3 series
- Metering Procedures and Instructions – GM AS M2 – M3 series
- Communications Procedures and Instructions – GM AS C2 – C3 series
- Safety Procedures and Instructions – GM SA G2 – G3 series
- Environmental Procedures – GD EN G2 series and GM EN G2 series

Operations procedures are contained in Operating Manuals. These cover aspects of operating the network such as equipment ratings, switching procedures, operation during outages, response to incidents, load shedding, system restart, synchronising, logging and statistics recording.

These standards are located on TransGrid's intranet site or in controlled local folders in the relevant offices.

2.1.6.4 Description of Engineering Records and Drawings

TransGrid maintains the following engineering records and drawings for the transmission system:

Drawings

All electrical layouts and diagrams for all sites and equipment are maintained in the Electronic Drawing Management System.

Maintenance Records

All records of completed maintenance work are maintained electronically in the Enterprise Resource Planning (ERP) System.

Operating Records

The operators log is used by TransGrid's control room staff to record all significant activity associated with operating the network.

Outage requests and records of all completed outages are maintained in TransGrid's outage system, THEOS. Management of outages under TransGrid's safety rules including Requests for Access, preparation of switching instructions and the management of Access Authorities is done via the HVPRI application.

2.2 Health and Safety Management System

2.2.1 Health and Safety Policy

TransGrid's Health and Safety Policy, a copy of which is in Appendix A, reflects the organisation's commitment to safety and underpins the Health and Safety Management System.

2.2.2 Health and Safety Commitment and Principles

TransGrid also has documented Health and Safety Principles based on the Policy. They are as follows:

- Safety is our first priority;
- All accidents are preventable;
- Working safely is a condition of employment;
- Everyone can demonstrate leadership in health and safety; and
- We are committed to protecting the health and safety of employees, contractors, visitors and the public.

2.2.3 Health and Safety Organisational Structure

The Board of TransGrid has the final responsibility for ensuring that the necessary resources and organisational procedures exist throughout TransGrid. This responsibility is discharged through the Managing Director and the Executive Health and Safety Committee.

Safety policies and procedures are approved by the Managing Director following review and recommendation by the Executive Health and Safety Committee and/or other relevant stakeholders. The Executive Health and Safety Committee's Charter is the development of corporate occupational health and safety policy and the promotion and monitoring of health and safety performance within TransGrid. The committee's goal is the elimination of all workplace injuries and incidents.

The Executive Health and Safety Committee has a number of subcommittees reporting to it. They are:

- Fire Protection Committee;
- Electric & Magnetic Fields Committee;
- Safety Rules Committee (which includes High Voltage Safe Working Practices);
- Personal Protective Equipment and Clothing Committee; and
- Safety Communications Steering Committee.

Each of TransGrid's seven major sites has an established Health and Safety (HS) Committee. These committees meet every two to three months to address local issues and discuss endorsed recommendations of the Executive HS Committee.

2.2.4 Health and Safety Management System

TransGrid's Health and Safety Management System outlines TransGrid's organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining health and safety systems.

The document provides guidance to managers, team leaders and employees for the effective implementation and maintenance of health and safety systems and procedures in each of TransGrid's Business Units.

An integral part of TransGrid's health and safety management system is a schedule of audits to monitor compliance with both TransGrid and legislative requirements. All TransGrid business units are audited at least once every three years.

TransGrid's Health and Safety Management System is also audited by SAI Global to ensure certification to AS 4801 Health and Safety Management System is maintained.

2.2.5 Safety Performance

TransGrid is required to report all fatal and non-fatal incidents involving electric shock, flash or burns or any falls from elevated positions associated with work on electrical apparatus as soon as practicable to the Director-General of Trade & Investment NSW.

TransGrid is also required to report any failure of equipment that could have consequences regarding the safety of staff, contractors or the public to the Director-General of Trade & Investment NSW. All lost time injuries and high consequence incidents (those with the potential to severely injure or harm) are reported to all senior leaders including TransGrid's Managing Director. TransGrid requires all contractors to provide details of any accident or incident.

All accidents and safety incidents are investigated to ascertain causes and develop corrective and preventive measures to eliminate future occurrences. The status of these investigation reports is reported weekly to TransGrid's Executive. Any safety incident involving the general public is viewed as a most serious occurrence that involves thorough investigation.

Occupational Health and Safety performance data is provided as required by the Electricity Supply (Safety and Network Management) Regulation 2008 in the Electricity Network Performance Report.

2.2.6 Accident Statistics

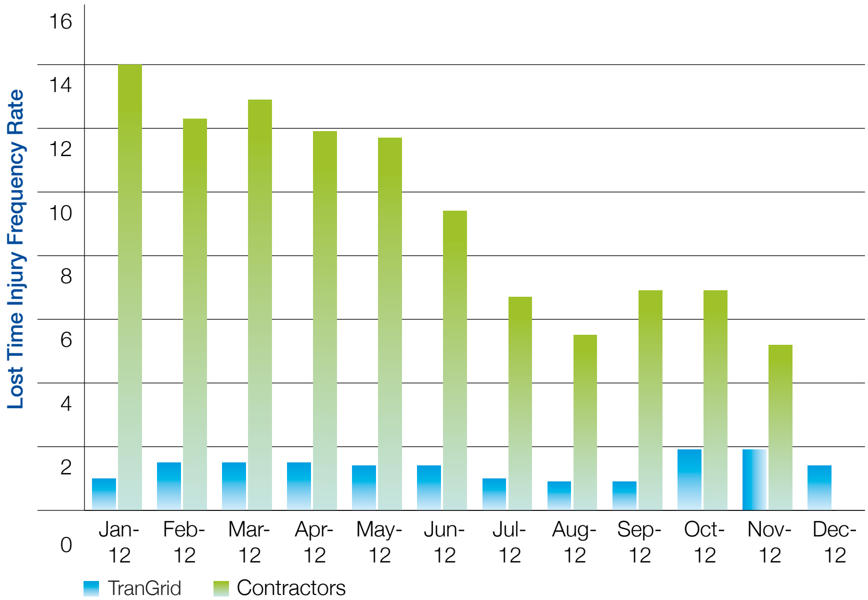
TransGrid Staff

Health and safety performance measures and statistics are recorded and maintained for employees and contractors in accordance with Australian Standard AS 1885. The following safety related statistics are kept on a rolling twelve month basis and reviewed monthly:

- Number of Lost Time Injuries (LTIs);
- Number of Non-Lost Time Injuries;
- Lost Time Injury Frequency Rate;
- Average Lost Time Injury Rate;
- Number of work days lost due to statistical LTI;
- Number of work days lost due to non-statistical LTI; and
- Number of days since last LTI.

A summary of TransGrid's Lost Time Injury Frequency Rate (LTIFR) is shown in the chart below. The frequency rate is calculated as injuries per million hours worked.

Lost Time Injury Frequency Rate



Note: Contractor statistics are reported one month in arrears.

The General Public

Statistics are kept on public accidents and incidents and their causes together with prevention strategies.

2.2.7 Safety Rules, Equipment Design, Use and Maintenance

TransGrid's Safety Rules detail the rules for safe work on the transmission system, and Operating Manuals provide the operating parameters for specific sites and operating practices and requirements to facilitate safe switching operations.

Safety equipment design, care, use, maintenance and frequency of maintenance, used by TransGrid employees and contractors, are detailed in TransGrid High Voltage Safety Equipment and Procedures which are located in TransGrid's Grid Standards (GD Series Documents):

- High Voltage Operating Rods – GD SA G2 002.
- Safe Work Practices on High Voltage Overhead Lines GD SR G3 162.
- Proving High Voltage Equipment De-energised – GD SA G2 014.
- Portable Earthing of High Voltage Electrical Equipment – GD SA G2 015.
- Safe Work Practices on High Voltage Cables – GD SR G3 172.
- Live Line Methods Manual – GM LL series.

Relevant Australian Standards and Codes of Practices are used in designing, selecting and maintaining equipment as applicable.

These standards are located on TransGrid's intranet site, or in controlled local folders in the relevant central or regional offices.

A range of Personal Protective Equipment (PPE) is used in TransGrid. PPE is selected with reference to relevant Australian Standards and Codes of Practice and by consultation with stakeholder employees. Guidelines for employees and managers for appropriate PPE are established in TransGrid's Guide to Safe Working Practices, Equipment and Tools – GD HS G2 050 which is accessible to all staff on the intranet.

2.2.8 Analysis of Hazards

2.2.8.1 Risk Assessment

TransGrid has in place a robust system to identify hazards and assess the risk of those hazards prior to commencing work, as described in HS Risk Assessment. An analysis of hazards is carried out by TransGrid to ensure that appropriate controls and preventative measures are implemented.

Management review and auditing of the work of staff and contractors is carried out to ensure that any new hazards are appropriately identified and safe processes of work are implemented.

This hazard identification and risk assessment system is regularly audited to ensure compliance.

2.2.8.2 Hazards During New Construction Work

New construction by contractors:

Major contractors to TransGrid are required to comply with the requirements of NSW Government OHS Management Systems Guidelines, developed by the Construction Agency Coordination Committee (CACC), and to abide by the Codes of Practice developed by the CACC and relevant TransGrid Policies and Procedures. They must also comply with relevant NSW Work Health and Safety Act (WHS) and Regulations and environmental legislation as included in all contracts and orders.

Contractors, their staff and agents are required to be inducted onto a site and sign a declaration acknowledging that they have been advised of the relevant HS issues associated with the work to be undertaken.

New construction by TransGrid:

TransGrid engages in new construction work both within the organisation and in the external market. As part of this process, TransGrid will submit a WHS Management Plan if required.

2.2.8.3 Measures to Prevent Hazards to Community and Environment

In addition to the steps taken to identify hazardous events, their potential causes and consequences to staff and contractors, TransGrid through its range of design standards, maintenance policies, plant refurbishment and replacement strategies and operational work practices undertakes to address all foreseeable events relating to plant and processes that may cause hazards to the environment and community.

More details of these processes are in section 2.1.6 of this Plan. Specific examples of hazards addressed are:

- Analysis of environmental hazards is contained in TransGrid's Environmental Management System (Part 2.3 of this Plan) and the Environmental Manual – GD EN G2 002. These include a consideration of section 4.3.1 of ISO 14001 for environmental aspects and impacts, and are summarised in an Environmental Risk Register. Relevant substations, transmission line and environmental standards address the issues raised in this process.
- The potential risks of electrical incidents involving the public have been assessed and strategies developed to address these are established in TransGrid's Public Electrical Safety Awareness Plan, Chapter 3 of this Plan.
- The risks of bushfires associated with the management of transmission lines and their easements are fully addressed in TransGrid's Bushfire Risk Management Plan, Chapter 4 of this Plan.
- Transformer fires and oil spills are major potential hazards to the community and environment. Should they happen, TransGrid maintains extensive safeguards to prevent these events from causing damage to the environment or community.

TransGrid's document Substation Oil Containment – GD AS G2 101 sets out items to be considered in the design of substations with regard to spill containment systems and other places where bulk oil or liquid hazardous materials are kept.

Other substation and environmental standards, covered by section 2.1.6.3 of this Plan, provide for the regular inspection of plant oil containment systems and emergency oil spill control equipment. Emergency response to a fire involving TransGrid assets, are managed by the process indicated in section 2.4.

2.2.9 Employee Competency System

To ensure that all TransGrid's employees and contractor staff who work on or near the electricity network assets have the appropriate competencies to undertake the work safely, TransGrid maintains and implements the following procedures and guidelines:

- Training Procedure – GD ES G2 066.
- Power System Safety Rules Authorisation.

In addition, TransGrid also implements training for qualification within the following National Training packages:

- Transmission, Distribution and Rail Sector Training Package – UET12; and
- Electrotechnology Training Package – UEE11.

2.2.10 Public Liability Insurance

TransGrid secures public liability insurance to cover risks associated with its normal business operations. The insurance is sourced from both domestic and internationally based organisations. Responsibilities and procedures for this insurance are covered by TransGrid's document Insurance and Damaged Assets Procedure – GD FN G2 019.

2.3 Environmental Management System

TransGrid has continued to develop and implement an Environmental Management System (EMS) in accordance with ISO 14001. TransGrid's EMS was first accredited in 1996 and the system successfully passed its last certification audit by SAI Global in 2012.

Key achievements over the past five years include:

- continued certification of the EMS to ISO 14001;
- review and update of TransGrid's Environment Policy;
- conduct of annual aspects/impacts workshop with key environmental staff;
- update of a number of EMS procedures;
- review of all operational procedures with environmental content;
- environmental audits completed in line with the environmental audit schedule; and
- completion of internal EMS audits.

2.3.1 Environment Policy

TransGrid's Environment Policy, a copy of which is provided in Appendix A, reflects the organisation's commitment to the protection of the environment.

The Environment Policy includes a commitment to:

- Maintain an Environmental Management System that provides the framework for setting and reviewing our environmental objectives and targets, including the implementation, monitoring and review of these objectives and targets;
- Continue to develop systems that recognise sensitive environmental and cultural sites on or near our infrastructure, and provides processes to manage and minimise our potential impacts;
- Integrate environmental management considerations into the planning, design, siting, construction, maintenance, operation, decommissioning and disposal of all TransGrid assets;
- Provide environmental training, assessment and authorisation under our Environmental Rules to employees and contractors to enable them to perform their duties in an environmentally sensitive manner;
- Engage with the community, customers, employees, government and other stakeholders regarding potential environmental or cultural impacts associated with our plans and activities; and
- Pursue opportunities to maximise resource efficiencies and reduce the generation of waste through reduction, reuse and recycling programs.

All TransGrid staff and contractors have a responsibility to protect the environment in which they work.

2.3.2 Environmental Organisational Structure

To effectively manage TransGrid's activities in an environmentally sensitive manner a range of environmental committees, working groups and specific environmental positions within the organisation have been created.

The current environmental structure provides an efficient mechanism for managing environmental issues on a day-to-day basis across the entire organisation and supports TransGrid's Environmental Management System.

Executive Environment Committee

The Managing Director, a number of Executive General Managers and other senior managers including the Corporate Environment Manager have an active role in the protection of the environment through their direct involvement in the Executive Environment Committee. This high level committee is responsible for setting the overall environmental management direction of the organisation and ensures strategies and programs are developed and implemented in a manner that complements the Corporate Plan and the Environment Policy.

The Executive Environment Committee meets quarterly to discuss environmental issues such as:

- → status of the Environmental Working Group;
- → Environmental Management System status;
- → environmental initiatives; and
- → environmental compliance, audit and monitoring.

2.3.3 Our Stakeholders

TransGrid's environmental management requires interaction with a variety of stakeholders who operate in a diverse range of locations and ecosystems spread across the state. TransGrid recognises its environmental responsibilities and is committed to actively working with the following stakeholders to improve environmental performance and reduce the environmental impacts of its operations.

STAKEHOLDER	RELATIONSHIP	INTERACTION
Office of Environment and Heritage and Environmental Protection Authority	Regulator	→ Licensor/Licensee negotiations. → Licence review. → Comment on proposed legislation changes. → Notification of incidents causing environmental harm. → Provision of feedback to EPA regarding their programs. → PCB and hazardous waste disposal. → WRAPP reporting.
NSW National Parks and Wildlife Service	Landowner and Land Manager	→ Liaison regarding permission for access and easement maintenance on NPWS sites. → Development of electronic Environmental Management Plans for all easements across lands administered by NSW National Parks. → Comment on TransGrid management practices. → Joint landscape restoration workshops.
Environment ACT	Landowner and Land Manager	→ Liaison regarding permission for access and easement maintenance on ACT lands. → Development of electronic Environmental Management Plans for all easements across lands administered by Environment ACT. → Comment on TransGrid management practices.
Forests NSW	Landowner	→ Liaison regarding access and easement maintenance.
Clean Energy Regulator	Regulator	→ National Greenhouse and Energy Reporting.
Local Councils	Stakeholder	→ Local environmental planning instruments. → Development approvals.
Environmental Organisations	Sponsorships and Partnerships	→ Funding and assistance for environmental projects: – Greening Australia. – Earthwatch. – River Recovery Programs. – Other minor sponsorships.
Community	Stakeholders and Landowners	→ Provision of advice regarding TransGrid's programs and policies. → Environmental Impact Assessment comment on development proposals. → Easement access and management. → Community engagement through environmental initiatives. → TransGrid's surplus land sales.

2.4 Emergency Management System

2.4.1 Emergency Management Procedures

Business continuity, emergency management and contingency planning are addressed through a number of documents including:

- Corporate and Regional Emergency Management Plan (CREMP), which aims to anticipate, respond and manage any type of emergency which impacts on safety, reliability, the environment, or TransGrid's business as quickly and safely as possible.
- The Continuity of Transmission Supply Plan – GD AS S1 012, which outlines the general approach to continuity of electricity supply following the loss of a significant network asset.
- An Information Technology Service Recovery Plan which covers continuity of IT processes.

Emergency management procedures are specified in the CREMP and are used to co-ordinate the management measures necessary to ensure a state of preparedness for emergencies which may impact upon reliability of supply, the safety of staff, members of the public or the environment. The CREMP is also required to respond to emergencies declared under the NSW State Emergency Management Plan (previously the State Disaster Plan) and AEMO's Power System Emergency Management Plan (PSEMP).

The CREMP categorises various levels of emergency and details the specific command structures and responsibilities associated with each. A risk management process supports this policy by identifying and evaluating key risks, and promoting a formal approach to management of those risks. The CREMP is specifically designed to enable an effective response to major incidents, the threat of which has been identified in the risk assessment process.

Whilst TransGrid's assets are exposed to the elements and are therefore impacted by natural events such as bushfires, cyclones and earthquakes, the CREMP also applies to failures of major system components and abnormal events such as vandalism and sabotage.

Each Region within TransGrid has for each of its operational centres a Site Emergency and Evacuation Plan for incidents such as fire or bomb threats. These plans are located prominently on notice boards throughout the offices and buildings. These plans comply with Australian Standard – *AS 3745-2010 Planning for Emergencies in Facilities.*

These plans detail the site emergency control personnel, evacuation measures including annual training exercises and debrief sessions and the testing of alarms. All visitors to sites are advised of the existence of these procedures as part of their site induction.

The above mentioned plans are reviewed following any significant emergency to ensure that they were applied, that they worked effectively and noting any areas requiring amendment.

Each substation site has an individually designed Emergency Response Manual to deal with environmental emergencies or incidents at that site. These manuals are maintained to ensure their currency and are subject to regular independent audits.

Security incidents are recorded in the Incident Notification System on the intranet and are regularly reviewed to identify trends and determine any appropriate action.

2.4.2 Collaboration

TransGrid actively participates in several industry forums and working groups for information sharing and collaborative action regarding security, including:

- Energy & Utility Services Functional Area, co-ordinated by Trade and Investment NSW;
- Energy Sector Group, part of the Trusted Information Sharing Network co-ordinated by the Federal Government; and
- NSW Utilities Metal Theft Working Group.

2.4.3 Operating Staff

TransGrid's system operation centres are staffed on a 24 hour basis. Operating staff at these centres are trained to operate the system in a safe manner in response to emergency conditions of all types, including:

- supply disruptions;
- asset damage;
- fire, explosion, impact;
- natural disaster; and
- civil disturbances.

In response to natural disasters and disturbances, the operator is required to contact the appropriate emergency service organisation. Operating staff escalate and coordinate responses with field staff who access other resources as required to address these emergencies in accordance with the CREMP.

Other relevant documentation includes:

- Operating Manuals;
- Fire Protection Manual Operations and Maintenance; and
- Environmental Management System (EMS) Framework and associated Emergency Response Manuals.

Operating Manuals that are relevant to emergency response include:

- Notification of System Incidents – OM 550;
- Operational Failure of a Control Centre – OM 667;
- Operational Communication Facilities – OM 801; and
- Restart of New South Wales System – OM 666.

2.4.4 Testing of the Emergency Procedures

The CREMP is tested on a regular basis by the simulation of emergency incidents. The testing sometimes involves the participation of other parties such as AEMO, distributors, other TNSPs and Jurisdictional bodies.

Local evacuation plans are tested by regular evacuation drills.

TransGrid's first aid and fire fighting capabilities are tested at the annual Safety Day, where skills of staff from across the state are tested under competition conditions.

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Part 3: Planning and Service Delivery

3.1 Corporate Planning

TransGrid's Corporate Plan defines the organisation's vision, mission, values, objectives and performance targets. It is the high level plan from which specific business unit plans and strategies flow.

The Corporate Plan is developed using a balance scorecard approach around five strategic themes:

- service the market;
- improve and innovate;
- contribute to our community;
- increase business value; and
- foster a performance culture.

The Corporate Plan is reviewed every year and performance is reported quarterly.

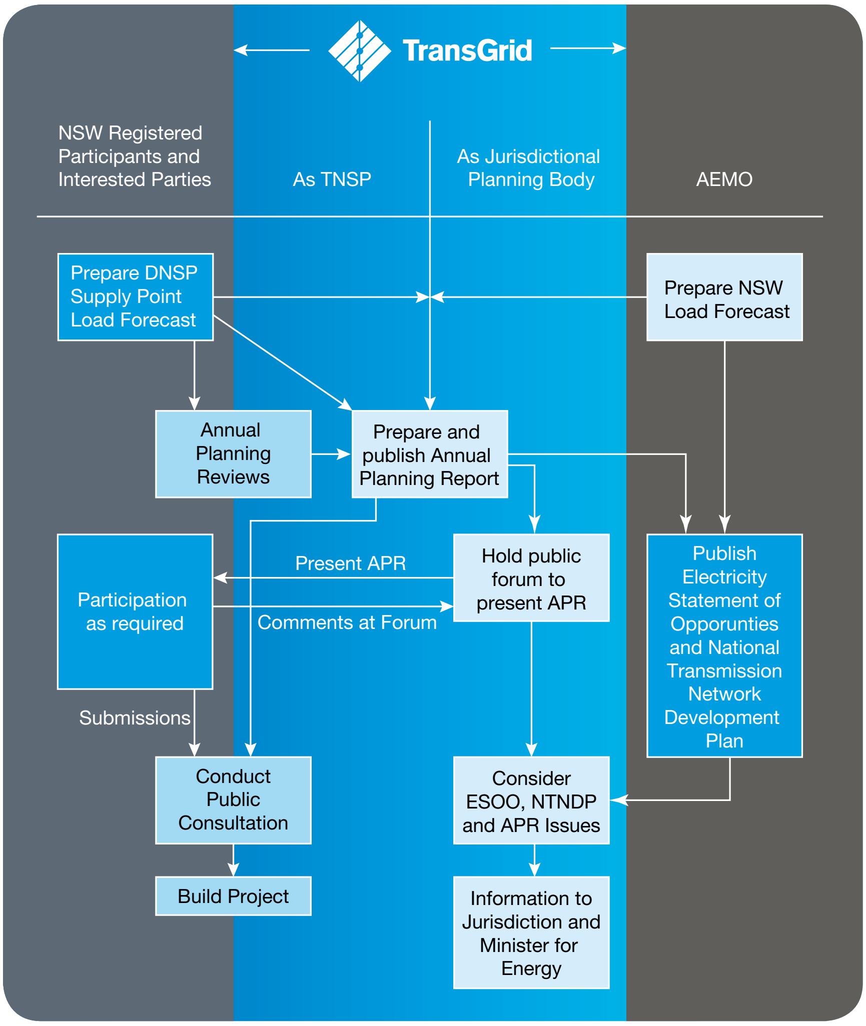
3.2 Network Planning

3.2.1 Overview

TransGrid carries out planning in accordance with its regulatory obligations under the National Electricity Rules (NER), Jurisdictional requirements and customer expectations. As the Jurisdictional Planning Body (JPB) for NSW, TransGrid works with the Australian Energy Market Operator (AEMO) to provide input to the Electricity Statement of Opportunities (ESOO) and National Transmission Network Development Plan (NTNDP).

As a registered Transmission Network Service Provider (TNSP) in the National Electricity Market (NEM), TransGrid is required to perform a yearly planning review and produce an Annual Planning Report (APR) with information relevant to supply demand balance, transmission network planning and distribution network planning.

The roles of AEMO, TransGrid and other parties in the planning process are set out in the following figure:



3.2.2 Annual Planning Report

The National Electricity Rules require each Transmission Network Service Provider (TNSP) to undertake an Annual Planning Review and to prepare and publish an Annual Planning Report (APR) by 30 June of each year.

The purpose of the Planning Review and the APR is to:

- Identify emerging constraints in New South Wales transmission networks over appropriate planning horizons;
- Provide advance information on the nature, quantification and location of the constraints. The level of information included in the APR is intended to be sufficient to encourage market participants and interested parties to formulate and propose options to relieve the constraints, including those that may include components of Demand Management (DM) and local generation or other options that may provide economically efficient outcomes;
- Discuss options that have been identified for relieving each constraint including network, local generation, DM and other options;
- Indicate, where possible, if and when TransGrid intends to issue a Request for Proposal (RfP) for non-network alternatives to relieve a constraint;
- Comply with NER requirements in respect of preparation of a

Transmission Network Service Provider's Annual Planning Report and the associated consultation on proposed new small network transmission assets; and

- Provide a basis for annual reporting to the New South Wales Minister for Energy (the Minister) on the outcome of the Annual Planning Review.

The APR is intended to provide electricity market participants and interested parties with information that will assist them in contributing to the optimum and economically efficient development of transmission networks in NSW.

3.2.3 Approach to Planning

TransGrid's approach to network planning of the NSW transmission network is derived from its planning obligation under the NER, jurisdictional requirements and customer expectations. The approach is documented each year in TransGrid's APR.

The approach used for the preparation of TransGrid's APR 2012 is as follows.

3.2.3.1 General

The NSW transmission network has been planned and developed by TransGrid and its predecessor organisations, commencing with the Electricity Commission of NSW, for over 50 years.

Under NSW legislation TransGrid has responsibilities that include planning for future NSW transmission needs, including interconnection with other networks.

The NSW Government has specified the Transmission Network Design and Reliability Standard to be applied by TransGrid.

In addition, as a Transmission Network Service Provider (TNSP) TransGrid is obliged to meet the requirements of the NER. In particular, TransGrid is obliged to meet the requirements of clause S 5.1.2.1:

> "*Network Service Providers* must plan, design, maintain and operate their *transmission networks* to allow the transfer of power from *generating units* to *Customers* with all *facilities* or equipment associated with the *power system* in service and may be required by a *Registered Participant* under a *connection agreement* to continue to allow the transfer of power with certain *facilities* or *plant* associated with the *power system* out of service, whether or not accompanied by the occurrence of certain faults (called *"credible contingency events"*).

The NER sets out the required processes for developing networks as well as minimum performance requirements of the network and connections to the network. It also requires TransGrid to consult with Registered Participants and interested parties and to apply the AER's regulatory test or Regulatory Investment Test – Transmission (RIT-T) as appropriate, to development proposals.

TransGrid's planning obligations are also interlinked with the licence obligations placed on Distribution Network Service Providers (DNSP) in NSW. TransGrid must ensure that the system is adequately planned to enable the licence requirements to be met.

TransGrid also has obligations to meet community expectations in the supply of electricity, including ensuring that developments are undertaken in a socially and environmentally responsible manner.

In meeting these obligations TransGrid's approach to network planning is socially and economically based and is consistent with both the NER and the regulatory test or RIT-T. It includes consideration of non-network options such as demand side response and DM and/or embedded generation, as an integral part of the planning process. Joint planning with DNSPs, directly supplied industrial customers, generators and interstate TNSPs is carried out to ensure that the most economic options, whether network options or non-network options, consistent with customer and community requirements are identified and implemented.

TransGrid has traditionally planned the network to achieve supply at least community cost, without being constrained by State borders or ownership considerations. Prior to commencement of the NEM transmission augmentations were subjected to a cost-benefit assessment according to NSW State Treasury guidelines. A similar approach is applied in the NEM where the AER's regulatory test or RIT-T is applied to meet the requirements of Chapter 5 of the NER.

Jurisdictional Planning Requirements

In addition to meeting requirements imposed by the NER, environmental legislation and other statutory instruments, TransGrid is expected by the NSW jurisdiction to plan and develop its transmission network on an "n-1" basis. That is, unless specifically agreed otherwise by TransGrid and the affected distribution network owner or major directly connected end-use customer, there will be no inadvertent loss of load (other than load which is interruptible or dispatchable) following an outage of a single circuit (a line or a cable) or transformer, during periods of forecast high load.

In fulfilling this obligation, TransGrid must recognise specific customer requirements as well as AEMO's role as system operator for the NEM. To accommodate this, the standard "n-1" approach can be modified in the following circumstances:

- Where agreed between TransGrid and a distribution network owner or major directly connected end-use customer, agreed levels of supply interruption can be accepted for particular single outages, before augmentation of the network is undertaken (for example the situation with radial supplies);
- Where requested by a distribution network owner or major directly connected end-use customer and agreed with TransGrid there will be no inadvertent loss of load (other than load which is interruptible or dispatchable) following an outage of a section of busbar or coincident outages of agreed combinations of two circuits, two transformers or a circuit and a transformer (for example supply to the inner metropolitan/CBD area of Sydney); or
- The main transmission network, which is operated by AEMO, should have sufficient capacity to accommodate AEMO's operating practices without inadvertent loss of load (other than load which is interruptible or dispatchable) or uneconomic constraints on the energy market. At present AEMO's operational practices include the re-dispatch of generation and ancillary services following a first contingency, such that within 30 minutes the system will again be "secure" in anticipation of the next critical credible contingency.

In 2005 the NSW Government introduced mandatory licence conditions on DNSPs which set out certain reliability standards for sub-transmission and distribution networks. The licence conditions specify "n-1, 1 minute" reliability standards for sub-transmission lines and zone substations supplying loads greater than or equal to specified minimums, e.g. 15 MVA in urban and non-urban areas.

The NSW Government requires TransGrid to provide a commensurate level of reliability in its network supplying NSW DNSPs.

These jurisdictional requirements and other obligations require the following to be observed in planning:

- At all times when the system is either in its normal state with all elements in service or following a credible contingency:
  - Electrical and thermal ratings of equipment will not be exceeded; and
  - Stable control of the interconnected system will be maintained, with system voltages maintained within acceptable levels;
- A quality of electricity supply at least to NER requirements is to be provided;
- A standard of connection to individual customers as specified by Connection Agreements is to be provided;
- As far as possible connection of a customer is to have no adverse effect on other connected customers;
- Environmental and social objectives are to be satisfied;
- Acceptable safety standards are to be maintained; and
- The power system in NSW is to be developed at the lowest cost possible whilst meeting the constraints imposed by the above factors.

Consistent with a responsible approach to the environment it is also aimed to reduce system energy losses where economic.

A further consideration is the provision of sufficient capability in the system to allow components to be maintained in accordance with TransGrid's asset management strategies.

National Planning Requirements

AEMO has the role of the national transmission planner and is required to produce a National Transmission Network Development Plan. The NTNDP has regard to jurisdictional planning and regulatory documents (such as APRs) and, in turn, the jurisdictional planning bodies need to have regard to the NTNDP in formulating their plans. The first NTNDP was published in 2010 with input from TransGrid. Through a close working relationship TransGrid's future plans will be consistent with AEMO's.

The Network Planning Process

The network planning process is undertaken at five levels:

1. Connection Planning

Connection planning is concerned with the local network directly related to the connection of loads and generators. Connection planning typically includes connection enquiries and the formulation of draft connection agreements leading to a preliminary review of the capability of connections. Further discussions are held with specific customers where there is a need for augmentation or for provision of new connection points.

2. Network Planning within the NSW Region

The main 500 kV, 330 kV and 220 kV transmission system is developed in response to the overall load growth and generation requirements and may be influenced by interstate interconnection power transfers. Any developments include negotiation with affected NSW and interstate parties.

The assessment of the adequacy of 132 kV systems requires joint planning with DNSPs. This ensures that development proposals are optimal with respect to both TransGrid and DNSP requirements leading to the lowest possible cost of transmission to the end customer. This is particularly important where the DNSP's network operates in parallel with the transmission network, forming a meshed system.

3. Inter-regional Planning

The development of interconnectors between regions and of augmentations within regions that have a material effect on inter-regional power transfer capability are coordinated with network owners in other states in accordance with the NER.

The inter-regional developments will be consistent with the NTNDP.

4. Consideration of Non-Network Alternatives

TransGrid's planning process includes consideration, and adoption where economic, of non-network alternatives which can address the emerging constraint(s) under consideration and may defer or cancel the need for network augmentations.

5. Compliance with NER Requirements

TransGrid's approach to the development of the network since the advent of the NEM is in accordance with the NER and other rules and guidelines promulgated by the AER and the AEMC.

Planning Horizons and Reporting

Transmission planning is carried out over a short-term time frame of one to five years and also over long-term time frames of five to 20 years or more. The short-term planning supports commitments to network developments with relatively short lead-times. The long-term planning considers options for future major developments and provides a framework for the orderly and economic development of the transmission network and the strategic acquisition of critical line and substation sites.

In the Annual Planning Report the constraints that appear over long-term time frames are considered to be indicative. The timing and capital cost of possible network options to relieve them may change significantly as system conditions evolve. TransGrid has published outline plans for long-term developments.

Identifying Network Constraints and Assessing Possible Solutions

An emerging constraint is identified during various planning activities covering the planning horizon. It may be identified through:

- TransGrid's planning activities;
- Joint planning with a DNSP;
- The impact of prospective generation developments;

- The occurrence of constraints affecting generation dispatch in the NEM;
- The impact of network developments undertaken by other TNSPs; or
- As a result of a major load development.

During the initial planning phase a number of options for addressing the constraint are developed. In accordance with NER requirements, consultation with interested parties is carried out to determine a range of options including network, DM and local generation options and/or to refine existing options.

A cost effectiveness or cost-benefit analysis is carried out in which the costs and benefits of each option are compared in accordance with the AER's regulatory test or RIT-T. In applying the applicable test the cost and benefit factors may include:

- Avoiding unserved energy caused by either a generation shortfall or inadequate transmission capability or reliability;
- Loss reductions;
- Alleviating constraints affecting generation dispatch;
- Avoiding the need for generation developments;
- More efficient generation and fuel type alternatives;
- Improvement in marginal loss factors;
- Deferral of related transmission works; and
- Reduction in operation and maintenance costs.

Options with similar Net Present Value would be assessed with respect to factors that may not be able to be quantified and/ or included in the regulatory test or RIT-T, but nonetheless may be important from environmental or operational viewpoints. These factors include:

- Reduction in greenhouse gas emissions or increased capability to apply greenhouse-friendly plant;
- Improvement in quality of supply above minimum requirements; and
- Improvement in operational flexibility.

Application of Power System Controls and Technology

TransGrid seeks to take advantage of the latest proven technologies in network control systems and electrical plant where these are found to be economic. For example, the application of static var compensators has had a considerable impact on the power transfer capabilities of parts of the main grid and has deferred or removed the need for higher cost transmission line developments.

System Protection Schemes have been applied in several areas of the NSW system to reduce the impact of network limitations on the operation of the NEM and to facilitate the removal of circuits for maintenance.

The broad approach to planning and consideration of these technologies together with related issues of protection facilities, transmission line design, substation switching arrangements and power system control and communication is set out in the following sections. This approach is in line with international practice and provides a cost effective means of maintaining a safe, reliable, secure and economic supply system consistent with maintaining a responsible approach to environmental and social impacts.

3.2.3.2 Planning Criteria

The NER specifies the minimum and general technical requirements in a range of areas including:

- A definition of the minimum level of credible contingency events to be considered;
- The power transfer capability during the most critical single element outage. This can range from zero in the case of a single element supply to a portion of the normal power transfer capability;
- Frequency variations;
- Magnitude of power frequency voltages;
- Voltage fluctuations;
- Voltage harmonics;
- Voltage unbalance;
- Voltage stability;
- Synchronous stability;
- Damping of power system oscillations;
- Fault clearance times;
- The need for two independent high speed protection systems; and
- Rating of transmission lines and equipment.

In addition to adherence to NER and regulatory requirements, TransGrid's transmission planning approach has been developed taking into account the historical performance of the components of the NSW system, the sensitivity of loads to supply interruption and state-of-the-art asset maintenance procedures. It has also been recognised that there is a need for an orderly development of the system taking into account the long-term requirements of the system to meet future load and generation developments.

A set of criteria, detailed below, are applied as a point of first review, from which point a detailed assessment of each individual case is made.

Main Transmission Network

The NSW main transmission system is the transmission system connecting the major power stations and load centres and providing the interconnections from NSW to Queensland and Victoria. It includes the majority of the transmission system operating at 500 kV, 330 kV and 220 kV.

This system comprises over 7,000 km of transmission circuits supplying a peak load of over 14,000 MW throughout NSW.

Power flows on the main transmission network are subject to overall State load patterns and the dispatch of generation within the NEM, including interstate export and import of power. AEMO operates the interconnected power system and applies operational constraints on generator dispatch to maintain power flows within the capability of the NSW and other regional networks. These constraints are based on the ability of the networks to sustain credible contingency events that are defined in the NER. These events mainly cover forced outages of single generation or transmission elements, but also provide for multiple outages to be redefined as credible from time to time. Constraints are often based on short-duration loadings on network elements, on the basis that generation can be re-dispatched to relieve the line loading within 15 minutes.

The rationale for this approach is that, if operated beyond a defined power transfer level, credible contingency

disturbances could potentially lead to system-wide loss of load with severe social and economic impact.

Following any transmission outage, for example during maintenance or following a forced line outage for which line reclosure has not been possible, AEMO applies more severe constraints within a short adjustment period, in anticipation of the impact of a further contingency event. This may require:

- The re-dispatch of generation and dispatchable loads;
- The re-distribution of ancillary services; and
- Where there is no other alternative, the shedding of load.

AEMO may direct the shedding of customer load, rather than operate for a sustained period in a manner where overall security would be at risk for a further contingency. The risk is, however, accepted over a period of up to 30 minutes. In performing its planning analysis, TransGrid must consider AEMO's imperative to operate the network in a secure manner.

Therefore in the first instance, TransGrid's planning for its main network concentrates on the security of supply to load connection points under sustained outage conditions, consistent with the overall principle that supply to load connection points must be satisfactory after any single contingency.

The main 500 kV, 330 kV and 220 kV transmission system is augmented in response to the overall load growth and generation requirements and may be influenced by interstate interconnection power transfers. Any developments include negotiation with affected NSW and interstate parties including AEMO to maintain power flows within the capability of the NSW and other regional networks.

The reliability of the main system components and the ability to withstand a disturbance to the system are critically important in maintaining the security of supply to NSW customers. A high level of reliability implies the need for a robust transmission system. The capital cost of this system is balanced by:

- Avoiding the large cost to the community of widespread shortages of supply;
- Providing flexibility in the choice of economical generating patterns;
- Allowing reduced maintenance costs through easier access to equipment; and
- Minimising electrical losses which also provides benefit to the environment.

The planning of the main system must take into account the risk of forced outages of a transmission element coinciding with adverse conditions of load and generation dispatch. Two levels of load forecast (summer and winter) are considered, as follows.

Loads at or exceeding a one in two year probability of occurrence (50% probability of exceedence)

The system will be able to withstand a single contingency under all reasonably probable patterns of generation dispatch or interconnection power flow. In this context a single contingency is defined as the forced outage of a single transmission circuit, a single generating unit, a single transformer, a single item of reactive plant or a single busbar section.

Provision will be made for a prior outage (following failure) of a single item of reactive plant.

Further the system will be able to be secured by re-dispatching generation (AEMO action), without the need for pre-emptive load shedding, so as to withstand the impact of a second contingency.

Loads at or exceeding a one in ten year probability of occurrence (10% probability of exceedence)

The system will be able to withstand a single contingency under a limited set of patterns of generation dispatch or interconnection power flow.

Further the system will be able to be secured by re-dispatching generation (AEMO action), without the need for pre-emptive load shedding, so as to withstand the impact of a second contingency.

These criteria do not apply to radial sections of the main system.

The probable patterns of generation applied to the 50% probability of exceedence load level cover patterns that are expected to have a relatively high probability of occurrence, based on the historical performance of the NEM and modelling of the NEM generation sources into the future. The limited set of patterns of generation applied to the 10% probability of exceedence load level cover two major power flow characteristics that occur in NSW. The first power flow characteristic involves high output from base-load generation sources throughout NSW and high import to NSW from Queensland. The second power flow characteristic involves high import to NSW from Victoria and southern NSW generation coupled with high output from the NSW base-load generators.

Under all conditions there is a need to achieve adequate voltage control capability. TransGrid has traditionally assumed that all on-line generators can provide reactive power support within their rated capability but in the future intends to align with other utilities in relying only on the reactive capability given by performance standards. Reactive support beyond the performance standards may need to be procured under network support arrangements.

A further consideration is the provision of sufficient capability in the system to allow components to be maintained in accordance with TransGrid's asset management strategies.

Overall supply in NSW is heavily dependent on base-load coal-fired generation in the Hunter Valley, western area and Central Coast. These areas are interconnected with the load centres via numerous single and double circuit lines. In planning the NSW system, taking into account AEMO's operational approach to the system, there is a need to consider the risk and impact of overlapping outages of circuits under high probability patterns of load and generation.

The analysis of network adequacy must take into account the probable load patterns, typical dispatch of generators and loads, the availability characteristics of generators (as influenced by maintenance and forced outages), energy limitations and other factors relevant to each case.

Options to address an emerging inability to meet all connection point loads would be considered with allowance for the lead time for a network augmentation solution.

Before this time consideration may be given to the costs involved in re-dispatch in the energy and ancillary services markets to manage single contingencies. In situations where these costs appear to exceed the costs of a network augmentation this will be brought to the attention of network load customers for consideration. TransGrid may then initiate the development of a network or non-network solution through a consultation process.

Relationship with Inter-Regional Planning

In addition to concerns about security of supply to load point connections, TransGrid also monitors the occurrence of constraints in the main transmission system that affect generator dispatch. TransGrid's planning therefore also considers the scope for network augmentations to reduce constraints that may satisfy the RIT-T.

Under the provisions of the NER a Region may be created where constraints to generator dispatch are predicted to occur with reasonable frequency when the network is operated in the "system normal" (all significant elements in service) condition. The creation of a Region does not however consider the consequences to load connection points if there should be a network contingency.

In effect the capacity of interconnectors that is applied in the market dispatch is the short-time capacity determined by the ability to maintain secure operation in the system normal state in anticipation of a single contingency. The operation of the interconnector at this capacity must be supported by appropriate ancillary services. However AEMO does not operate on the basis that the contingency may be sustained but TransGrid must consider the impact of a prolonged plant outage.

As a consequence it is probable that for parts of the network that are critical to the supply to loads, TransGrid would initiate augmentation to meet an 'n-1' criterion before the creation of a new Region.

The development of interconnectors between regions will be undertaken where the augmentation satisfies the RIT-T. The planning of interconnections will be undertaken in consultation with the jurisdictional planning bodies of the other states.

It is not planned to maintain the capability of an interconnector where relevant network developments would not satisfy the RIT-T.

Networks Supplied from the Main Transmission Network

Some parts of TransGrid's network are primarily concerned with supply to local loads and are not significantly impacted by the dispatch of generation (although they may contain embedded generators). The loss of a transmission element within these networks does not have to be considered by AEMO in determining network constraints, although ancillary services may need to be provided to cover load rejection in the event of a single contingency.

Supply to Major Load Areas and Sensitive Loads

The NSW system contains six major load areas with indicative loads as follows:

LOAD AREA	INDICATIVE PEAK LOAD
The NSW north, supplied from the Hunter Valley, Newcastle and over QNI	1,000 MW
Newcastle area	2,400 MW (this includes aluminium smelters with a load greater than 1,000 MW)
Greater Sydney	6,000 MW
Western Area	600 MW
South Coast	700 MW
South and South West	1,600 MW

Some of these load areas, including individual smelters, are supplied by a limited number of circuits, some of which may share double circuit line sections. It is strategically necessary to ensure that significant individual loads and load areas are not exposed to loss of supply in the event of multiple circuit failures. As a consequence it is necessary to assess the impact of contingency levels that exceed 'n-1'.

Outages of network elements for planned maintenance must also be considered. Generally this will require 75% of the peak load to be supplied during the outage. While every effort would be made to secure supplies in the event of a further outage, this may not be always possible. In this case attention would be directed to minimising the duration of the plant outage.

Urban and Suburban Areas

Generally the urban and suburban networks are characterised by a high load density served by high capacity underground cables and relatively short transmission lines. The connection points to TransGrid's network are usually the low voltage (132 kV) busbars of 330 kV substations. There may be multiple connection points and significant capability on the part of the DNSP to transfer load between connection points, either permanently or to relieve short-time loadings on network elements after a contingency.

The focus of joint planning with the DNSP is the capability of the meshed 330/132 kV system and the capability of the existing connection points to meet expected peak loadings. Joint planning addresses the need for augmentation to the meshed 330/132 kV system and TransGrid's connection point capacity or to provide a new connection point where this is the most economic overall solution.

Consistent with good international practice, supply to high-density urban and central business districts is given special consideration. For example, the inner Sydney metropolitan network serves a large and important part of the State load. Supply to this area is largely via a 330 kV and 132 kV underground cable network. The two 330 kV cables are part of TransGrid's network and the 132 kV

cable system is part of Ausgrid's network. The jointly developed target reliability standard for the area is that the system will be capable of meeting the peak load under the following contingencies:

(a) The simultaneous outage of a single 330 kV cable and any 132 kV feeder or 330/132 kV transformer; or

(b) An outage of any section of 132 kV busbar.

Thus an 'n-1' criterion is applied separately to the two networks. The decision to adopt a reliability criterion for the overall network that is more onerous than 'n-1' was made jointly by TransGrid and Ausgrid after consideration of:

- The importance and sensitivity of the Sydney area load to supply interruptions;
- The high cost of applying a strict 'n-2' criterion to the 330 kV cable network;
- The large number of elements in the 132 kV network;
- The past performance of the cable system; and
- The long times to repair cables should they fail.

The criterion applied to the inner Sydney area is consistent with that applied in the electricity supply to major cities throughout the world. Most countries use an 'n-2' criterion. Some countries apply an 'n-1' criterion with some selected 'n-2' contingencies that commonly include two cables sharing the one trench or a double circuit line.

The above criterion is applied in the following manner in planning analysis:

1. Under system normal conditions all elements must be loaded within their "recurrent cyclic" rating;
2. System loadings under first contingency outages will remain within equipment recurrent cyclic ratings without corrective switching other than for automatic switching or "auto-change-over";
3. Cyclic load shedding (in areas other than the Sydney CBD) may be required in the short term following a simultaneous outage of a single 330 kV cable and any 132 kV transmission feeder or 330/132 kV transformer in the inner metropolitan area until corrective switching is carried out on the 330 kV or 132 kV systems;
4. The system should be designed to remove the impact of a bus section outage at existing transmission substations. New transmission substations should be designed to cater for bus section outages;
5. The load forecast to be considered is based on "50% probability of exceedence";
6. Loading is regarded as unsatisfactory when 330/132 kV transformers and 330 kV or 132 kV cables are loaded beyond their recurrent cyclic rating; and
7. Fault interruption duty must be contained to within equipment ratings at all times.

Outages of network elements for planned maintenance must also be considered. Generally this will require 75% of the peak load to be supplied during an outage. While every effort would be made to secure supplies in the event of a further outage, this may not be always possible. In this case attention would be directed to minimising the duration of the outage.

Non Urban Areas

Generally these areas are characterised by lower load densities and, generally, lower reliability requirements than urban systems. The areas are sometimes supplied by relatively long, often radial, transmission systems. Connection points are either on 132 kV lines or on the low voltage busbars of 132 kV substations. Although there may be multiple connection points to a DNSP they are often far apart and there will be little capacity for power transfer between them. Frequently supply limitations will apply to the combined capacity of several supply points together.

The focus of joint planning with the DNSP will usually relate to:

- Augmentation of connection point capacity;
- Duplication of radial supplies;
- Extension of the 132 kV system to reinforce or replace existing lower voltage systems and to reduce losses; and
- Development of a higher voltage system to provide a major augmentation and to reduce network losses.

TransGrid's aim is to provide a level and reliability of supply at connection points that is complementary to that provided by the DNSP within its own network. For example Essential Energy provides fully duplicated supply ('n-1' reliability) to a load area of 15 MW or more and requires TransGrid to provide a commensurate level of reliability at connection points to its network.

Supply to one or more connection points would be considered for augmentation when the forecast peak load at the end of the planning horizon exceeds the firm 'n-1' capacity of TransGrid's network. However, consistent with the lower level of reliability that may be appropriate in a non-urban area, an agreed level of risk of loss of supply may be accepted. Thus augmentations may actually be undertaken:

- When the forecast load exceeds the firm capacity by an agreed amount;
- Where the period that some load is at risk exceeds an agreed proportion of the time; or
- An agreed amount of energy (or proportion of annual energy supplied) is at risk.

As a result of the application of these criteria some radial parts of the 330 kV and 220 kV network are not able to withstand the forced outage of a single circuit line at time of peak load, and in these cases provision has been made for under-voltage load shedding.

Provision is also required for the maintenance of the network. Additional redundancy in the network is required where maintenance cannot be scheduled without causing load restrictions or an unacceptable level of risk to the security of supply.

Transformer Augmentation

In considering the augmentation of transformers, appropriate allowance is made for the transformer cyclic rating and the practicality of load transfers between connection points. The outage of a single transformer (or single-phase unit) or a transmission line that supports the load carried by the transformer is allowed for.

Provision is also required for the maintenance of transformers. This has become a critical issue at a number of sites in NSW where there are multiple transformers in service. To enable maintenance to be carried out, additional transformer capacity or a means of transferring load to other supply points via the underlying lower voltage network may be required.

Consideration of Low Probability Events

Although there is a high probability that loads will not be shed as a result of system disturbances no power system can be guaranteed to deliver a firm capability 100% of the time, particularly when subjected to disturbances that are severe or widespread. In addition extreme loads, above the level allowed for in planning, can occur, usually under extreme weather conditions.

The NSW network contains numerous lines of double circuit construction and whilst the probability of overlapping outages of both circuits of a line is very low, the consequences could be widespread supply disturbances.

Thus there is a potential for low probability events to cause localised or widespread disruption to the power system. These events can include:

- Loss of several transmission lines within a single corridor, as may occur during bushfires;
- Loss of a number of cables sharing a common trench;
- Loss of more than one section of busbar within a substation, possibly following a major plant failure;
- Loss of a number of generating units; and
- Occurrence of three-phase faults, or faults with delayed clearing.

In TransGrid's network appropriate facilities and mechanisms are put in place to minimise the probability of such events and to ameliorate their impact. The decision process considers the underlying economics of facilities or corrective actions, taking account of the low probability of the occurrence of extreme events. TransGrid will take measures, where practicable, to minimise the impact of disturbances to the power system by implementing power system control systems at minimal cost in accordance with the NER.

3.2.3.3 Protection Requirements

Basic protection requirements are included in the NER. The NER requires that protection systems be installed so that any fault can be detected by at least two fully independent protection systems. Backup protection is provided against breaker failure. Provision is also made for detecting high resistance earth faults.

Required protection clearance times are specified by the NER and determined by stability considerations as well as the characteristics of modern power system equipment. Where special protection facilities or equipment are required for high-speed fault clearance they are justified on either an NER compliance or a benefit/cost basis.

All modern distance protection systems on the main network include the facility for power swing blocking (PSB). PSB is utilised to control the impact of a disturbance that can cause synchronous instability. At the moment PSB is not enabled, except at locations where demonstrated advantages apply. This feature will become increasingly more important as the interconnected system is developed and extended.

3.2.3.4 Transient Stability

In accordance with the NER transient stability is assessed on the basis of the angular swings following a solid fault on one circuit at the most critical location that is cleared by the faster of the two protections (with intertrips assumed in service where installed). At the main system level a two phase-to-ground fault is applied and on 132 kV systems which are to be augmented a three-phase fault is applied.

Recognition of the potential impact of a three-phase fault at the main system level is made by instituting maintenance and operating precautions to minimise the risk of such a fault.

The determination of the transient stability capability of the main grid is undertaken using software that has been calibrated against commercially available system dynamic analysis software.

Where transient stability is a factor in the development of the main network, preference is given to the application of advanced control of the power system or high-speed protection systems before consideration is given to the installation of high capital cost plant.

3.2.3.5 Steady State Stability

The requirements for the control of steady state stability are included in the NER. For planning purposes steady state stability (or system damping) is considered adequate under any given operating condition if, after the most critical credible contingency, simulations indicate that the halving time of the least damped electromechanical mode of oscillation is not more than five seconds.

The determination of the steady state stability performance of the system is undertaken using software that has been calibrated against commercially available software and from data derived from the monitoring of system behaviour.

In planning the network, maximum use is made of existing plant, through the optimum adjustment of plant control system settings, before consideration is given to the installation of high capital cost plant.

3.2.3.6 Line and Equipment Thermal Ratings

Line thermal ratings have often traditionally been based on a fixed continuous rating and a fixed short-time rating. TransGrid applies probabilistic-based line ratings, which are dependent on the likelihood of coincident adverse weather conditions and unfavourable loading levels. This approach has been applied to selected lines whose design temperature is about 100 degrees Celsius or less. For these lines a contingency rating and a short-time emergency rating have been developed. Typically the short-time rating is based on a load duration of 15 minutes, although the duration can be adjusted to suit the particular load pattern to which the line is expected to be exposed. The duration and level of loading must take into account any requirements for re-dispatch of generation or load control.

TransGrid is presently installing ambient condition monitors on critical transmission

lines to enable the application of real-time line conductor ratings in the generation dispatch systems.

Transformers are rated according to their specification. Provision is also made for use of the short-time capability of the transformers during the outage of a parallel transformer or transmission line.

TransGrid owns two 330 kV cables and these are rated according to manufacturer's recommendations that have been checked against an appropriate thermal model of the cable.

The rating of line terminal equipment is based on manufacturers' advice.

3.2.3.7 Reactive Support and Voltage Stability

It is necessary to maintain voltage stability, with voltages within acceptable levels, following the loss of a single element in the power system at times of peak system loading. The single element includes a generator, a single transmission circuit, a cable and single items of reactive support plant.

To cover fluctuations in system operating conditions, uncertainties of load levels, measurement errors and errors in the setting of control operating points it is necessary to maintain a margin from operating points that may result in a loss of voltage control. A reactive power margin is maintained over the point of voltage instability or alternatively a margin is maintained with respect to the power transfer compared to the maximum feasible power transfer.

The system voltage profile is set to standard levels during generator dispatch to minimise the need for post-contingency reactive power support.

Reactive power plant generally has a low cost relative to major transmission lines and the incremental cost of providing additional capacity in a shunt capacitor bank can be very low. Such plant can also have a very high benefit/cost ratio and therefore the timing of reactive plant installations is generally less sensitive to changes in load growth than the timing of other network augmentations. Even so, TransGrid aims to make maximum use of existing reactive sources before new installations are considered.

TransGrid has traditionally assumed that all on-line generators can provide reactive power support within their rated capability but in the future intends to align with other utilities in relying only on the reactive capability given by performance standards. Reactive support beyond the performance standards may need to be procured under network support arrangements.

Reactive power plant is installed to support planned power flows up to the capability defined by limit equations, and is often the critical factor determining network capability. On the main network, allowance is made for the unavailability of a single major source of reactive power support in the critical area affected at times of high load, but not at the maximum load level.

It is also necessary to maintain control of the supply voltage to the connected loads under minimum load conditions.

The factors that determine the need for reactive plant installations are:

- → In general it has proven prudent and economic to limit the voltage change between the pre and post-contingency operating conditions;
- → It has also proven prudent, in general, and economic to ensure that the post-contingency operating voltage at major 330 kV busbars lies above a lower limit;
- → The reactive margin from the point of voltage collapse is maintained to be greater than a minimum acceptable level;
- → A margin between the power transmitted and the maximum feasible power transmission is maintained; and
- → At times of light system load it is essential to ensure that voltages can be maintained within the system highest voltage limits of equipment.

At some locations on the main network relatively large voltage changes are accepted, and agreed with customers, following forced outages, providing voltage stability is not placed at risk. These voltage changes can approach, and in certain cases, exceed 10% at peak load.

On some sections of the network the possibility of loss of load due to depressed voltages following a contingency is also accepted. However there is a preference to install load shedding initiated by under-voltage so that the disconnection of load occurs in a controlled manner.

When determining the allowable rating of switched reactive plant the requirements of the NER are observed.

3.2.3.8 Transmission Line Voltage and Conductor Sizes Determined by Economic Considerations

Consideration is given to the selection of line design voltages within the standard nominal 132 kV, 220 kV, 275 kV, 330 kV and 500 kV range, taking due account of transformation costs.

Minimum conductor sizes are governed by losses, radio interference and field strength considerations.

TransGrid strives to reduce the overall cost of energy and network services by the economic selection of line conductor size. The actual losses that occur are governed by generation dispatch in the market.

For a line whose design is governed by economic loading limits the conductor size is determined by a rigorous consideration of capital cost versus loss costs. Hence the impact of the development on generator and load marginal loss factors in the market is considered. For other lines the rating requirements will determine the conductor requirements.

Double circuit lines are built in place of two single circuit lines where this is considered to be both economic and to provide adequate reliability. Consideration would be given to the impact of a double circuit line failure, both over relatively short terms and for extended durations. This means that supply to a relatively large load may require single rather than double circuit transmission line construction where environmentally acceptable.

In areas prone to bushfire any parallel single circuit lines would preferably be routed well apart.

3.2.3.9 Short-circuit Rating Requirements

Substation high voltage equipment is designed to withstand the maximum expected short-circuit duty in accordance with the applicable Australian Standard.

Operating constraints are enforced to

ensure equipment is not exposed to fault duties beyond the plant rating.

In general the short circuit capability of all of the plant at a site would be designed to match or exceed the maximum short circuit duty at the relevant busbar. In order to achieve cost efficiencies when augmenting an existing substation the maximum possible short-circuit duty on individual substation components may be calculated and applied in order to establish the adequacy of the equipment.

Short circuit duty calculations are based on the following assumptions:

- All main network generators that are capable of operating, as set out in connection agreements, are assumed to be in service;
- All generating units that are embedded in distribution networks are assumed to be in service;
- The maximum fault contribution from interstate interconnections is assumed;
- The worst-case pre-fault power flow conditions are assumed;
- Normally open connections are treated as open;
- Networks are modelled in full;
- Motor load contributions are not modelled at load substations; and
- Generators are modelled as a constant voltage behind sub-transient reactance.

At power station switchyards allowance is made for the contribution of the motor component of loads. TransGrid is further analysing the impact of the motor component of loads and is assessing the need to include such contributions when assessing the adequacy of the rating of load substation equipment.

3.2.3.10 Substation Switching Arrangements

Substation switching arrangements are adopted that provide acceptable reliability at minimum cost, consistent with the overall reliability of the transmission network. In determining a switching arrangement, consideration is also given to:

- Site constraints;
- Reliability expectations with respect to connected loads and generators;
- The physical location of “incoming” and “outgoing” circuits;
- Maintenance requirements;
- Operating requirements; and
- Transformer arrangements.

TransGrid has applied the following arrangements in the past:

- Single busbar;
- Double busbar;
- Multiple element mesh; and
- Breaker-and-a-half.

In general, at main system locations, a mesh or breaker-and-a-half arrangement is now usually adopted.

Where necessary, the expected reliability performance of potential substation configurations can be compared using equipment reliability parameters derived from local and international data.

The forced outage of a single busbar zone is generally provided for. Under this condition the main network is planned to have adequate capability although loss of load may eventuate. In general the forced outage of a single busbar zone should not result in the outage of any base-load generating unit.

Where appropriate a 330 kV bus section breaker would ordinarily be provided when a second “incoming” 330 kV line is connected to the substation.

A 132 kV bus section circuit breaker would generally be considered necessary when the peak load supplied via that busbar exceeds 120 MW. A bus section breaker is generally provided on the low voltage busbar of 132 kV substations when supply is taken over more than two low voltage feeders.

3.2.3.11 Autoreclosure

As most line faults are of a transient nature all of TransGrid’s overhead transmission lines are equipped with autoreclose facilities.

Slow speed three-pole reclosure is applied to most overhead circuits. On the remaining overhead circuits, under special circumstances, high-speed single-pole autoreclosing may be applied.

For public safety reasons reclosure is not applied to underground cables.

Autoreclose is inhibited following the operation of breaker-fail protection.

3.2.3.12 Power System Control and Communication

In the design of the network and its operation to designed power transfer levels, reliance is generally placed on the provision of some of the following control facilities:

- Automatic excitation control on generators;
- Power system stabilisers on generators and SVCs;
- Load drop compensation on generators and transformers;
- Supervisory control over main network circuit breakers;
- Under-frequency load shedding;
- Under-voltage load shedding;
- Under and over-voltage initiation of reactive plant switching;
- High speed transformer tap changing;
- Network connection control;
- Check and voltage block synchronisation;
- Control of reactive output from SVCs; and
- System Protection Schemes (SPS).

The following communication, monitoring and indication facilities are also provided where appropriate:

- Network wide SCADA and Energy Management System (EMS);
- Telecommunications and data links;
- Mobile radio;
- Fault locators and disturbance monitors;
- Protection signalling; and
- Load monitors.

Protection signalling and communication is provided over a range of media including pilot wire, power line carrier, microwave links and increasingly optical fibres in overhead earthwires.

3.2.3.13 Scenario Planning

Scenario planning assesses network capacity, based on the factors described above, for a number of NEM load and generation scenarios. The process entails:

1. Identification of possible future load growth scenarios. These are

developed based on AEMO's forecasts to be used in the next NTNDP. TransGrid uses the key data for each scenario to prepare load forecasts for NSW. These are published in the APR and by AEMO in the forthcoming Electricity Statement of Opportunities. The forecast can also incorporate specific possible local developments such as the establishment of new loads or the expansion of existing industrial loads.

2. Development of a number of generation scenarios for each load growth scenario. These generation scenarios relate to the development of new generators and utilisation of existing generators. This is generally undertaken by a specialist electricity market modelling consultant, using their knowledge of relevant factors, including:
   - Generation costs;
   - Impacts of government policies; and
   - Impacts of energy related developments such as gas pipeline projects.
3. Modelling of the NEM for load and generation scenarios to quantify factors which affect network performance, including:
   - Generation from individual power stations; and
   - Interconnector flows.
4. Modelling of network performance for the load and generation scenarios utilising the data from the market modelling.

The resulting set of scenarios is then assessed over the planning horizon to establish the adequacy of the system and to assess network and non-network augmentation options.

The future planning scenarios developed by TransGrid will take into account AEMO's future scenarios from the NTNDP.

3.2.4 Consideration of Local Generation and Demand Management Options

The Annual Planning Report provides advance information to the market on the nature and location of emerging network constraints. This is intended to encourage interested parties to formulate and propose feasible non-network options, including Demand Management (DM), Demand Side Response (DSR) and local or embedded generation options, to relieve the emerging network constraints.

The advantages that non-network options offer in relieving transmission network constraints are that they may:

- Reduce, defer or eliminate the need for new transmission or distribution investment; and/or
- Reduce, defer or eliminate the costs and environmental impacts of construction and operation of fossil fuel based power stations.

TransGrid considers DM, local/embedded generation and bundled options on an equal footing with network options when planning its network augmentations and applying the AER's regulatory test and the Regulatory Investment Test for Transmission (RIT-T).

For any option to be considered during the evaluation and analysis process, it must be feasible and capable of being implemented in time to relieve the emerging constraint.

For an option to be recommended for implementation after the evaluation and analysis, it must satisfy the regulatory test (and now the RIT-T). It must also have a proponent who is committed to implement the option and to accept the associated risks, responsibilities and accountabilities.

It is expected that local generation and demand management options would emerge either from joint planning with DNSPs, the market or from interested parties.

TransGrid's joint planning with the NSW DNSPs provides a mechanism to identify opportunities for local generation and demand management options. The NSW DNSPs follow a similar process to TransGrid in preparing planning reports for their networks, thereby providing another useful source of information for proponents of generation and demand management options.

Demand Management or Demand Side Reponse

DM or DSR options may include, but are not limited to, combinations of the following:

- Reduction in electricity demand at points of end-use through:
  - Improved energy efficiency devices and systems;
  - Thermal insulation; and
  - Alternative reticulated energy sources such as natural gas.
- Reduction in peak electricity consumption at points of end-use through:
  - Tariff incentives;
  - Load interruption and reduction incentives;
  - Arrangements to transfer load from peak to off-peak times;
  - Energy storage systems;
  - Standby generators; and
  - Power factor correction equipment.

Embedded or Local Generation

Embedded or local generation options may include generation or cogeneration facilities located on the load side of a transmission constraint. Alternative energy sources may include, but are not limited to:

- Bagasse;
- Biomass;
- Gas (e.g. natural gas or LPG);
- Hydro;
- Solar; and
- Wind.

Promotion of DM and Local Generation Alternatives by TransGrid

TransGrid actively promotes DM and local generation alternative through:

- Identifying opportunities for DM and local generation options through joint planning with the Distributors and engaging expert external consultants where warranted;
- Informing the market of constraints via the Annual Planning Report and consultations for alleviating individual constraints;
- Participation in initiatives and reviews that include consideration of DM and its relationship to the development of electricity networks; and
- Joint sponsorship of research projects involving DM and embedded generation.

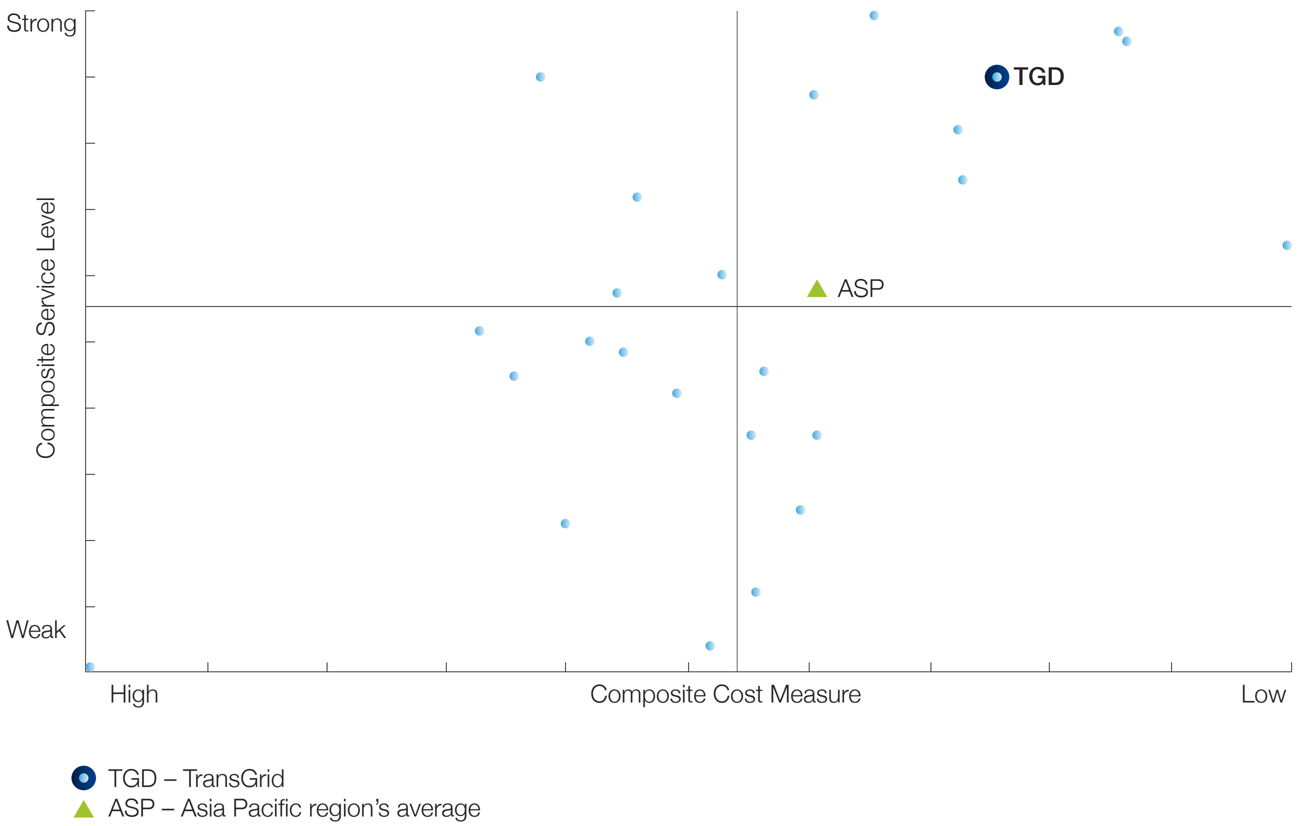
3.3 Service Standards

Internationally there is a range of service standards that are used to assess the performance of transmission networks. These include cost, reliability of supply, availability of the network, forced outages and equipment performance.

An individual organisation's performance in any one of these performance measures is very much dependent on a variety of factors such as their planning criteria, external environment, asset age, funding arrangements and technology employed. Accordingly "best practice" for an organisation may not necessarily result in the particular organisation being a "best performer" when benchmarked.

TransGrid participates in an international benchmarking study, the International Transmission Operations & Maintenance Study (ITOMS) which benchmarks the performance of over 25 companies in terms of cost and service level. In the latest study, ITOMS 2011, TransGrid continues to be one of the leading performers with relatively low cost amongst the participants and above average service level as evident in the below graph:

ITOMS 2011 Overall Composite Benchmark – Weighted Average



3.3.1 Network Reliability

Reliability is a measure of the service level of the transmission network as perceived by the customer. It relates to the amount of energy not supplied resulting from a temporary failure of a component of the network. The measure used to describe reliability is system minutes where:

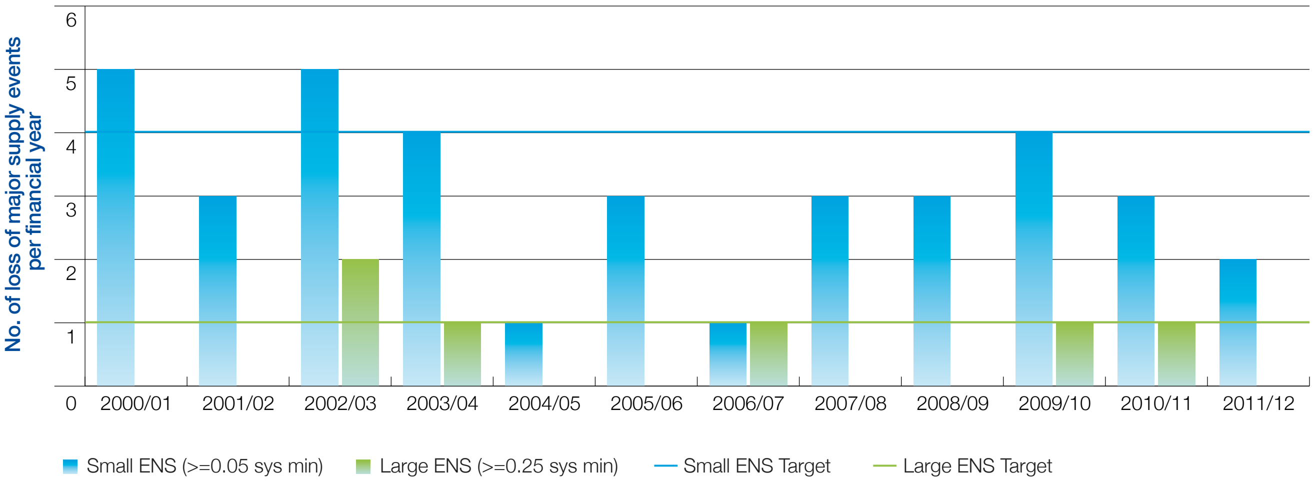
$$\text{System minutes} = \frac{\text{Energy not supplied (MWh) x 60}}{\text{Annual system maximum demand}}$$

TransGrid's objective is to use all reasonable and practicable efforts to minimise the number and duration of unplanned interruptions.

For the 2009-2014 regulatory period, the AER has set annual network reliability targets, on a statistical basis, related to the number of energy not supplied (ENS) events greater than specified values. These targets are four events or fewer for events with an ENS over 0.05 system minutes, and one or fewer events with an ENS greater than 0.25 system minutes.

The following graph shows TransGrid's reliability performance since 2000/2001:

Network Reliability



In addition, the service standards for reliability are cascaded down to individual customers and provide further details of performance at each supply point. A summary of this performance over recent years is given in the tables below.

Loss of Supply in MWh per Customer per Year

	ACTEW AGL	NORSKE SKOG	ESSENTIAL ENERGY	AUSGRID	ENDEAVOUR ENERGY	TOMAGO ALUMINIUM	VISY PAPER
2001/02	0	0	41	0	47.7	0	0
2002/03	0	0	809.3	19.8	46.4	0	28.3
2003/04	13	0	147	266	34.7	0	0
2004/05	0	0	33.5	0	0	0	0
2005/06	15.7	0	128.67	2.25	4.68	0	0
2006/07	0	0	267.05	0	0.63	0	0
2007/08	0	0	79.73	0	4.9	0	0
2008/09	0	0	58.04	0	0	41.25	0
2009/10	0	0	97.01	34.2	76.95	91.8	0
2010/11	0	0	82.48	457.8	6.42	0	0
2011/12	0	0	66.07	0	27.4	0	0

Number of Interruptions Involving Loss of Supply per Customer per Year

	ACTEW AGL	NORSKE SKOG	ESSENTIAL ENERGY	AUSGRID	ENDEAVOUR ENERGY	TOMAGO ALUMINIUM	VISY PAPER
2001/02	0	0	7	0	2	0	0
2002/03	0	0	14	2	3	0	1
2003/04	1	0	8	1	1	0	0
2004/05	0	0	8	0	0	0	0
2005/06	1	0	10	1	2	0	0
2006/07	0	0	8	0	2	0	0
2007/08	0	0	7	0	1	0	0
2008/09	0	0	5	0	0	1	0
2009/10	0	0	14	2	2	1	0
2010/11	0	0	5	2	2	0	0
2011/12	0	0	6	0	1	0	0

3.3.2 Transmission Asset Availability

Transmission asset availability is generally expressed as a percentage of time the transmission system is continually available to transfer energy, with 100% indicating no network outages. The measure indicates the effectiveness of strategies to minimise the number and duration of planned maintenance outages by the optimisation of maintenance frequencies and the coordination of routine, defect and capital works outages. It also reflects the success of maintenance policies and practices in reducing unplanned circuit outages.

Transmission asset availability consists of transmission line, transformer and reactive plant availability components. Each individual measure has its respective performance target and method of calculation outlined in the AER Service Target Performance Incentive Scheme.

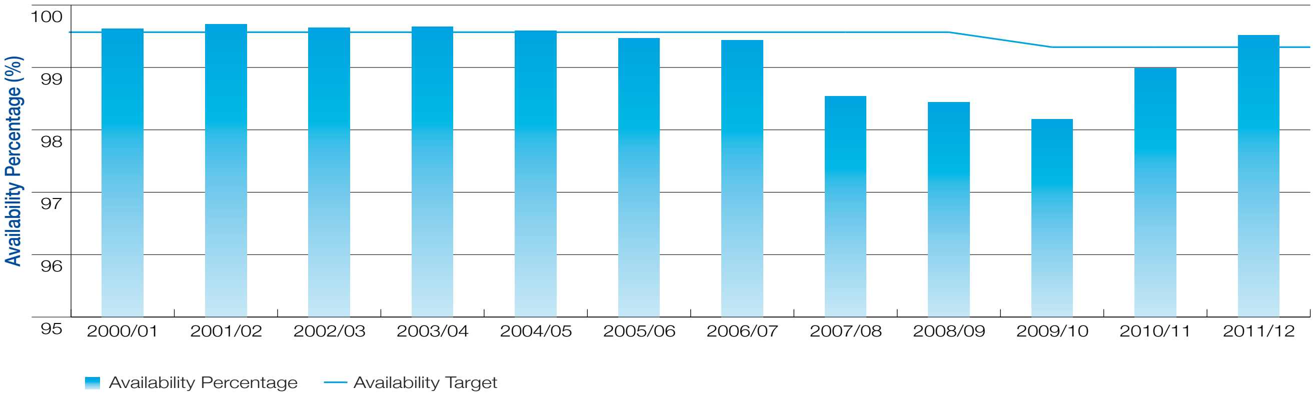
For instance, transmission line availability is calculated as follows:

$$\text{Transmission Line availability (\%)} = \frac{\text{100 x sum of available hours for each circuit}}{\text{8760 x no. of Transmission lines}}$$

In this calculation the denominator represents the total sum of possible circuit hours available in a year. TransGrid's objective is to use all reasonable and practicable efforts to minimise the number and duration of planned and unplanned interruptions. For the current regulatory period of 2009-2014, TransGrid has a target to achieve 99.26% transmission line availability every year.

The following graph shows TransGrid's transmission line availability performance since 2000/2001. The decrease in circuit availability since 2007 reflects TransGrid's substantial capital works program, particularly rebuilding of existing transmission lines that are approaching their end of life and replacements of wood poles in deteriorating condition with concrete poles. However, last financial years figure indicates TransGrid's transmission line availability exceeded its target.

Transmission Line Availability



3.3.3 Market Impact of Transmission Constraints

Since early in the commencement of the National Electricity Market, TransGrid has monitored the occurrence of transmission constraints on its network and the impact on market participants. A transmission constraint occurs where not all of the low cost generation available can be dispatched due to limits of the transmission network, and higher cost generation from an alternative source is dispatched to make up the required total generation.

In July 2009 TransGrid became the first transmission provider in the National Electricity Market to participate in the market impact component of the AER's Service Target Performance Incentive Scheme. The market impact component provides an incentive for transmission providers to reduce the occurrence of constraints during outages of transmission network elements. The incentive can be influenced by generation bid patterns as well as the operation of the transmission network.

TransGrid has achieved a positive incentive result each year since the scheme's inception.

Chapter 1:
Network Safety and Reliability
Part 4: Asset Strategies

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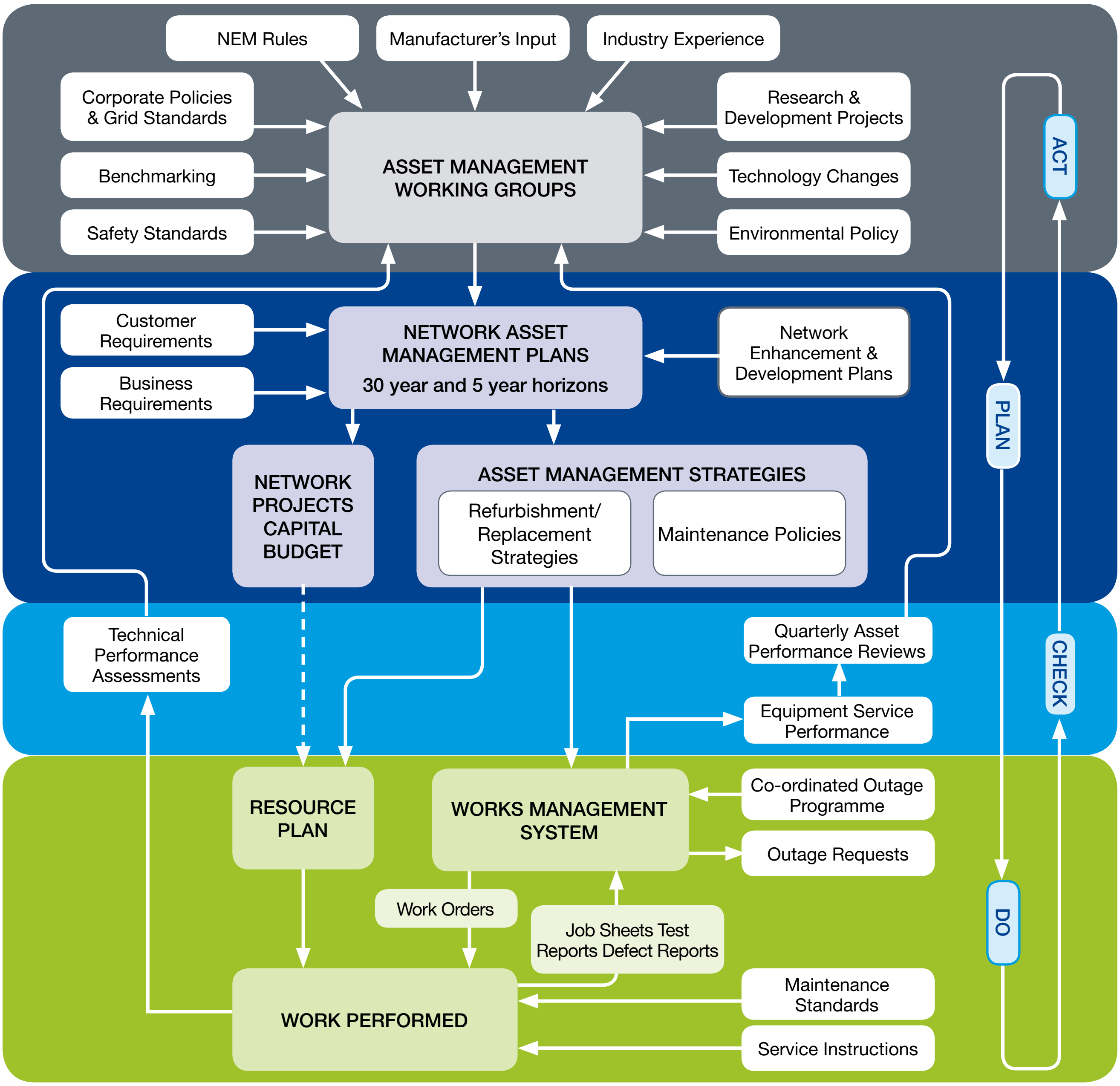
Part 4: Asset Strategies

4.1 Asset Maintenance and Operating Strategies

Principles of TransGrid's Asset Management Processes

TransGrid uses well-developed and documented processes to ensure that its existing assets are effectively and efficiently managed. A simple overview of the Asset Management Process is shown in the figure below:

TransGrid Asset Management Process



Elements of TransGrid's Asset Management Process

1. Structure

The development and updating of both the Asset Management Strategies and the Maintenance Policies is carried out by Working Groups made up of a cross-section of maintenance, design and asset management staff. The Working Groups meet regularly to discuss issues and resolve problems identified.

2. Asset Management Policy

The key corporate policy is the Asset Management Policy which is a high level document describing the principles of asset management that apply to all of TransGrid's assets.

The work identified as necessary is categorised as either capital or operating for budgetary purposes. The operating work is further split into two categories:

(i) Maintenance work – which is routine and repetitive in nature and specified by the relevant maintenance policy.

(ii) Major Operating Projects – these are non-repetitive and require the investment of significant resources on a one-off basis. Refurbishment work and some replacements fall into this category. The performance issues and proposed solutions are detailed in the relevant Asset Management Strategy.

3. Asset Management Strategies

Asset Management Strategies are prepared for each of the following functional areas:

- Substations;
- Underground cables;
- Transmission lines;
- Easements;
- Protection schemes;
- Metering installations;
- Telecommunications; and
- Control systems and SCADA.

These Asset Management Strategies are updated annually and detail both the short and medium term strategies used to address issues beyond the scope of routine maintenance activities.

Information relating to the performance of the assets such as maintenance history, defect history and availability of spares are all used in the review process to determine if any action is required on a specific issue.

Condition monitoring information is used extensively to identify equipment approaching the end of its useful service life thus allowing for planned replacement or refurbishment programs to be implemented.

4. Asset Maintenance Policies

Maintenance Policies for each of the functional areas are also reviewed annually and updated as required. As with the Asset Management Strategies, extensive use is made of maintenance history, defect history, benchmarking and condition monitoring data.

The maintenance policies are implemented through the Ellipse Enterprise Resource Planning (ERP) System that schedules, initiates and records both routine and non-routine maintenance and defect repairs.

TransGrid has a policy of minimal intrusive maintenance, preferring instead to carry out diagnostic testing to determine if a need exists for any further work. Maintenance is generally targeted according to the following criteria:

- Significance of a failure of the item;
- Past reliability and service performance;
- Physical location/environmental factors; and
- Operating history.

5. Maintenance Planning

Asset maintenance plans are detailed in a Maintenance Policy and Asset Management Strategy for each asset category. Each Maintenance Policy describes the routine maintenance frequency and extent of routine maintenance for each item of plant. The Asset Management Strategies take a broader perspective and detail refurbishment, replacement and repair strategies for particular types, makes or categories of equipment.

In planning any routine or non routine work (including new project or construction work) that involves a system outage a significant effort is made to package as much work as possible to minimise the number and duration of any outages as these may impact on the availability of the network.

6. Risk Management

TransGrid has in place a system of risk management planning and monitoring, which is based on the standard AS/NZS ISO31000:2009 Risk Management-Principles and Guidelines. This overall framework sets the high level approach to identifying and managing risks across the organization.

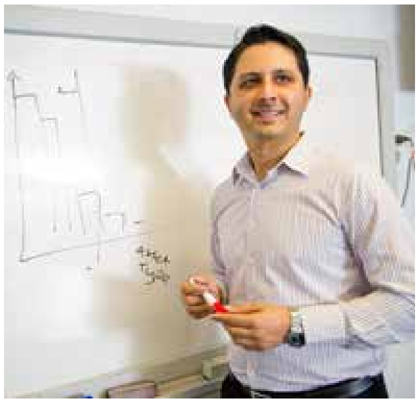
Following on from the broad risk management framework the Maintenance Polices and Asset Management Strategies are reviewed specifically using risk management principles, considering the criticality and exposure associated with a particular course of action that could materially affect the network and the quality, availability and reliability of supply to our customers.

7. Loss of Equipment

The outcome of some events occurring on the network will be the temporary or permanent loss of specific network equipment.

TransGrid's asset procurement policy ensures that, for reasons of economy, there is a reasonable degree of plant commonality across the state. There are a number of unique installations where there is only limited opportunity for direct interchange of spare equipment. In most cases, however, spare equipment can be readily obtained and modified if necessary to effect temporary repairs.

Emergency transmission line structures are held by TransGrid, which can be quickly assembled and erected, in the unlikely event of major line failures. These are held at key sites throughout the state and are suitable for most tower line locations.



A number of spare transformers are held at strategic locations throughout the state. A formal policy exists defining the number of spares of a given type to be held based on the size of the transformer population. Other spares such as circuit breakers, instrument transformers, surge arrestors and protection relays are constantly monitored to ensure optimal levels are held.

8. Asset Performance Reviews

The ultimate measure of whether the asset management process is achieving its stated goals is determined by the performance of the transmission network. Consequently within TransGrid a number of methods are used to objectively measure the outcomes of the process and these are used to indicate whether:

- Policies are appropriate;
- Policies are being applied;
- Equipment performance is satisfactory; and
- Performance and costs are comparable.

The actual methods used to perform this function include the following:

Technical Performance Assessments

Technical Performance Assessments are carried out across the state on a yearly basis and the assessment formally audits the technical performance of the maintenance and operations groups. The assessment is conducted over a number of days and checks processes, documentation and the physical condition of the assets.

Independent internal assessors with specialist knowledge of the functional area conduct the assessments. A formal report detailing non-conformances, observations and improvement opportunities is prepared and follow up reports required to ensure that any issues identified are addressed.

Quarterly Asset Performance Reviews

Once each quarter design, maintenance, operating and asset management staff are brought together to specifically review the performance of the network assets during the previous three months.

All forced and emergency outages during the period are reviewed and where necessary further action initiated. The group also reviews the long-term outage and reliability trends to determine issues requiring further investigation.

Issues identified by either a Technical Performance Assessment or the Quarterly Asset Performance Review are passed on to the relevant Working Group for inclusion in their policy and strategy deliberations.

9. Benchmarking

Since 1995 TransGrid has been a participant in the International Transmission Operating and Maintenance Study (ITOMS) that benchmarks maintenance activities performed by high voltage transmission utilities. The study typically involves some twenty five transmission organisations from Australia, New Zealand, USA, Europe, UK, Scandinavia and the Middle East.

The ITOMS results are used by TransGrid as a basis to carry out a detailed review of the various maintenance policies and strategies being adopted by not only overseas utilities but also most of the Australian utilities. The results from ITOMS 1999 through ITOMS 2011 have confirmed the success of TransGrid's maintenance policies and asset management processes and provided data to enable implementation of further improvements.

Since 2010 TransGrid also participates in the International Transmission Asset Management Study. The aim of participation in this study is to learn from the asset management practices of other transmission utilities, and ensure that TransGrid remains at the forefront of asset management practices.

10. Asset Management Process Continuous Improvement

PAS 55 is a widely recognised Asset Management Framework. It allows asset management performance against a maturity scale to be objectively measured and to enable the targeting of improvement programs in those areas considered to give the best value.

TransGrid recently completed a PAS 55 gap analysis and consulted with various asset management specialists and other organisations with an asset management focus. This work has initiated a move towards PAS 55 certification to formally recognise TransGrid's existing asset management capabilities and provide a framework for continuing development of core asset management competencies.

4.2 Specific Asset Profiles and Strategies

4.2.1 Asset Profiles

Introduction

This section details the numbers and age profiles of the existing assets within TransGrid's network as at 1 January 2013.

The particular assets identified include the following:

- Substations;
- Transmission lines;
- Underground cables;
- Protection schemes;
- Metering installations;
- Telecommunications; and
- Control systems and SCADA.

1. Substations

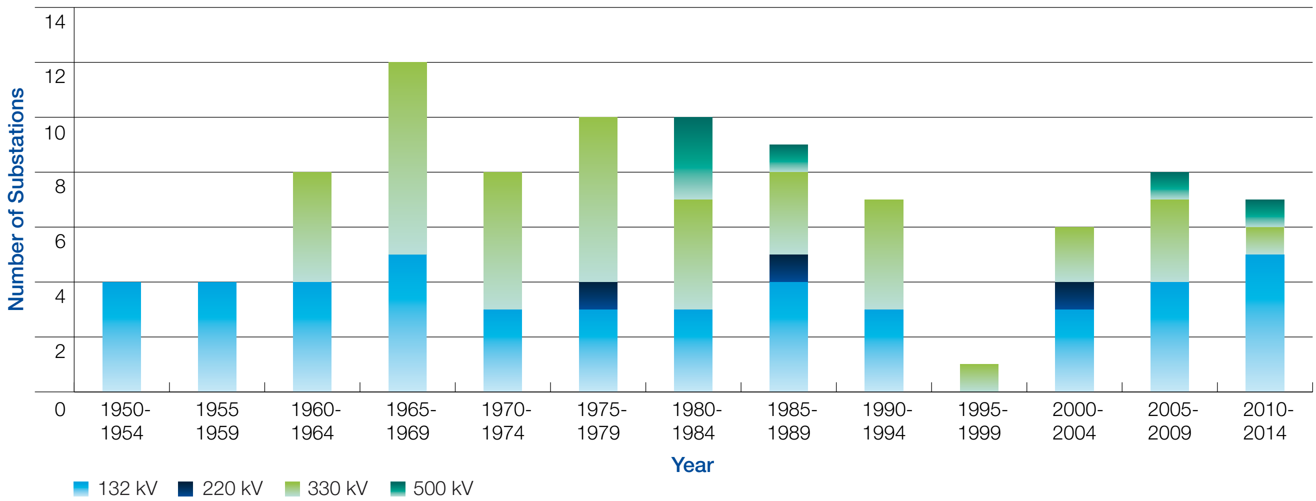
Introduction

TransGrid has a total of 94 substations and switching stations within its network ranging in voltage from 132 kV, 220 kV, 330 kV to 500 kV. Their locations vary from coastal to rural, sub-tropical to dry-desert, sea level to high altitude, corrosive locations to stable atmospheres.

Each substation or switching station may comprise high voltage circuit breakers, power transformers, instrument transformers, reactors, static VAr compensators, capacitor banks, control and protection schemes, property and buildings, civil works, switchyard structures and hardware, buffer zones, and a multitude of other associated power supplies, cabling and ancillary equipment.

As shown from the age profiles below, 30% of TransGrid's substations and switching stations were commissioned before 1970, with the oldest being Burrinjuck commissioned in 1950 and the most recent being Williamsdale and Orange North Substation commissioned in 2012.

Substation and Switching Station Age Profile

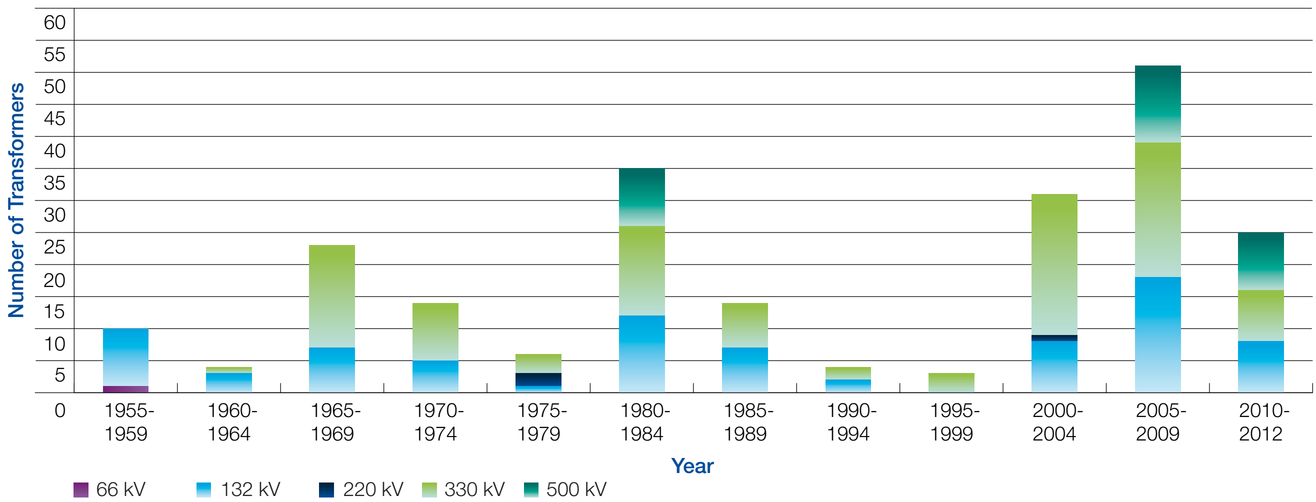


Power Transformers

TransGrid's power transformer population comprises 220 individual units and of these 71% are rated above 100MVA with a primary voltage of 132 kV or higher. 27% of this population comprises single-phase units and 92% of three phase equivalent transformer installations have on-load tapchangers.

The power transformer age profile shown below indicates that 17% were commissioned before 1970, and some of the oldest units were manufactured in 1955.

Transformer Age Profile



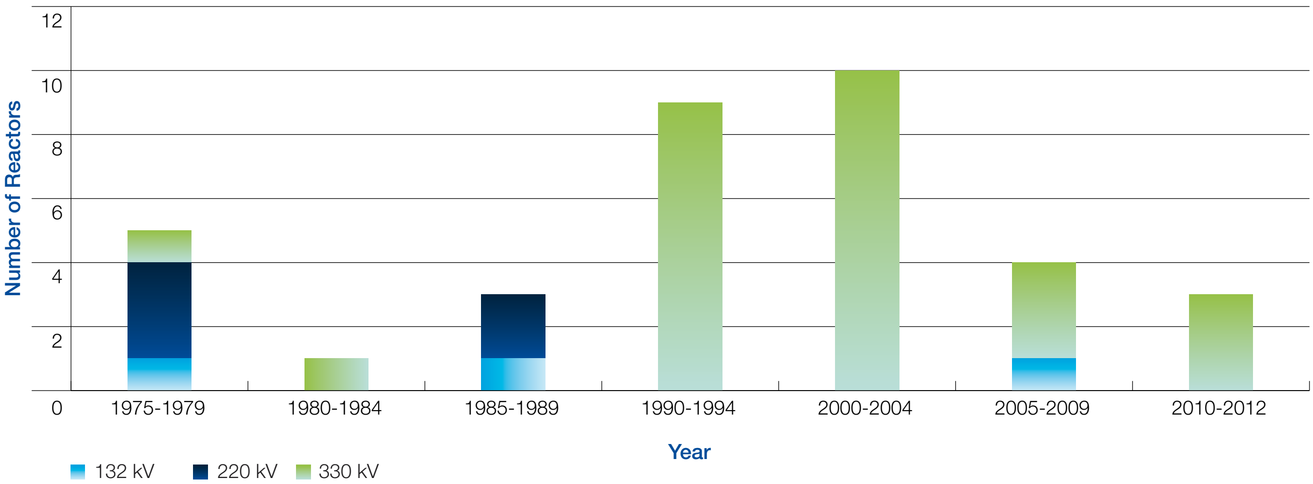
Reactors

TransGrid's reactor population comprises oil-filled, SF_6 insulated and air cored types.

TransGrid's oil filled reactor population comprises two series reactors at 330 kV, and 27 three-phase equivalent shunt reactors. These shunt reactors consist of nine single-phase units at 330 kV, 16 three-phase units at 330 kV, five three-phase units at 220 kV and three three-phase units at 132 kV.

The age profile for oil filled reactors shown below indicates that 14% of the individual installed units were commissioned before 1980 and the oldest units were manufactured in 1975.

Oil Filled Reactors Age Profile

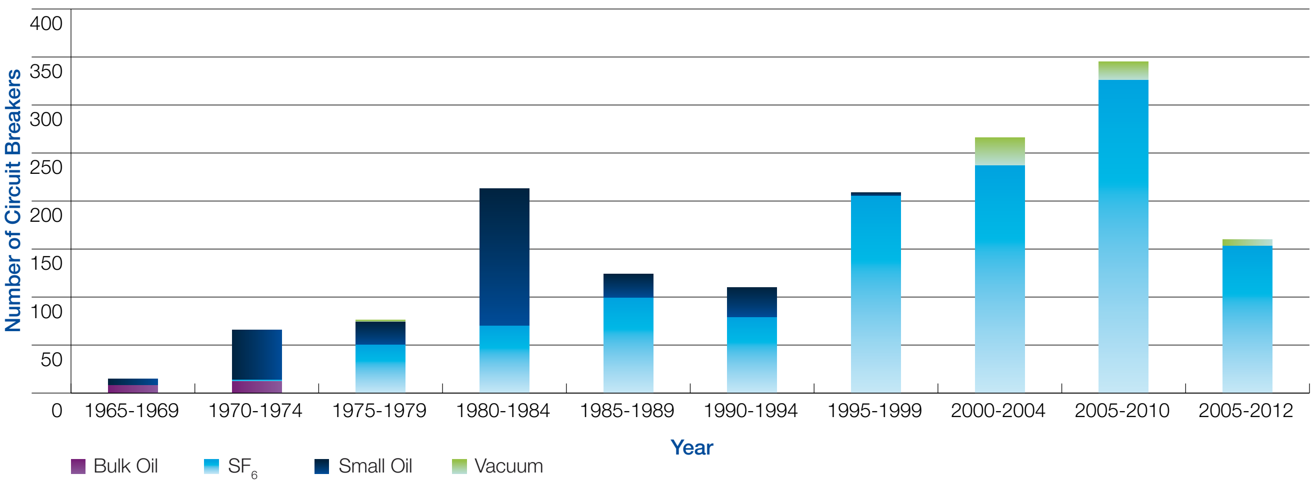


TransGrid operates three single-phase SF_6 gas insulated reactors at Haymarket. In addition, TransGrid maintains 21 single-phase air-cored series reactors at 132 kV and 33 single-phase air-cored shunt reactors at 33 kV. These units are not included in the above profile.

Circuit Breakers

TransGrid's circuit breaker population comprises 1584 units in the voltage range from 11 kV to 500 kV. The types of circuit breakers used include Bulk Oil (BO), Small Oil Volume (SOV), Vacuum and SF_6.

Circuit Breaker Age Profile



All recent circuit breaker purchases at 66 kV and above are of the SF_6 type with a preference for spring operating mechanism. The type and age profiles given above reflect the various numbers and types of circuit breakers installed on the network as at 1 January 2013.

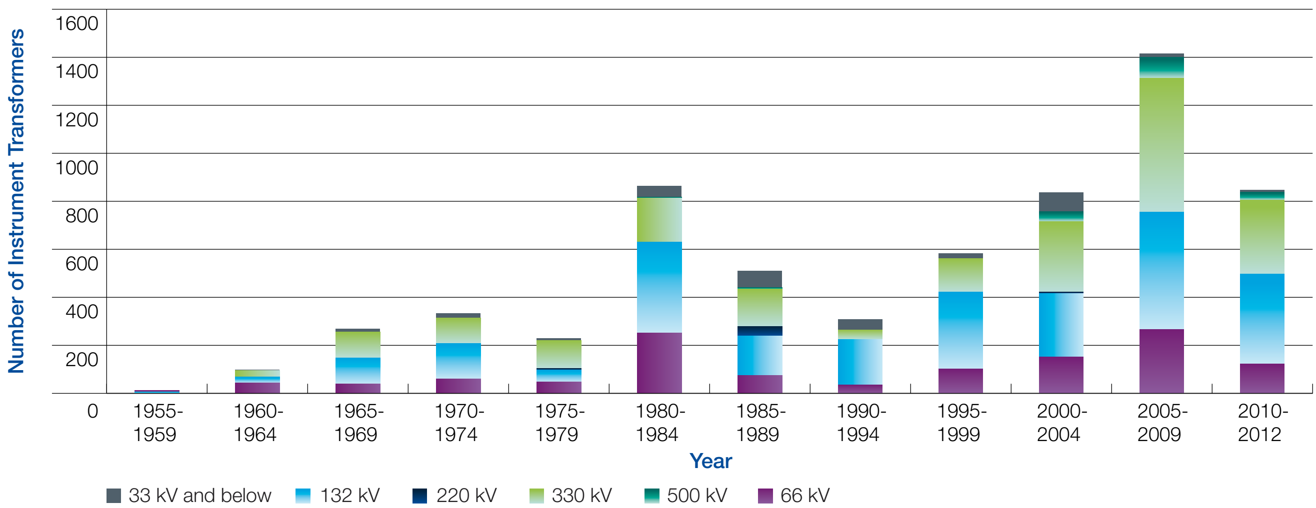
Instrument Transformers

TransGrid manages a total instrument transformer population of approximately 6304 units ranging in voltage from 11 kV to 500 kV, comprising :

- 3876 Current Transformers (approximately 61% of population);
- 770 Magnetic Voltage Transformers (approximately 12% of population); and
- 1658 Capacitor Voltage Transformers (approximately 26% of population).

The age profile shows that 7% of these units were manufactured before 1970 and some of the oldest units before 1960. All of the above units are of the post freestanding type and any instrument transformers contained within metal clad switchgear, gas insulated switchgear, power transformers and oil filled reactors are not included in the above statistics.

Instrument Transformers Age Profile



Static Var Compensators

TransGrid has five Static VAr Compensators (SVCs) located at:

- Broken Hill Substation
  2 SVCs, each -25/+25 MVAr, commissioned 1986.
- Lismore Substation
  1 SVC, -100/+150 MVAr, commissioned 2000.
- Armidale Substation
  1 SVC, -120/+280 MVAr, commissioned 2000.
- Sydney West Substation
  1 SVC, -100/+280 MVAr, commissioned 2004.

The two Kemps Creek SVCs have been de-commissioned in 2012. These SVCs were installed in 1990 to support the interconnection of South Australia. They had reached the end of their service life and there was no longer a system need that required their replacement.

Gas Insulated Switchgear

TransGrid owns two Gas Insulated Switchgear (GIS) installations located at:

- Beaconsfield West Substation
  132 kV, commissioned 1979.
- Haymarket Substation
  330 kV and 132 kV, commissioned 2004.

Additional GIS substations are being installed at Holroyd and Rookwood as part of a project to meet customer needs in the inner metropolitan area of Sydney.

Shunt Capacitors

TransGrid has a total of 128 shunt capacitor banks in service within the network with an installed capacity of 7946 MVAr ranging in voltage from 33 kV to 330 kV. 97% have been manufactured and installed since 1980.

The majority of the capacitor units installed are of the internal fuse type but some externally fused units have also been used. All units are PCB free.

Surge Arresters

Surge arresters are used to protect expensive items of plant such as transformers from failure due to transient voltage surges. There are over 2020 arresters installed within TransGrid's system.

Bushings

TransGrid's transformers and reactors contain some 2094 bushings ranging in voltage from 500 kV to 11 kV. In general the age profile would follow closely that of the transformers and reactors. These indicate that approximately half of the transformer bushings are more than 20 years old and approximately half of the reactor bushings are over 10 years of age.

Control and Alarm Systems

Control and alarm systems within TransGrid's 94 substations and switching stations range widely from composite mechanical relays to systems built using discrete components that use printed circuit cards, composite electronic relays, programmable logic controllers or microprocessor based systems of various configurations. The age profiles of these systems range from the early 1950s to the present modern technology and some sites have a combination of interconnected systems.

Ancillary Equipment

All substation and switching stations also contain ancillary equipment such as disconnectors, earth switches, surge arresters, busbars, batteries and battery chargers, control and protection cabling, security systems, fire protection equipment, air conditioning, light and power.

Substation Property and Buildings

Each of TransGrid's substations and switching stations contain a control room building, which may vary in size from a small single level building to, particularly in the case of older establishments originally designed for local staffing, a large multi-level building. These buildings generally contain a relay room, battery room, communication room, amenities room and workshop.

Sites also may contain fencing, roads, drainage systems, landscaping, environmental buffer zones and other services, which need to be kept in good order.

The age profile for these sites is normally the same as the substation and the style and construction methods vary due to the location, environmental issues and the era built.

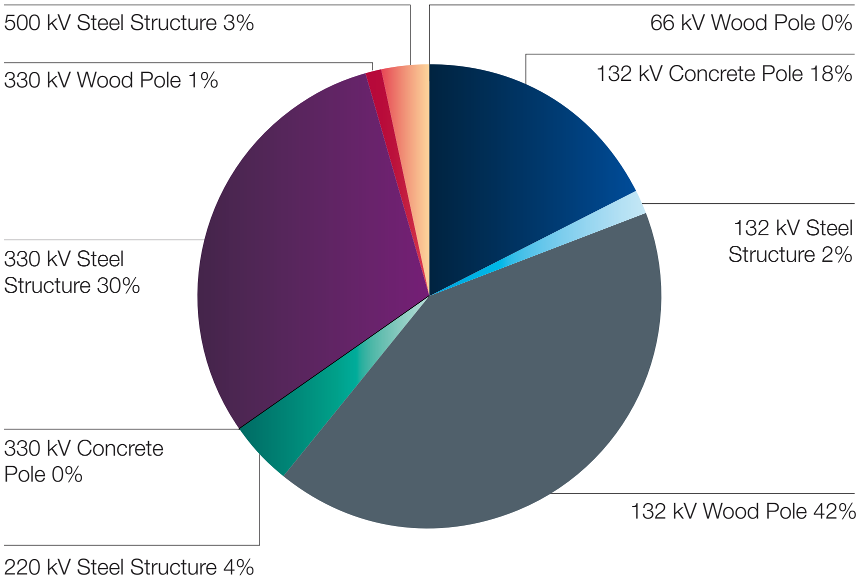
2. Transmission Lines

TransGrid has a total of 10,979 route kilometres and 12,773 circuit kilometres of transmission line with details of constructed and operating voltage given in the following table:

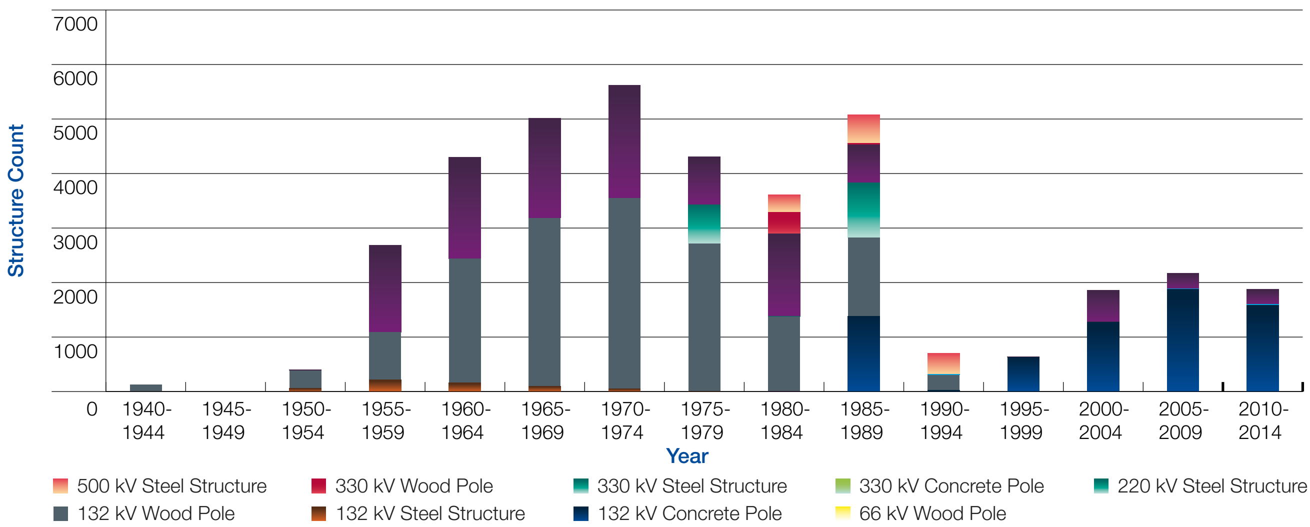
	TRANSMISSION LINES (km)	
Line Type	Route	Circuit
500 kV in Service at 500 kV	514	1,023
500 kV in Service at 330 kV	20	40
Total 500 kV	**534**	**1,067**
330 kV in Service at 330 kV	4,539	5,370
330 kV in Service at 132 kV	96	191
Total 330 kV	**4,635**	**5,561**
220 kV in Service at 220 kV	681	681
Total 220 kV	**681**	**681**
132 kV in Service at 132 kV	5,129	5,468
Total 132 kV	**5,129**	**5,468**
Totals	**10,979**	**12,773**

These lines are of steel lattice tower, steel pole, concrete pole and wood pole construction. The construction line type and age profiles are shown below in terms of structure numbers:

Transmission Line Type Profile



Transmission Line Structures Age Profile



3. Underground Cables

The primary cable assets owned by TransGrid are:

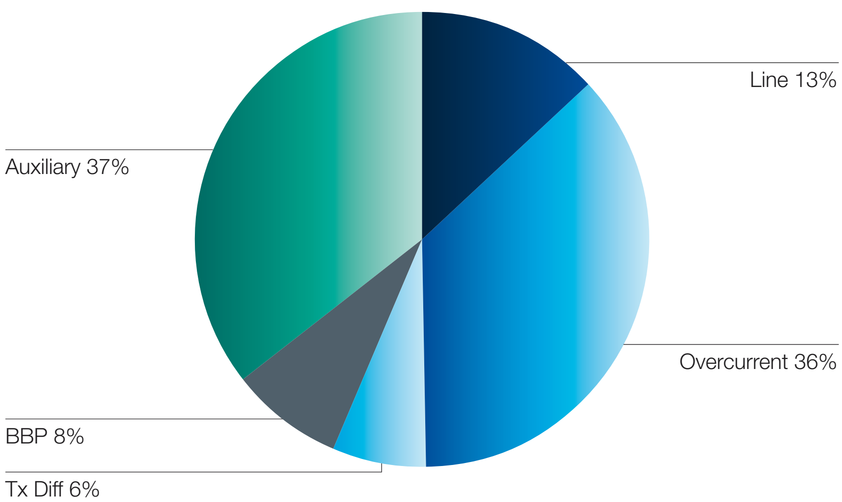
- 330 kV cable 41, 19.7km, installed between the Beaconsfield West Substation and the Sydney South Substation at Picnic Point. This is a paper-oil cable system that was placed into service in 1979. Associated with 41 cable is the pilot cable 160.
- 330 kV cable 42, 28km, installed between the Haymarket Substation and the Sydney South Substation at Picnic Point. This is a Polypropylene Laminated Paper (PPLP) fluid filled cable system that was placed into service in 2004. Associated with 42 cable is a 4km length of tunnel between Sydney Park, St Peters and Haymarket substation.

TransGrid is in the process of installing new 330 kV power cables as part of a project to meet the needs of customers in the Inner Metropolitan area of Sydney. Two circuits, referred to as cables 43 and 44, will be installed between the Holroyd Substation at Greystanes and Rookwood Road Substation at Potts Hill, a cable route distance of approximately 16km. The cables will have a cross linked polyethylene (XLPE) insulation system. Completion is scheduled for late 2013.

Included in the same contract is the installation of a 330 kV cable in TransGrid's existing tunnel between Haymarket substation and the Sydney Park portal, a cable route length of 3.5km. The cable construction is identical to the Holroyd Rookwood Road Cables. Ausgrid will complete the link to TransGrid's Beaconsfield substation. The cable will be operated at 132 kV. Completion of the TransGrid section is scheduled for mid 2013.

TransGrid also has short lengths of cable energised at 132 kV, 66 kV, 33 kV and 11 kV which in general, though not exclusively, run within substation boundaries.

Protection Relay Profile



4. Protection Relays

Introduction

Protection equipment at TransGrid sites can be grouped into a number of broad categories. These include:

- Line protection relays (distance, pilot wire and current differential);
- Transformer differential relays;
- Busbar protection relays;
- Overcurrent relays (instantaneous and IDMT); and
- Auxiliary relays (timers, multitrips, followers).

The graph below apportions these categories:

Auxiliary relays represent the largest category and whilst installed in all protection schemes these can generally be considered as secondary components. The primary components of a protection scheme will normally be comprised of one or more relays from the other four categories.

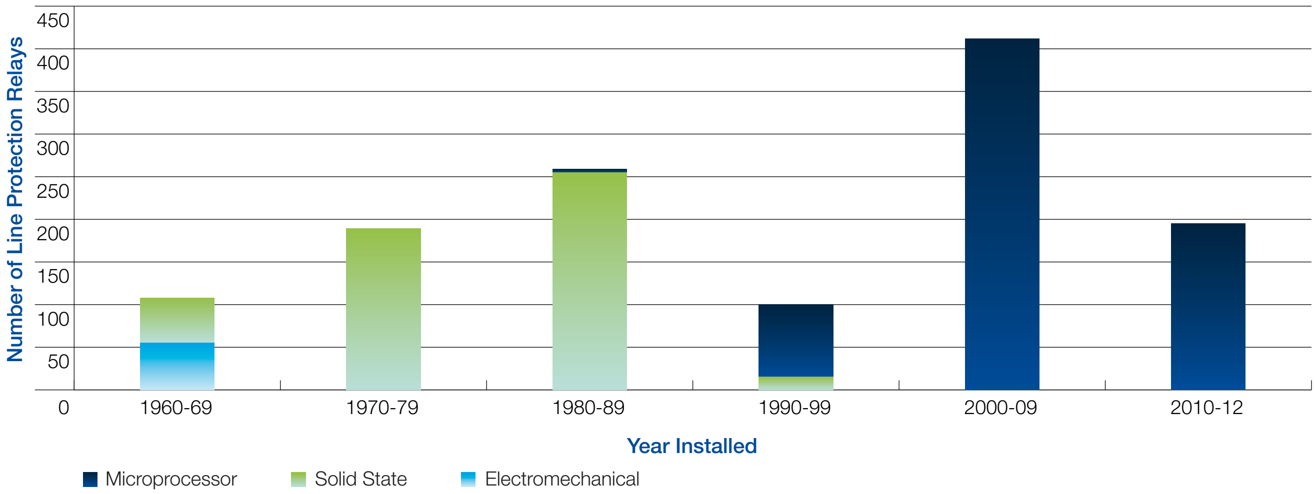
The population, condition, performance and status of manufacturer support of this equipment represent some of the factors that need to be considered when determining a replacement program. The replacement program would also need to include the upgrading of auxiliary relays as a natural consequence of any primary relay change.

It is recognised that all primary relays currently installed on TransGrid's system will need to be replaced at some time. The population and age of the primary protection equipment installed on TransGrid's network is set out in the following pages.

Line Protection Relays

TransGrid's line protection relay population comprises over 1263 individual schemes ranging in age from 0 to 52 years. The age profile shown below indicates that 24% of TransGrid's line protection relay population was commissioned before 1980, with some of the oldest schemes being manufactured in 1960.

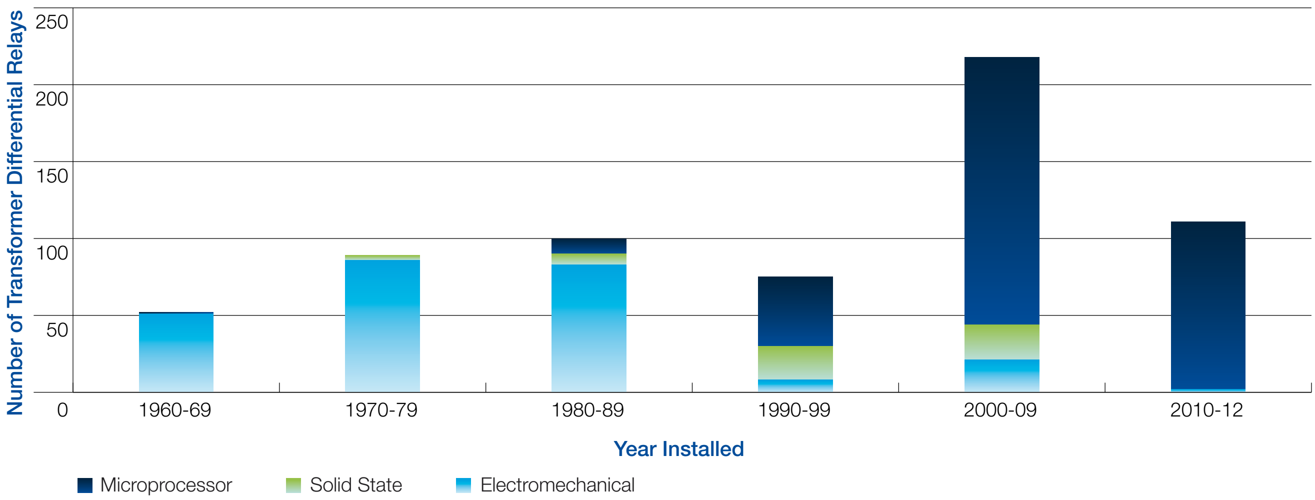
Age Profile of Line Protection Relays



Transformer Differential Relays

TransGrid's transformer differential relay population comprises around 645 individual schemes ranging in age from 0 to 52 years. The age profile shown below indicates that 22% of TransGrid's transformer differential relay population was commissioned before 1980, with some of the oldest schemes being manufactured in 1960.

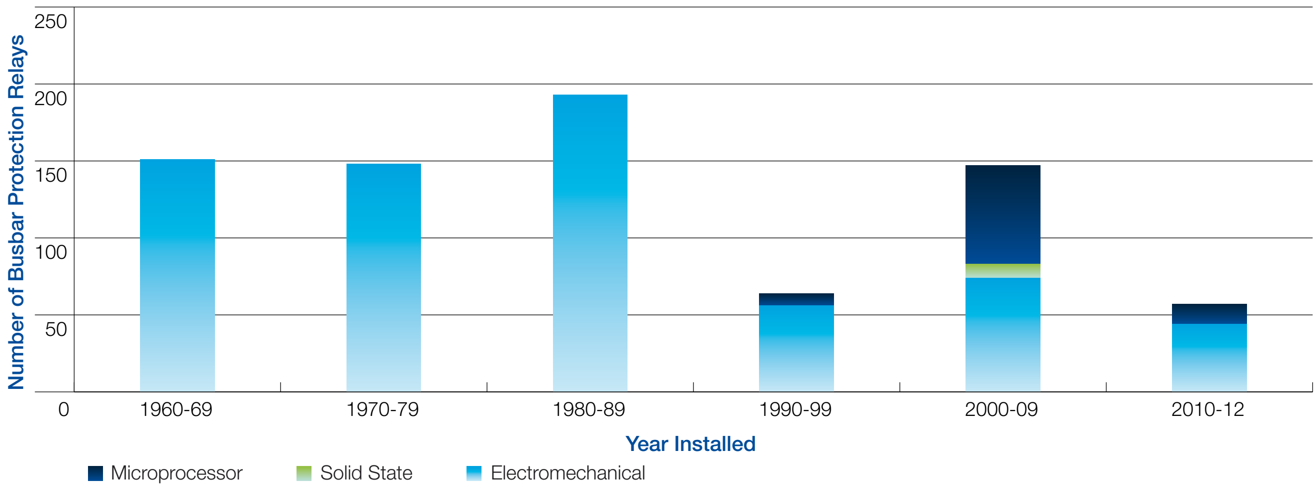
Age Profile of Transformer Differential Relays



Busbar Protection Relays

TransGrid's busbar protection relay population comprises over 760 individual schemes ranging in age from 0 to 52 years. The age profile shown below indicates that 39% of TransGrid's busbar protection relay population was commissioned before 1980, with some of the oldest schemes being manufactured in 1960.

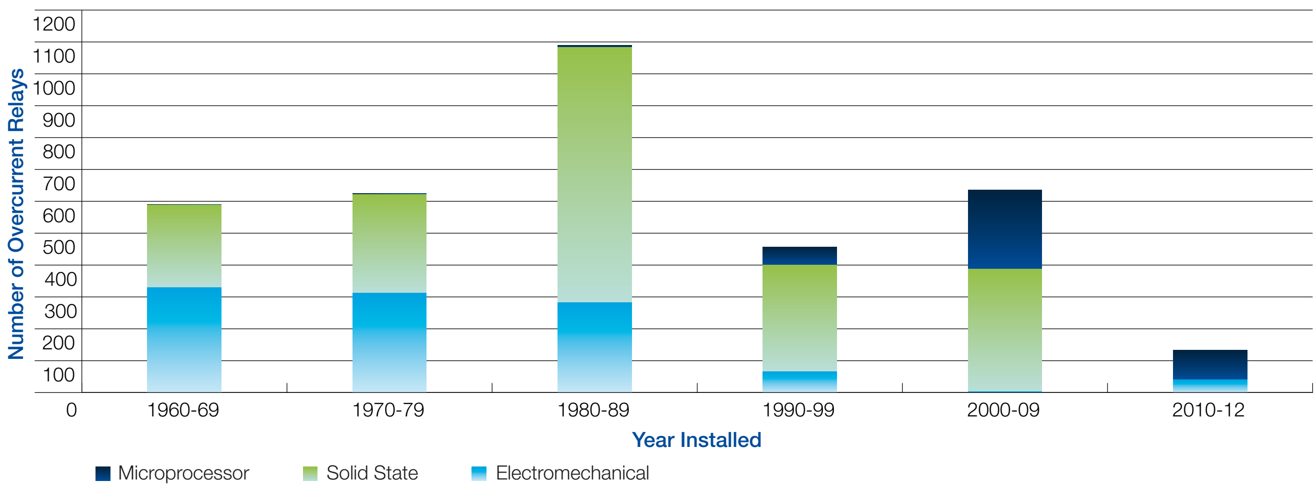
Age Profile of Busbar Protection Relays



Overcurrent Protection Relays

TransGrid's overcurrent protection relay population comprises approximately 3529 individual relays ranging in age from 0 to 52 years. The age profile shown below indicates that 34% of TransGrid's overcurrent protection relay population was commissioned before 1980, with some of the oldest schemes being manufactured in 1960.

Age Profile of Overcurrent Relays



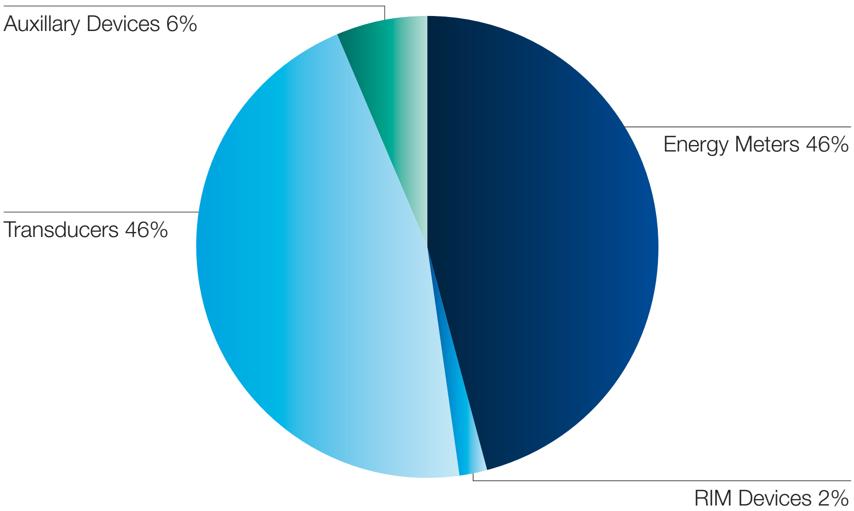
5. Metering

Metering equipment at TransGrid sites can be grouped into a number of broad categories. These include:

- Energy meters;
- Remote Interrogation Meters (RIMs);
- Auxiliary devices (voltage selection relays, transformers); and
- Transducers.

The following graph apportions these categories:

Metering Installation Profile



NEM metering installation equipment represents the largest category and consists of energy meters, Remote Interrogation Meters (RIMs) and auxiliary devices (modems and voltage selection relays), forming the essential components of any revenue or backup metering scheme. Transducers form the second largest category and provide an important function in relation to SCADA or real time operational data used to manage the operation of the high voltage network.

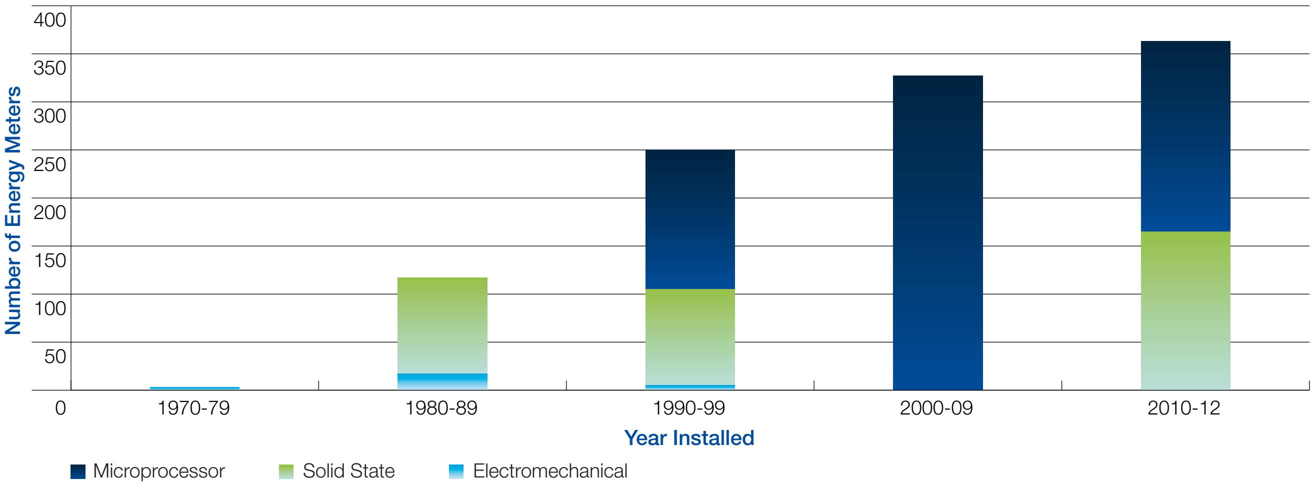
Replacement programs will generally include the upgrading of auxiliary devices as a consequence of any revenue or backup metering scheme replacements.

It is recognised that 36% of energy meters, 100% of RIMs and 47% of transducers currently installed on TransGrid's system will need to be replaced in current strategies. The population and age of the primary metering equipment installed on TransGrid's network is set out in the following pages.

Energy Meters

TransGrid's energy meter population comprises some 1060 individual units ranging in age to 42 years old. The age profile shown below indicates that 21% of TransGrid's energy meter population are older induction disc and early electronic pulsing meters that were commissioned before 2000 and require replacement with modern interval meters.

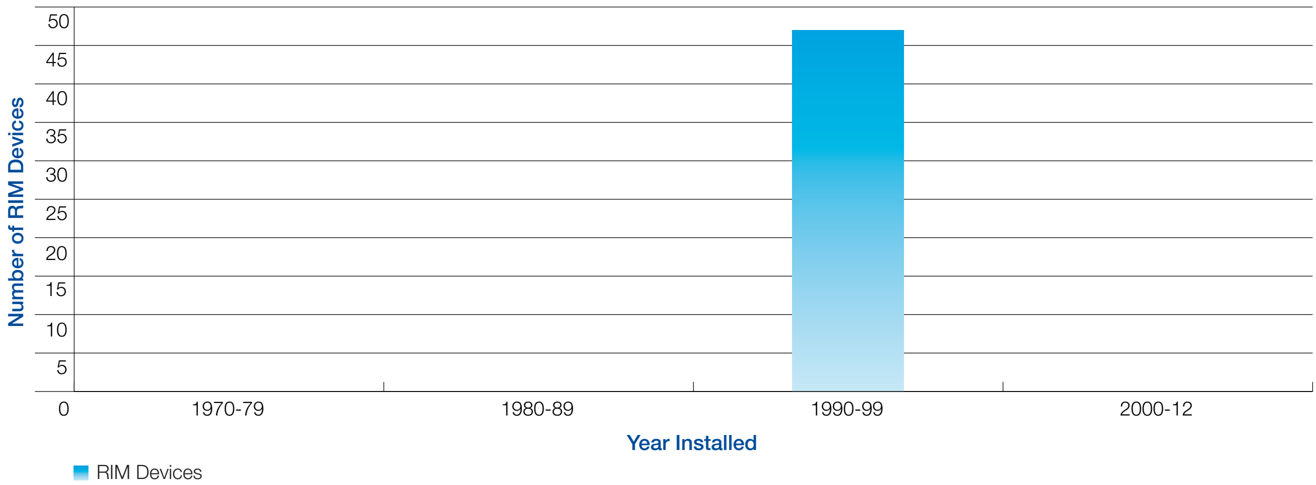
Age Profile of Energy Meters



Remote Interrogation Meters (RIMs)

TransGrid's datalogger (RIM) population comprises 47 individual units, the majority of which are 12 to 22 years of age. These devices are only used in conjunction with pulsing meters and are progressively being phased out and no longer used, as modern meters incorporate internal data logging functionality.

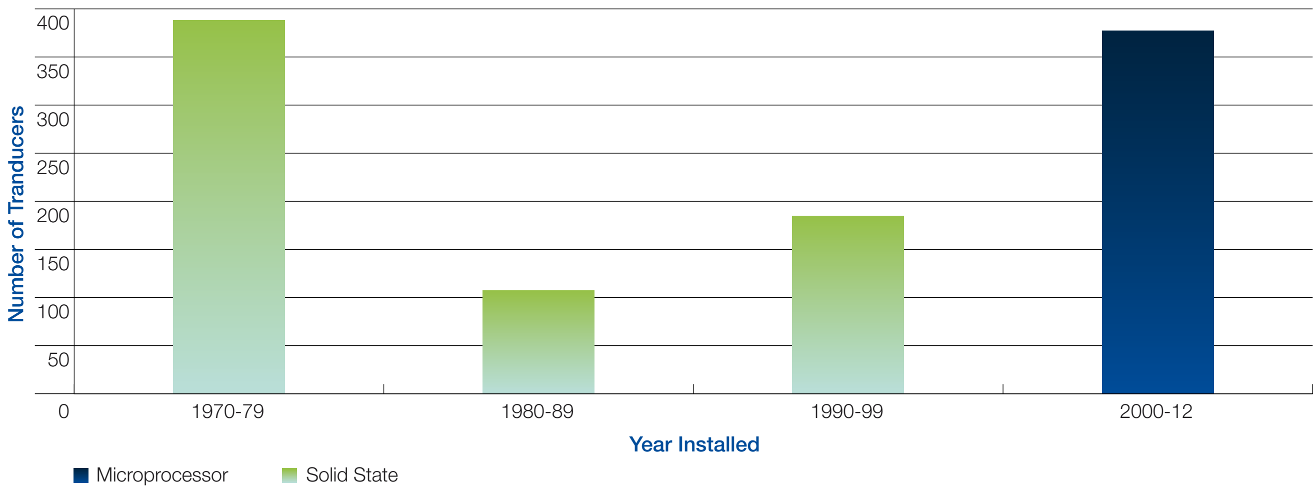
Age Profile of RIM Devices



Transducers

TransGrid's transducer population comprises almost 1057 individual units up to 42 years old. The age profile shown below indicates that 37% of TransGrid's transducer population was commissioned before 1980.

Age Profile of Transducers



Note: Some substations such as at Gadara, Molong and Balranald do not include discrete transducers but utilise equivalent functions built into the protection relays.

6. Communications

TransGrid owns 127 communication rooms located within substations, regional centres and TransGrid's head office. Each communication room provides voice, data and protection services to the equipment and staff on site. Being part of the site the communication room utilises the ancillary equipment installed within the building (batteries, chargers, 240V AC and 415V AC).

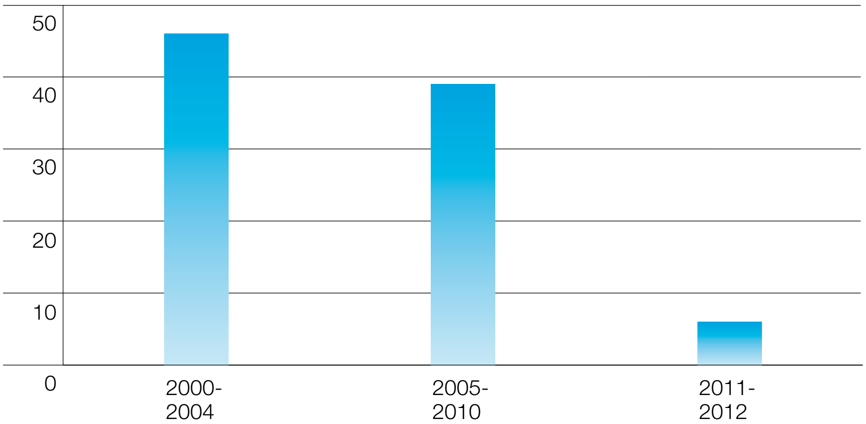
TransGrid owns 86 microwave and VHF radio repeater sites located across NSW. All repeater sites are stand-alone and have individual ancillary equipment. These include power and lighting, battery and chargers, air conditioning, access roads, security fencing and radio towers, poles or structures.

Data on all equipment is listed below.

Bay Alarm Systems

Each communication room and major repeater sites marshal individual alarms from equipment and provides an audible and visual display. These alarms are grouped and sent to the SCADA network. This is achieved by the Bay Alarm System. Version 1 is no longer supported and is being replaced as and when required by version 2. Version 2 uses an off the shelf rack mount PC and Bechoff distributed I/O.

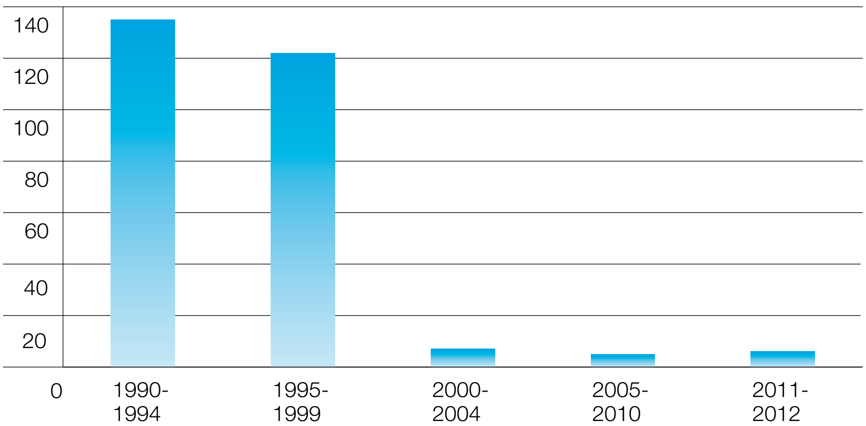
Bay Alarm Systems



Backup Alarm Systems

TransGrid owns 170 backup alarm systems that provide a combined alarm service as a secondary service to SCADA SMART alarm (1997). It is a microprocessor-based system capable of transmitting and receiving 10 simultaneous alarms. SMART alarms currently account for the entire population of backup alarm systems in the network. This system has an expected life of 20 years.

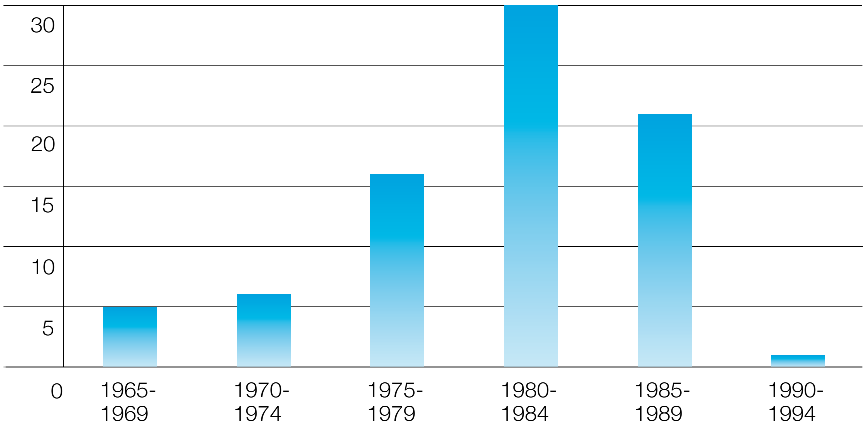
Backup Alarms



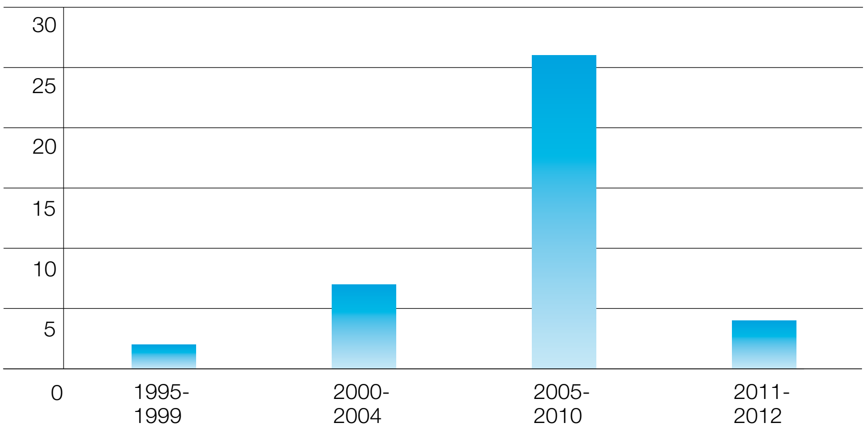
Power Line Carrier

TransGrid owns some 75 Power Line Carrier (PLC) systems that provide communication services between substations. These systems carry voice, SCADA and backup alarm systems.

Voice PLC (Fujitsu)



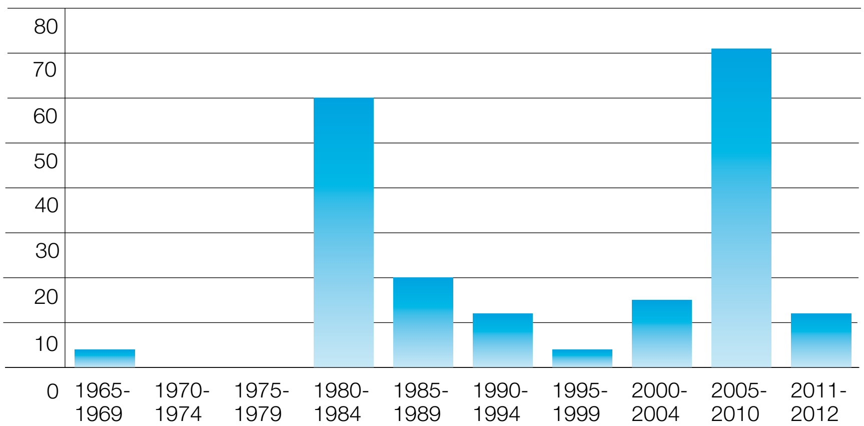
Voice PLC (Dimat)



Power Line Carrier Protection Intertrip Systems

TransGrid owns over 176 PLC Intertrip systems. These systems provide intertrip functions over transmission lines.

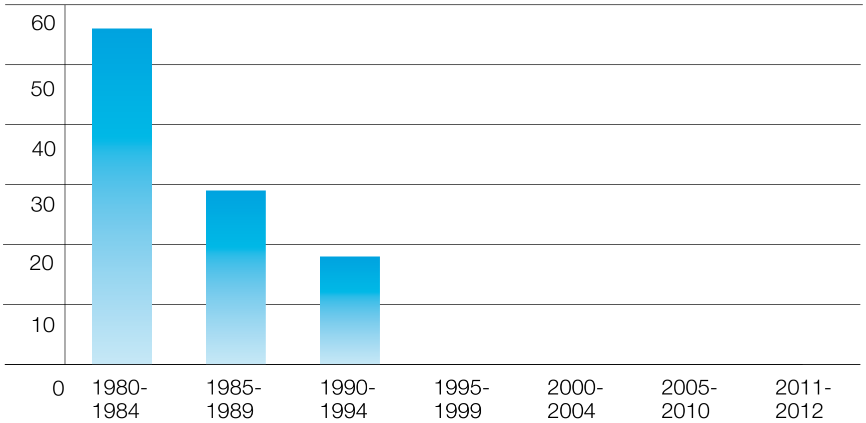
Protection I/Ts PLC



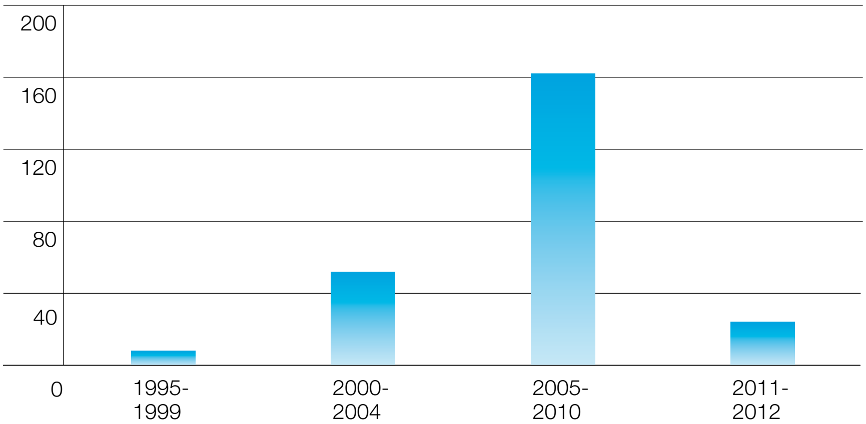
VF Protection Intertrip Systems

TransGrid owns about 392 VF Intertrip systems. These systems provide Intertrip function over Voice Frequency bearers (Microwave, and Optic Fibre).

VF I/Ts (Fuji)



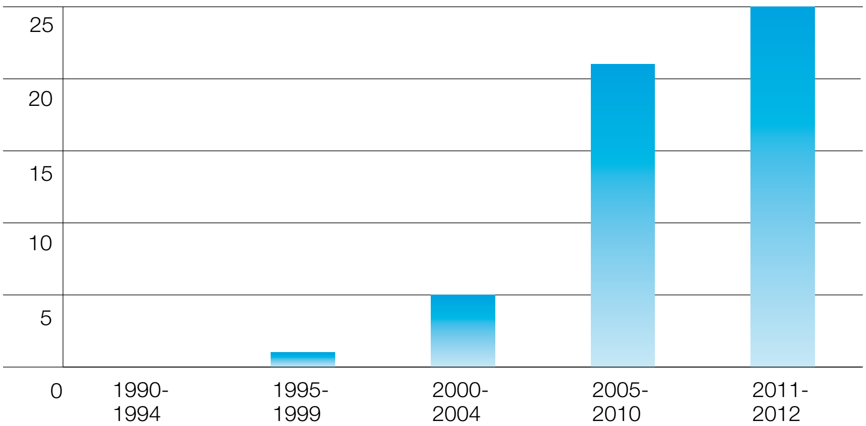
VF I/Ts (Dewar)



Telephone Equipment

TransGrid owns and operates 52 networked Ericsson telephone exchanges. These exchanges provide voice communications between System Control Rooms and individual substations.

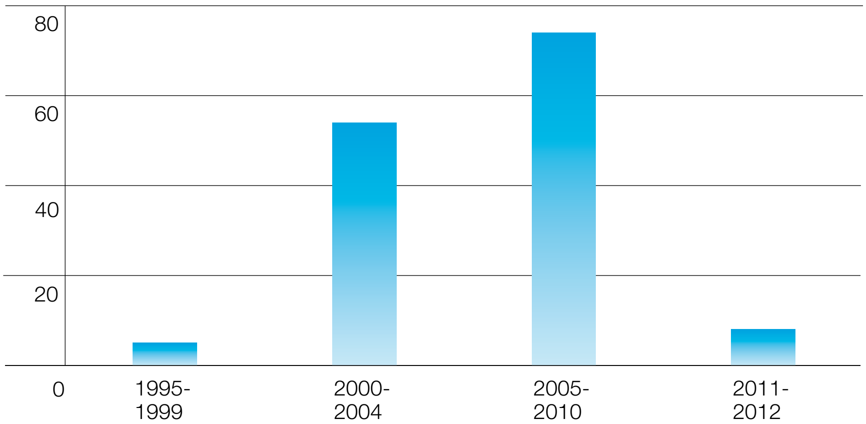
Telephone Exchanges



Microwave Radio Equipment

TransGrid owns and operates microwave systems that in conjunction with the OPGW network provide communication bearers to a number of substations.

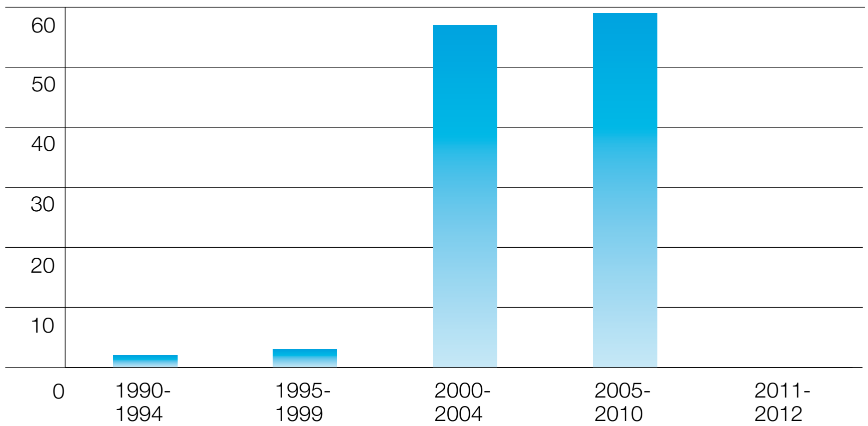
Microwave Systems



VHF Radio Equipment

TransGrid owns and operates a VHF Radio network covering all Substations and major transmission lines in NSW.

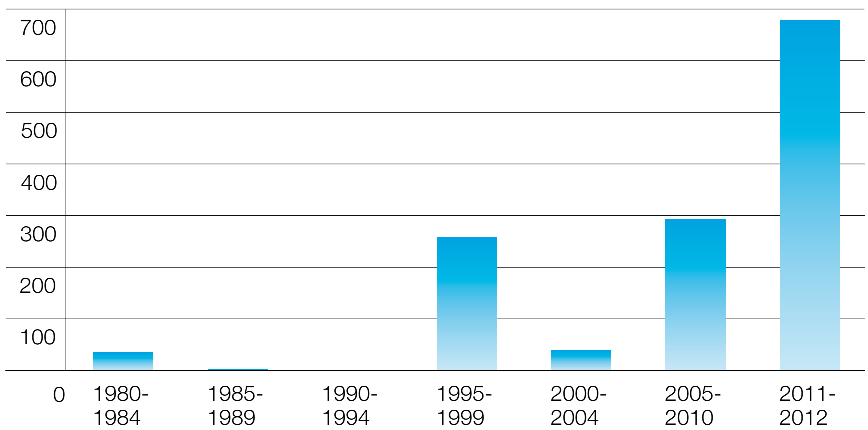
VHF Radio Systems



Substation Control Systems

TransGrid owns and operates 96 Substation Control Systems consisting of 2166 individual RTU units. These RTUs provide local and remote control of the Substations.

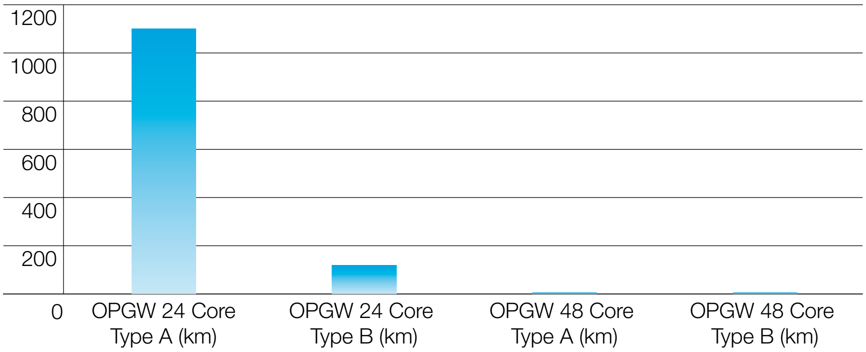
RTU Units



Optical Fibre Network (OPGW)

The overhead earth wire optic fibre (OPGW) backbone network in conjunction with microwave networks provide communication bearers from Western Sydney to the Victorian border (Southern System), Western Sydney to Mt Piper (Western System) and Western Sydney to the Queensland border (Northern System). The OPGW network provides the majority of backbone communication.

OPGW



4.2.2 Specific Asset Management Strategies

Introduction

This section describes the specific maintenance policies and refurbishment and replacement strategies that have been developed to ensure the continued performance of the existing network assets. The condition of assets is continuously monitored through inspection and testing and the resulting body of data is analysed to determine the need for any action that might be required to obtain optimum asset life.

1. Substations

Routine Maintenance

Routine maintenance is carried out in accordance with TransGrid's Substation Maintenance Policy. The principles employed include the following:

- Maintenance is minimised while maintaining required standards of safety, reliability, availability and risk performance;
- Non-intrusive maintenance is used whenever possible to determine and monitor the condition of plant;
- Plant is tested in accordance with targeted maintenance strategies, which are based on plant service experience and manufacturer's recommendations;
- For major plant, detailed Service Instructions have been prepared and are being used by field maintenance staff; and
- Regular site inspection of all installations is carried out on a monthly basis, with a more detailed inspection every six months.

Circuit Breakers – Circuit breakers are maintained on either time or operational basis. The table below summarises the different maintenance types and frequencies.

TYPE OF CB	INSPECTION	DETAILED INSPECTION	MINOR SERVICE	MAJOR SERVICE
Oil	6 monthly	–	4 yearly	12 yearly or 800 operations
Air blast	6 monthly	–	4 yearly	12 yearly or 800 operations
SF6	6 monthly	4 yearly	8 yearly	2500 operations

The types of diagnostic testing carried out on circuit breakers include: measurement of contact resistance, measurement of the speed of operation of contact opening and closing, insulation medium tests, and checks on operating mechanisms.

Power Transformers and Oil Filled Reactors – power transformers have four main components (tapchanger, bushings, windings and oil) that require routine maintenance on either time or operational basis. The table below summarises the different maintenance types and frequencies.

COMPONENT	EXTERNAL INSPECTION	MINOR MAINTENANCE	MAJOR MAINTENANCE	NUMBER OF OPERATIONS
Tapchanger*	6 monthly	4 yearly	4 to 8 yearly (except vacuum type)	Depends on type and make of unit
Bushings	6 monthly	N/A	4 yearly	N/A
Windings	N/A	N/A	4 Yearly	N/A
Oil System	6 monthly	Annual Sample	As Required	N/A

* Tapchangers are also run through taps annually.

The frequency of maintenance also depends on transformer/reactor condition and to some degree on its type. Annual oil samples are taken for dissolved gas analysis (DGA), furans and oil quality tests.

More recently, on-line condition monitoring facilities are being installed on selected power transformers and oil filled reactors. These devices provide continuous monitoring of the condition of the equipment while they remain in service and provide an early warning of internal problems that could lead to failure.

Instrument Transformers – Instrument transformers include current transformers and voltage transformers. Most voltage transformers are of the capacitive type and a purpose built on-line voltage unbalance system developed by TransGrid is used to monitor their internal condition.

Oil filled current transformers are tested externally by measuring dielectric dissipation factor (DDF), insulation resistance (IR) and are oil sampled. Oil tests include moisture content and dissolved gas analysis (DGA) tests. The normal frequency of testing is a 4-yearly cycle with more frequent testing if results indicate a need.

Apart from a check on gas monitoring devices and inspection/cleaning, no maintenance is required for SF_6 insulated instrument transformers.

Other Plant – Other plant such as disconnectors, surge arrestors and capacitor banks are maintained at the same service intervals as the main plant they are associated with. Batteries are maintained in accordance with our service experience, nominally at four yearly intervals until the banks have been in service for 14 years, after which they are tested every two years.

Non-Routine Maintenance

Non-routine maintenance covers breakdown repairs, defect repairs, plant modifications and other work not covered by routine maintenance.

Asset Renewal Projects

Asset renewal projects are non-routine works requiring substantial resources that are non-repetitive in nature. They include both refurbishment and replacement of equipment and may also include capital work such as transformer life extension.

The following factors are used to identify, analyse and substantiate any new asset renewal project:

- Need for work based on issues such as performance, maintenance needs, safety, lack of spare parts, environmental factors, type faults;
- Risk assessment analysis associated with continued repairs, future reliability, system security;
- Total quantity and costs which may consider either refurbishment or replacement options;
- Time period over which the work has to be done; and
- Priority factor giving importance relative to other projects.

Asset renewal programs are determined by condition, economic, safety or environmental considerations.

Increasing use of condition monitoring is being made to substantiate equipment replacement and refurbishment. On-line continuous condition monitoring systems are becoming available for substation plant such as power transformers and oil filled reactors, bushings, on-load tapchangers and circuit breakers.

TransGrid has implemented a targeted strategy to purchase selected on-line monitoring devices for installation at an appropriate range of locations.

Substation Reconstruction

TransGrid substations date from 1950 onwards and at some sites a wide range of issues exist due to deterioration in the condition of:

- HV plant;
- Protection systems, metering and control systems; and
- Infrastructure such as earthing systems, buildings, steelwork, cabling, kiosks etc.

Where a range of issues have developed at a site, the most efficient and effective approach to management of the substation may be reconstruction.

Management of these issues through individual strategies applied at a site is difficult to achieve in situ due to the need to maintain the substation in operation and maintain supply. Risks associated with the safety of work, reliability of supply and ability to complete the work in required timeframes are introduced, and the availability of specialised resourcing to complete the work through contracting can be limited or unavailable. It is unlikely that all site issues will be resolved by this type of piecemeal approach.

Greenfield reconstruction allows the use of construction contractors with no site constraints to interfere with the efficiency of work and with much lower risks to safety and the reliability of plant. In addition, the total substation is renewed and built to meet current needs and design standards. Greenfield reconstruction is preferred where it is feasible and cost effective.

Brownfield reconstruction may be required as a result of constraints that prevent Greenfield reconstruction. In these cases, work staging is developed to minimise the interaction with in-service equipment and to maximise the efficiency of work.

Currently, complete or partial reconstruction is being planned for Wallerawang (underway), Orange (underway), Upper Tumut (underway), Cooma, Burrinjuck, Yanco, Taree, Vales Point, Tamworth 132 kV, Wagga 132 kV and Canberra substations.

Power Transformers and Oil Filled Reactors

Investigations into the performance of transformers have identified potential issues that may impact on the expected operational life of some units. These issues relate to problems with on-load tapchangers, high voltage bushings, loose windings, cooling systems, oil quality and moisture ingress. All of these issues when identified early enough can be satisfactorily and economically managed thereby ensuring the continued performance of the transformer or reactor.

Following an assessment of transformer/reactor condition, a refurbishment program is developed to address issues identified for particular transformers or reactors. The condition assessments are based on a review of:

- Diagnostic data collected from electrical testing;
- Oil analysis results;

- defect history;
- maintenance outcomes; and
- from the results of physical inspections.

Refurbishment will typically include items from the following list, tailored to the condition of each transformer or reactor:

- Refurbishment or replacement of insulating oil to improve quality;
- Dry-out to reduce moisture content in paper and oil;
- Retightening and re-clamping of loose windings;
- Replacement of faulty high voltage bushings;
- Repair of oil leaks;
- Painting and corrosion repairs;
- Refurbishment or replacement of tapchangers, which may include sealing of diverter compartments; and
- Refurbishment of cooling, control or protection equipment.

In addition to refurbishment works, TransGrid implements projects on specific transformers or reactors to maximise the useful service life of the units. Some of these projects include:

- Fitting of on-line continuous monitoring systems to the on-load tapchanger, high voltage bushings, transformer oil and thermal systems on critical transformers; and
- Relocation of transformers or reactors to other substations within TransGrid's network to better utilise or match their design ratings against the substation loadings and to defer expenditure on new transformers and reactors.

Once a transformer or reactor is assessed to have reached the end of its reliable service life a replacement unit is installed. TransGrid has standardised on ratings and capacity for transformers to take advantage of efficiencies attained by streamlining management of transformer spares.

The NSW Annual Planning Report identifies specific network constraints where existing substation transformer thermal capacities are not able to meet the required loads. For these situations the two normal options considered include the installation of extra transformers into the substation or replacement of the existing transformers with higher rated units. Where transformers are replaced to increase transformer capacity at a site, the condition of the transformers to be removed is assessed and depending on the assessed condition, they are either refurbished and relocated to another site, stored as spare units or scrapped.

Circuit Breakers

There are two main types of high voltage circuit breakers in use on TransGrid's network: small oil volume and SF_6.There are also a relatively small number of vacuum circuit breakers at lower voltage levels and it is likely that the vacuum interrupters will become available at higher voltages.

Small oil volume circuit breakers are considered to be obsolete technology and this type of circuit breaker is no longer manufactured. Maintenance costs for this type of circuit breaker are higher than for SF_6 units, and a substantial level of maintenance knowledge and effort are required to ensure continued reliability of the circuit breakers. Support for these circuit breakers from manufacturers is limited as this type is no longer supplied.

Poor performance on small oil volume circuit breakers usually relates to oil leaks, high contact resistance and operating times. TransGrid service experience indicates an expected economic life of circuit breakers to be up to 40 years. However, factors such as reliability and supportability may result in a shorter economic life for specific circuit breaker types.

There are specific strategies for replacement of the following circuit breakers.

Although modern SF_6 circuit breakers have proven to be reliable and need minimum maintenance, early generation SF_6 circuit breakers supplied between 1975 and 1987 suffer from type faults leading to corrosion and SF_6 gas leaks. Refurbishment programs to rectify these problems have been largely unsuccessful and plans are now in place to replace the affected circuit breakers.

Switching of large shunt capacitor banks can result in transient voltage disturbances that impact on the performance of end use customer equipment. To minimise voltage disturbances point-on-wave switching technology is incorporated into the circuit breaker design at locations where the capacitor banks are rated at 80MVAr and greater.

Instrument Transformers

TransGrid's instrument transformer maintenance policy provides for regular inspection and testing to detect any units that may need specific attention.

Replacement of oil filled instrument transformers is generally carried out based on condition monitoring results of the insulation system. Oil samples and dissolved gas analysis has been the most commonly used monitoring method for these units.

On-line condition monitoring devices have been used by TransGrid on capacitor voltage transformers for some time, where a voltage unbalance alarm indicates a potentially faulty unit and, if confirmed, the unit is replaced.

CIRCUIT BREAKER REPLACEMENTS FROM 2008 ONWARDS		
Type/Manufacturer/Model of circuit breaker	**Voltage**	**Project time frame**
SOV/Delle/HPGE	66 kV	2018
SOV/ASEA/HLD	132 kV	2020
SOV/ASEA/HLR	132 kV	2014
SOV/Sprecher/HPF	330 kV	2015
SF_6/M&G/FA2	330 kV	2019
SF_6/M&G/FA4	500 kV	2017
SOV/ASEAHLR	66 kV	Selected units
OIL/Magrini	11 kV	2016
SF_6/SIEMENS 3AS2	330 kV	Selected units
SF_6/SIEMENS 3AQ2	330 kV	Selected units

Static Var Compensators

The following SVC's are installed on TransGrid's system:

LOCATION	CONNECTED VOLTAGE (kV)	SVC VOLTS (kV)	RATING (MVAr)	COMMISSIONED
Armidale (1)	330	13.6	+280/-120	2000
Broken Hill (2)	22	22	+/-25 each	1986
Lismore (1)	132	26	+150/-100	2000
Sydney West (1)	330	18	+280/-100	2004

Thyristor controls on the older SVCs are based on a mixture of analogue circuits and digital controls, are no longer supported by the original suppliers and are failing. In SVC's the controls and thyristor valves are highly integrated and replacement of control systems normally also requires that valves are replaced at the same time.

The types of microprocessor based electronic control systems used on the more recently installed SVCs typically have a life limited to 20 years and it will be necessary to plan for possible control system replacement after that time, depending on the condition and reliability of equipment.

Gas Insulated Switchgear

The Gas Insulated Switchgear (GIS) located at Beaconsfield West was commissioned in 1979 and the manufacturer has indicated that the implemented technology is outdated and therefore the future availability of spare parts is not assured. There are also issues with difficult to manage SF_6 leaks and problems with the early two pressure type SF_6 circuit breakers incorporated in the GIS.

Replacement of the GIS is well advanced and the equipment will progressively be decommissioned as feeders are transferred onto the new GIS equipment that has been installed and commissioned.

330 kV and 132 kV GIS was commissioned at Haymarket in 2004 and new 132 kV GIS is to be installed at Rookwood Substation and Holroyd Substations during 2013-2014. These are two new sites forming part of the project to meet the future needs of customers in the inner metropolitan area of Sydney.

Shunt Capacitors

TransGrid has 123 shunt capacitor bank installations of various configurations ranging in voltage from 11 kV to 330 kV.

Unlike most other items of electrical equipment the condition of power capacitors cannot be monitored and hence the estimated life of these capacitors is expected to be between 25 to 35 years. Therefore existing capacitor banks are expected to be replaced because of normal life cycle deterioration at the rate of approximately 100MVAr per year.

Batteries and Battery Chargers

Every TransGrid substation and switching station contains a number of batteries and they provide a vital link in the reliable operation of the network. Different batteries are used for the substation protection/control schemes than for the communication schemes.

The majority of TransGrid's substation batteries are of the Nickel Cadmium type. There are a number of sealed lead acid types in use for communications applications.

Regular maintenance and condition checks are being carried out to ensure that all in-service batteries are kept in good condition. The batteries are replaced when their capacity drops below 70% and this generally occurs after 20 years of service. Battery chargers are normally replaced when spare parts are no longer available.

Surge Arresters

Earlier 'gapped' type surge arrestors were based on Silicon Carbide non linear resistors with air gaps inserted in series to obtain a sharp cut off for the device. Moisture ingress in these types of surge arrestor can lead to explosive failure.

Modern surge arrestors use a Zinc Oxide non-linear resistor with no gap and have a minimal maintenance requirement and a much lower chance of explosive failure.

Testing of 'gapped' type surge arrestors is required to identify possible moisture ingress. This is performed at 4 yearly intervals and failure in the interval between tests is possible. The possibility of water ingress and explosive failure also increases with deterioration of components exposed to weather.

To address the increasing risk of explosive failure of 'gapped' surge arrestors, a program is underway to replace of all of these units still in service.

Transformer Bushings

TransGrid has a bushing population of just over 2000 bushings. They are predominantly installed in transformers and reactors and are the means by which a high voltage conductor passes through earthed metal work. At voltages of 132 kV and above, high voltage bushings are usually of a condenser construction and generally take one of the following forms:

- → Oil impregnated paper;
- → Resin bonded paper (SRBP); and
- → Resin impregnated paper.

As is the case with any solid or liquid insulation, aging and degradation of insulating properties will occur as a result of prolonged electrical, thermal and mechanical stresses and it is these factors that will generally determine the life expectancy of bushings. Generally a service life of 30 years could be expected from bushings provided other factors do not come into play. SRBP bushings by the nature of their manufacture have a higher level of failure than the other types as a result of delamination of the layers and

void formation. These types of bushings will be progressively replaced.

Bushing failures often have far reaching effects that extend beyond the loss of the bushing itself as often a failure may lead to the loss of a transformer through fire.

Maintenance on bushings is generally integrated into the transformer maintenance and involves the measurement of DDF via a test point located on the flange.

Other Substation Plant

Other equipment such as disconnectors, earth switches, cables, light and power circuits, fire fighting equipment, security equipment and control systems are all monitored and refurbished or replaced as required.

Substation Property and Buildings

All buildings, fencing, roads, civil structures, drainage systems, landscaping, environmental buffer zones and other services are monitored and refurbished or replaced as required. Redundant buildings in need of extensive maintenance will be progressively demolished.

2. Transmission Lines

Routine Maintenance

A routine maintenance strategy is in place to ensure that all transmission line structures are regularly inspected. These inspections aim to detect component deterioration or defects such that remedial work can be undertaken to maximise the line safety and security, and minimise the risk of loss of supply.

Inspection cycles for each individual line are based on line location, form of construction, past performance, current condition and significance in the transmission system. All transmission lines are inspected from the air once per year to gain an overall assessment of condition and determine any visible defects or specific actions required outside regular vegetation management cycles.

A summary of maintenance requirements is shown in the following table:

CONSTRUCTION	TASK	FREQUENCY
Steel Tower, Steel Pole and Concrete Pole	Aerial Inspection	Annual
	Ground Inspection	1-3 yearly
	Foundation Inspection	6 yearly
	Lidar Inspection	1-3 yearly
	Thermographic Inspections	3-12 yearly dependent on line loading
	Aerial Photographic Inspection	5 yearly
Wood Pole	Aerial Inspection	Annual
	Ground Inspection	1-3 yearly
	Ground Line Inspection (UGI)	3-6 yearly
	Climbing Inspection	3-6 yearly
	Lidar Inspection	1-3 yearly
	Thermographic Inspections	3-12 yearly dependent on line loading
	Aerial Photographic Inspection	10 yearly

Inspections are scheduled to make the most efficient use of the inspection resources, such that the foundation, ground line or climbing inspections are carried out at a frequency that is a multiple of the ground inspection frequency for that line. Eg a two yearly ground inspection would lead to a four or six yearly UGI and climbing inspection for a wood pole line. This allows for the ground inspection to be carried out at the time of the UGI or climbing inspection by the same crew.

Easement Maintenance

TransGrid's easements are maintained on a periodic basis with return periods of up to six years. Areas where only limited clearing is allowed such as waterway crossings or other sensitive areas will be targeted for maintenance on a more frequent localised basis. The annual aerial inspection shall identify any out of the ordinary defects that require attention prior to the next routine maintenance. This method provides efficient programmed preventative maintenance in blocks of area rather than more frequent reactive maintenance in isolated pockets.

Replacement and Life Extension Strategies

As part of TransGrid's Asset Management Process, a number of emerging medium to long-term issues have been identified and detailed strategies have been developed to manage these emerging issues and extend the useful life of TransGrid's transmission lines.

Insulators

Widespread insulator type replacement has not been required on the TransGrid network for over a decade. There were families of insulators identified in that time where type faults and failures were occurring. Testing of these insulators identified elevated risks of failure, so the particular types were replaced.

More recent insulator issues have been related to corrosion of pins and caps with age due to coastal and industrial pollution, and possibly due to some corona effects. These items are readily identifiable from line inspections with enough lead times to program replacements as required to address the issue. The costs of electro-mechanical testing is generally equivalent to the cost of replacing around 10 structures worth of insulators with polymer long rod items during a short outage, so as visual deterioration signs become significant, they are programmed for replacement.

Steel Tower Ageing

Steel towers over 45 years are targeted for condition assessment to determine whether overhaul works are required to maintain serviceability. Items identified during these climbing assessments are deteriorating nuts, bolts, fittings, earthwire, conductor, steelwork, foundations and other items. These are classified in accordance with a photographic condition sheet, and life extension work is proposed, or the tower is assessed as requiring another condition assessment visit in a number of years.

It is expected that towers located west of the Dividing Range will generally not require any life extension work, and that the next inspection would be in the order of 15-20 years' time. Towers over 45 years old in more coastal environments are exhibiting varying degrees of corrosion from nuts and bolts to extensive steelwork surface corrosion.

Overhead Earthwire (OHEW) Replacement

Earthwire is replaced due to fault rating limitations, corrosion problems or for the installation of OPGW (OHEW with embedded optical fibre for communications).

Fault rating limitations have occurred on sections close to substations where fault levels have risen over time. As fault levels are identified as approaching the limitations of the earthwires, projects are raised to replace the affected sections of earthwire.

Galvanised steel earthwire close to marine or industrial environments suffers from accelerated corrosion. Amongst the most susceptible are some older lines in the Newcastle-Sydney-Wollongong region.

OHEW has been sampled from some locations where it is visibly pitted. Testing of these samples has shown that at this stage there is no significant reduction in the strength of these earthwires. As such, a watching brief continues as part of the 45 year and other climbing inspections, with more samples to be removed in the future where these inspections identify advancing corrosion. Where major line works are undertaken on a line with corroded earthwire, replacement of that earthwire as part of the work will be considered.

Steel Towers

Steel towers have an anticipated service life averaging around 75 years. It is expected that this life will be somewhat reduced for towers in coastal or corrosive industrial environments, to approximately 50 years. TransGrid has a number of towers in coastal environments that are showing significant signs of loss of galvanised coating and corrosion. 330 kV transmission line 11 Sydney South – Dapto is a coastal line constructed in the early 1960s with significant corrosion occurring on the tower steelwork and fittings. This line has commenced a life extension program involving painting with a zinc coating that has an expected effective life of 20-25 years. Due to various issues encountered during the work to date, reviews are underway to determine whether re-coating the entire tower is the most cost effective program for the life extension work. Most of the corroded nuts, bolts and fittings on this line have been replaced in preparation for steelwork life extension.

Other steel tower lines in coastal or corrosive environments showing loss of galvanised coating and progression of corrosion are 330 kV transmission lines in the Central Coast area from Sydney North to Newcastle, and other line sections constructed in the early 1960s around Liddell and Bayswater Power Stations. The specific issues and line condition assessment are being identified through the 45 year inspection programme.

Grillage Foundations

Early practice in steel tower construction, particularly where access was difficult, was to place a steel quadraped on the bottom of each tower leg and back fill with earth. Over time, the reaction between the soil and the buried steel has corroded the zinc coating away and then the steel of many foundations. Early strategies focussed on encasing the leg with concrete to prevent further corrosion. Sacrificial anodes were then installed on all structures with grillage foundations over the period since 1996.

New testing methods have been documented to determine the condition of sacrificial anodes. Results are showing that some of the anodes in more aggressive locations are depleted. Better methods are continuing to be developed to clarify the requirements for the number of anodes required at each location to provide adequate protection into the future when anodes require replacement. Anodes that are identified as deteriorating are scheduled for replacement in accordance with the maintenance procedures.

Wood Poles

Wood poles are generally replaced following detection of significant defects during routine maintenance. In the past less than 1% of the overall pole population has been replaced each year.

On some specific lines, however, the defect rate has increased to a level where it is no longer cost effective to detect the defective poles by inspection prior to failure, or where it becomes economic to undertake large-scale replacements to extend the useful life of the line. The principal causes of these accelerated defect rates are wood decay due to rot generally at ground line, and the impact of termites. TransGrid has almost completed the replacement of all structures that were up rated in the 1970s by addition of a timber pole section attached to the top of existing poles with a steel cylinder. These structures were susceptible to wood rot in the area of the cylinder, leading to premature pole failure.

A strategy has been implemented to establish replacement projects for nominated lines to replace all wood poles with steel or concrete. The timing of each project and rate of replacement shall take into account rate of defect, funding requirements, availability of outages, availability of local resources and projected system augmentations. It is expected that these replacement projects will progress with the holding of sufficient replacement poles of suitable sizes and strengths to allow for the replacements as poles are identified to be deteriorating through routine underground or climbing inspections.

In the five year period these lines include:

- → 94B Wellington – Beryl 132 kV
- → 96H Coffs Harbour – Koolkhan 132 kV
- → 99J Yanco – Griffith 132 kV
- → 99F Wagga – Yanco 132 kV
- → 970 Yass – Burrinjuck 132 kV

In addition to these lines, 944 Wallerawang – Orange 132 kV has been scheduled for a complete rebuild due to its condition. This line will be rebuilt with new concrete structures, new conductor and OHEW.

Concrete Poles

It is expected that concrete poles will have a significantly longer service life than wood poles. These poles have generally not had sufficient service life to require the establishment of life extension strategies. Corrosion of fittings, cross arm bracing and pole steps are likely to be the issues that will determine the service life and life extension strategies.

In the Griffith area, one of the first installations of a concrete pole transmission line was made in the irrigation area. Condition assessments have identified that there is corrosion of the steel reinforcing occurring on some of these poles. It is anticipated that these poles that were installed in this highly corrosive area will need to be replaced within the next 10 to 15 years on a defect basis.

Aerial Laser Surveys

TransGrid has surveyed all transmission lines using Aerial Laser Surveys (ALS). The results of the ALS showed that under the most onerous operating conditions a number of spans may infringe design clearances. As a result of the surveys, there is a requirement to address any issues identified through a variety of methods ranging from simple insulator rearrangements through re-tensioning of sections to complete replacement of structures. This work is being addressed utilising a prioritised list of lines with greater numbers of infringing spans and in areas that are more likely to be frequented by the public. Public risk mitigation strategies have been undertaken in areas where clearances may be reduced in normal operating conditions.

Aerial Marker Balls

Aerial Marker Balls have been installed on all TransGrid spans as required by AS3891.1 during a programme in 2011-12. Some spans were impractical for installation of marker balls as they were too steep to access the earthwires by helicopter. The risks associated with these limited locations are minimal, as the line is generally adjacent to a cliff at these locations and pilots should not be flying in close proximity to those locations.

Waterway Crossings

Roads and Maritime Services issued a new Electricity Industry Code in August 2008 for the Crossing of Navigable Waterways by electrical infrastructure.

The primary purpose of this Code is to promote navigation safety outcomes, reduce safety risks to waterway users and the protection of property, including electricity supply.

The Code is, therefore, a guide to owners of infrastructure that crosses waterways (crossing controller) for promoting navigation safety outcomes when planning, installing, maintaining and modifying existing crossings.

The Code is based on a risk management matrix that considers site conditions such as usage patterns, vessel height, water levels, electrical clearances and visibility.

All new crossings take into account the risks posed by the proposal and provide solutions so that the crossings do not pose unacceptable risks to navigation safety. The solutions may include the installation of signage, an alternative type crossing (such as submarine crossing) or the re-routing of the overhead proposal.

Special provisions have been included for existing crossings and risk assessments have been completed for all crossings identified where signage was required to be upgraded to meet Roads and Maritime Services requirements. All high priority signs have been installed and there are 6 low priority signs left to be installed by March 2013.

Emergency Structures

TransGrid, and other TNSPs, hold emergency transmission line structures to restore structures that have been damaged by events such as vehicle impact, severe storm events, vandalism or sabotage.

TransGrid have steel pole emergency structures for single circuit lines in readily accessible sites. These have served TransGrid satisfactorily primarily due to failures having occurred in these locations and with adequate backup provided by parallel circuits during the restoration period.

It is recognised throughout the industry that there is an increased risk to the interconnected National Electricity Market following a failure. It has been agreed between all TNSPs to each hold and maintain an Emergency Restoration System that has common components and that can be shared in the event of a major emergency. The system is based on guyed masts that can be erected rapidly in many configurations to suit the different line designs. This system continues to be implemented and supported in TransGrid.

3. Underground Cables

TransGrid has two 330 kV power cables supplying the Sydney Central Business District. These are the only high voltage cable systems TransGrid has installed in public areas. Both cables are of a paper and insulating fluid insulation system.

Cable 41 Sydney South – Beaconsfield West was commissioned in 1979. The cable and cable accessories were manufactured and installed by Sumitomo from Japan.

Cable 42 Sydney South – Haymarket was commissioned in 2004. The cable and cable accessories were manufactured and installed by J-Power Systems from Japan.

Routine Maintenance

Routine maintenance is carried out in accordance with TransGrid's Underground Cable Assets Maintenance Policy. The key details of this policy include:

- Cable route patrol and maintenance;
- Reading and recording of cable fluid pressure gauges;
- Checking of accuracy of cable pressure alarms;
- Sampling and testing of cable fluid;
- Inspection of cable sealing ends;
- Testing of cable outer sheath and link box maintenance;
- Monitoring of joint movement; and
- Monitoring and maintaining cable tunnels and accessories.

The frequencies of these activities are set out in the Policy.

Non-Routine Maintenance

Due to the nature and location of the underground cables in public roads and footways, various defect repairs and modifications not covered by routine maintenance are carried out. These need to be assessed on a case-by-case basis.

Asset Renewal Projects

Cable 41 Condition Assessment

TransGrid and external cable specialists have conducted a condition review of Cable 41. Fully dried out thermal resistivity (TR) results of backfill and bedding at various locations along the cable route were found to be much higher than designed. Ground temperatures measured by the Cable 42 Cable Monitoring System (which follows a similar route to Cable 41) were found to be higher than what was assumed for the design of Cable 41.

The rating of the cable if all worst case scenarios aligned was determined to be unacceptable for reliable grid operation. However, it is unlikely that all beddings, backfill and surrounding soil would ever fully dry out. Finite element analysis of a partially dried model shows a 13% reduction in summer rating. The rating reduction may result in augmentation projects having to be brought forward. A temperature monitoring system is also being used to provide improved cable ratings and maintain circuit reliability.

Oil System Modifications

On cable 41, remote on-line monitoring of oil pressure has been trialled. The trial has been successful, however the oil pressure transducers used do not provide adequate resolution for differential pressure monitoring. With further work and improved resolution transducers, a differential (phase to phase comparison) pressure alarm system can be implemented which is expected to be considerably more sensitive than the current absolute pressure system. Further work is proposed on this system.

Civil Works

The cable 42 tunnel from Sydney Park to Haymarket was put into service prior to all works being completed to achieve the required 100-year design life. A water treatment plant to replace the temporary oil and solids separator for the treatment of water pumped from the tunnel has been installed. When fully commissioned, the plant will discharge treated water to stormwater and remaining solids to the sewer.

A number of items are still outstanding to ensure the tunnel has a reasonable life span.

These include:

- Improved tunnel drainage systems that are not susceptible to clogging from solids;
- Improvements to the pumping system; and
- Lining works to minimise the ingress of water and the stabilisation of the rock surrounding the tunnel.

These items are included in a capital life extension program for the tunnel and will be completed after the installation of the Haymarket to Sydney Park cable.

4. Protection Schemes

Routine Maintenance

The routine maintenance policy determines the frequency and extent of maintenance required for a given relay type. A summary is given in the table below:

PROTECTION SCHEME	CATEGORY	MAINTENANCE REGIME
Distance	Numerical Self-Checking	6 yearly full routine maintenance Annual in-service auto-reclose checks (for 330 kV & above circuits)
	All others	6 yearly full routine maintenance 3 yearly performance check Annual in-service auto-reclose checks (for 330 kV and above circuits)
Transformers and Reactors	All	4 yearly full routine maintenance
Busbar	Numerical Self-Checking	6 yearly full routine maintenance
	All others	6 yearly full routine maintenance 3 yearly performance check
Other Protection Schemes (e.g. SVCs and capacitors)	Numerical Self-Checking	6 yearly full routine maintenance
	All others	6 yearly full routine maintenance 3 yearly performance check

Non-Routine Maintenance

Relays used for the protection system are inspected and tested on a routine basis and where failures or problems are found an investigation is carried out. Subject to the results of the investigations, relays will be replaced, modified or monitored under a "watching brief".

Capital Replacements

A number of staged replacement programs for protection relays are currently scheduled to allow significant improvements to the maintenance, performance and functionality of this equipment on the network.

In the short term (five years), these staged programs form the initial steps in the replacement of selected relay types on the network.

In the medium term, trials have commenced for performing complete secondary system replacements at sites where the majority of secondary systems equipment is scheduled for replacement, or the overall secondary systems equipment condition is assessed as approaching the end of its serviceable life.

The following criteria are considered and priorities established on the basis of:

- Relay age;
- Relay failure rates – including history of particular relay mal-operations and the impact on system performance;
- Relay location and criticality in the network – including speed and performance of relays and their "fitness for purpose";
- Manufacturer support;
- The availability of spares and appropriate maintenance tools;
- The ability to repair a relay and the cost of repair; and
- Relay routine and fault maintenance costs.

To allow a projection for the number of replacement schemes to be developed, the following assumptions have been made:

- All main protection relays will be progressively replaced over a 15 year period. This is to improve the reliability of protection relays and to increase functionality through remote interrogation (LAN connectivity), GPS clock synchronisation, internal circuit breaker fail, fault recording and event logging. It will also simplify panel designs and reduce maintenance requirements;
- Relays will be replaced on a priority basis according to the criteria identified above;
- Existing relays not targeted for replacement in the period 2013 to 2018 continue to perform satisfactorily;
- Appropriate resources are available to perform replacement programs;
- The expected life of new relays is estimated at between 15 to 20 years; and
- Repair of these new relays is possible during their 15 to 20 year lifetime.

With consideration given to these assumptions and TransGrid's existing relay population, estimates for the replacement program have been developed. These estimates are based on the following action plan:

- Relays that can no longer be supported due to lack of manufacturer support, inadequate spares and/or poor service condition or performance will be progressively replaced in the period 2013-2018;
- The remaining relays will be assessed every 5 years for suitability for replacement as part of the preparation of 5 yearly protection asset replacement plans and budget proposals;
- The new relays will themselves need replacement from about 15 years of age; and
- Overcurrent relay functionality will be incorporated into the primary relay replacements.

Other strategies being implemented include:

- Upgrading of fault recorder equipment;
- GPS clock synchronisation of protection relays equipped with this functionality;
- Ethernet connectivity of protection equipment to substation condition monitoring data servers to permit web-based reviews of relay and fault recorder fault/system disturbance data; and
- Further development of newer testing methods incorporating scheme testing to improve maintenance techniques and reduce operating costs.

5. Metering Installations

Routine Maintenance

TransGrid is a registered Metering Provider (Category B) under the National Electricity Rules, qualified to design, install, maintain and repair revenue and check metering installations. All National Electricity Market (NEM) metering installations are maintained and tested in accordance with the requirements of the National Electricity Rules.

A summary of the routine maintenance performed for the primary metering equipment is given in the table below:

METERING EQUIPMENT	CATEGORY	MAINTENANCE REGIME
Revenue Meters	Electronic	5 yearly calibration check
	Induction Disc	2.5 yearly calibration check (5 yearly for Type 3 & 4 metering installations)
Check & Statistical Meters	All	5 yearly calibration check
Dataloggers	All	4 monthly pulse checks
Transducers	All	5 yearly calibration check
CTs and VTs	Used in NEM installations	10 yearly calibration check
Metering Installations	Independent Checks	2.5 yearly
	Inspections	2.5 yearly

Non-Routine Maintenance

NEM metering installations are constantly monitored for performance to ensure compliance with the accuracy and data integrity requirements of the NER. Defects and data problems are quickly detected and promptly fixed to ensure accurate metering data is always available for the settlement of the National Electricity Market.

Capital Replacements

Replacement plans for metering equipment need to cater for the evolving needs of both regulated and unregulated customers in the National Electricity Market. Customer requirements and technological advances will determine what level of metering performance is acceptable. Meters that are now considered of modern design may become functionally inadequate within a relatively short period of time.

Regulated metering equipment will typically include panels, transducers and statistical meters providing operational and network planning data. Unregulated metering equipment generally includes revenue (and check) meters, RIMs and telecommunications equipment (phone services) used to collect and transfer metering data for the settlement of the National Electricity Market.

Strategies for replacing unregulated metering equipment will largely be determined by the financially responsible market participant (customer) and are therefore beyond the scope of this document, except where all secondary systems equipment is being replaced at a site as part of a regulated control room replacement or substation rebuild project.

Traditionally, the replacement of metering equipment has largely been driven by three main criteria:

1. The inability to repair equipment that has failed in service due to lack of spares and support from the manufacturer;
2. New National Electricity Market metering (NER) functionality requirements; and
3. The need to keep up to date with technological developments and the utilisation of these advances in the most efficient manner.

In the short term (five years) the replacement program for regulated metering equipment has been developed on the basis of:

- Equipment condition and performance;
- Failure rates;
- The ability to repair the equipment and the cost of repair. (Dependent upon the availability of spares and manufacturer support); and
- Metering equipment compliance with National Electricity Rules requirements.

The following assumptions underpin the planned replacement strategy:

- All main meter types will progressively be replaced over a 15 year period;
- Meters and transducers will be replaced on a priority basis according to the criteria identified above;
- Transducers may also be replaced as part of control system upgrades and bay refurbishment programs;
- New metering panels will be installed where all or the majority of meters at a site are targeted for replacement, or where older proprietary rack mount systems are used that are not compatible with the meters available on the current meter period orders;
- Existing meters and transducers not targeted for replacement in the period 2013 to 2018 will continue to perform satisfactorily;
- Appropriate resources are available to perform replacement programs; and
- The expected life of new meters and transducers, and their suitability (fitness for purpose) is estimated at between 15 to 20 years.

With consideration given to these assumptions and TransGrid’s existing metering equipment populations, estimates for the replacement program have been developed, based on the following action plan:

- Metering equipment that can no longer be supported due to lack of manufacturer support, inadequate spares and/or poor service condition or performance, or that no longer comply with National Electricity Rules requirements will be progressively replaced in the period 2011-2019;
- The remaining metering equipment will be assessed every 5 years for suitability for replacement as part of the preparation of 5 yearly metering asset replacement plans and budget proposals; and
- This new metering equipment will need replacement from about 15 years of age.

6. Communication Equipment

Routine Maintenance

Routine maintenance is carried out where appropriate to ensure reliable performance of communication systems.

A summary of some of the key routine maintenance periods is shown in the table below:

COMMUNICATION PLANT ITEM	MAINTENANCE PERIOD
Digital Microwave	Nil required
PDH Microwave & VHF Antenna & Feeders	Annually
Line Traps & Secondary Coupling	6 yearly
PLC Intertrips	3 yearly
VF Intertrips	3 yearly
Radio Sites	Quarterly to annually – site dependant
Optical Systems including PCM	3 yearly
VHF Repeater and Link Equipment	Annually
Control Systems	Nil required
OPGW Fibre	6 monthly

Non-Routine Maintenance

Non-routine maintenance is carried out as required in order to achieve a communication systems availability target of 99.5%. Fault repair and equipment replacement is prioritised with regard to the severity and impact of the fault.

Major Operating Projects

Communication Property and Buildings

All buildings, fencing, roads, civil structures, drainage systems, radio towers and other services are monitored and refurbished or replaced as required. Redundant buildings in need of extensive maintenance will be progressively demolished.

TYPE OF WORK REQUIRED	ESTIMATED NUMBER OF SITES/YEAR
Repair and Paint Repeater Site Buildings	15 sites/5 years
Repair and Paint Communication Room Buildings	15 sites/5 years
Repair Radio Tower Structures	15 sites/5 years
Repair/Replace Fences and Gates	4 sites/5 years
Repair Roads	10 sites/5 years

Bay Alarms

Each communication room marshals individual alarms from equipment and displays them as an audible and visual display. This is achieved by Bay Alarm Systems. The Computer Alarm System (CAS) is used throughout the network to provide this service. Version 2 using Beckoff I/O of the CAS is a microprocessor-based system that provides remote interrogation and control facilities. It is able to span multiple buildings over fibre optic cable.

Version 1 of the Bay Alarm Systems has been in operation for 10 years, components are no longer available and the system cannot span multiple buildings. As such has version 1 of the CAS has reached the end of life. Version 2 CAS is expected to remain in service for the foreseeable future.

Backup Alarm Systems

SMART Alarm transceivers have been installed as the backup alarm system. They provide a 10-function alarm service in both transmit and receive directions and have been designed to interface with all of TransGrid's communications channels. SMART alarms currently account for the entire population of backup alarm systems in the network.

This system has an expected life of 20 years and at present there are no performance issues.

Power Line Carrier (PLC)

Approximately 60% of the population of PLC systems are Dimat, 10% ABB and the remaining 30% are Fujitsu systems. The majority of older Fujitsu Power Line Carrier systems on TransGrid's network have been replaced in the past 5 years.

A program was commenced in 2006 to remove Fujitsu PLC systems from the network and is currently ongoing, with a view to replace all the existing units by the end of the 2016 financial year.

The numbers of systems planned for replacement are as follows:

PERIOD (YEARS)	PLC REPLACEMENT SYSTEMS/YEAR
2014	6
2015	7
2016	6
2017	5

Power Line Carrier Protection Intertrip Systems

Approximately 70% of the population of PLC voice systems are Dimat and the remaining 30% are Fujitsu systems. The majority of older Fujitsu Power Line Carrier voice systems on TransGrid's network have been replaced in the past 5 years.

A program was commenced in 2004 to remove these systems from the network and is currently ongoing, with a view to replace all the existing units by the end of the 2018 financial year.

The numbers of systems planned for replacement are as follows:

PERIOD (YEARS)	PLC INTERTRIP REPLACEMENT SYSTEMS/YEAR
2014	18
2015	10
2016	10
2017	10

VF Protection Intertrip Systems

There are two main types of Voice Frequency Protection Intertrip Systems in use on TransGrid's network. These are the Fujitsu and Dewar systems.

The Fujitsu systems were manufactured prior to 1987 and are no longer supported by the manufacturer.

A 20 year replacement program for the Fujitsu systems commenced in 2006. The Dewar VF systems are currently supported by the manufacturer and have an expected life of 25 years. These systems are expected to be replaced from about 2018 at the rate of 6 systems per year.

The number of Fujitsu systems planned for replacement is as follows:

PERIOD (YEARS)	VF INTERTRIP REPLACEMENT SYSTEMS/YEAR
2014	8
2015	8
2016	8
2017	8

Telephone Equipment

In 2009 TransGrid's telephone network was divided into two parts:

- → A Voice Over IP (VoIP) business telephone network supporting the 7 manned business centres; and

- The Operational Telephone Network (OTN) servicing all substations.

The Ericsson OTN installed in 2011 is fit for purpose with replacement planned for 2020.

Microwave Radio Network

Under projects due for completion in 2013, all backbone microwave systems are being replaced with Sagem systems. This equipment is supported by the manufacturer and has an expected life of 10 years.

Spur microwave systems are planned for replacement in 2013-2014.

Optic Fibre Network

TransGrid has three major overhead earth wire optical fibre networks that provide all major backbone communication bearers.

The Fujitsu OLTE and FSX equipment is being replaced in 2013 by Sagem equipment. This new equipment has an expected life of 10 years.

VHF Radio Network

TransGrid's radio network consists of fixed repeaters and links, and a mobile fleet installed in vehicles or as desk stations.

The fixed repeaters and links consist of Midland Transceivers. This equipment was manufactured in 1997 and is supported by Exicom and is expected to provide service till the year 2020.

The mobile fleet and desk base stations are Tait 2000 series transceivers. This equipment was manufactured in the early 1990s and is supported by Tait. Current spares are adequate to continue services till 2018.

Repeater Site Ancillary Equipment

TransGrid's repeater sites require ancillary equipment to provide site services.

These services are:

- **Batteries at each site**
  Sealed lead acid batteries have a life of approximately 10 years and are replaced as and when required.
- **Battery Charger**
  Chargers at each site range between 12V, 24V or 50V. They have a life of approximately 30 years and are replaced as and when required.
- **Air Conditioners**
  Air Conditioners at each site are either wall mount or split units. These units run continuously for up to 24 hours a day. The life cycle is 5 to 10 years determined by location. They are replaced as and when required.
- **Feeders and Antennae**
  Aerial feeders and antennae provide transmission medium for microwave and VHF services. The life cycle is 10 to 20 years determined by location. They are replaced as and when required or when systems are replaced.
- **Cabling**
  Cabling consists of power, alarm and service wiring. Location and possible rodent damage determine the cabling life cycle. They are replaced as and when required.

TYPE OF WORK REQUIRED	ESTIMATED NUMBER OF SITES/YEAR
Battery and Charger Replacement	20 sites/5 years
Air Conditioning	32 sites/5 years
Antennae and Feeders	16 sites/5 years
Cabling	4 sites/5 years

SCADA Outstations

TransGrid has several different types of remote terminal units (RTUs) in-service that are used to provide data acquisition and supervisory control functions. These RTUs are installed in substations, power stations and other assets.

Following the completion of the ABB SCADA project, a replacement program was initiated to replace the existing Toshiba RTUs with Logica and Serck RTUs. This program is expected to be completed by the end of the 2014 financial year.

Over the period covered by this Plan the existing MITS MD1000 control equipment (which was installed in the early 1990s) is planned to be replaced, as this equipment is no longer manufactured or supported. The number of units to be replaced is as follows:

PERIOD (YEARS)	CONTROL EQUIPMENT REPLACEMENT SITES/YEAR
2014	10
2015	10
2016	10
2017	10

In addition to the MITS replacement program, orphan control systems installed at Gadara, Balranald, Molong and the Armidale SVC (all built as turnkey projects in 2000) are to be replaced during the period covered by this Plan.

4.2.3 Environmental Strategies

To assist TransGrid to protect the environment in which it operates TransGrid has had in place an Environmental Management System accredited to ISO 14001 since 1996. TransGrid is committed to conducting its activities and services in a manner that minimises pollution and complies with relevant environmental legislation, industry standards and codes of practice.

TransGrid aims to enhance its systems and processes in a manner that promotes continuous improvement in environmental management and which will lead to the achievement of industry best practice.

By working in partnership with communities, non-government organisations and landowners, TransGrid is protecting and enhancing the environment in which it works.

Impacts of Climate Change

TransGrid has in place a Management of Climate Change procedure which considers:

- The impact of climate change upon the organisation;
- TransGrid's contribution to the impacts of internal and external stakeholder management issues; and
- The strategies for TransGrid to enable innovation, management and adaptation to climate change.

The strategy defines nine initiatives TransGrid is taking to respond to climate change:

- → Assess the impacts of climate change on the transmission network and its performance;
- → Reduce TransGrid's network and non-network greenhouse gas emissions;
- → Reporting of our greenhouse gas emissions;
- → Identify and respond to the opportunities and impacts associated with a carbon pollution reduction scheme and/or energy efficiency trading scheme;
- → Remain informed of community, political and regulatory developments and adjust policy accordingly;
- → Proactively inform and educate employees about climate change and actions TransGrid is taking to respond to it;
- → Identify how climate change will impact upon our customers and customer base and manage accordingly;
- → Create the necessary internal environment to ensure that TransGrid encourages innovative practices; and
- → Periodically review strategic implementation to ensure that TransGrid remains adaptable.

Environmental Aspects of Substations and Premises

Substations may impact on the environment through their visual appearance, noise emission or escape of oil. Also any work activity proposed to take place at a substation or premises could potentially affect the environment. This particularly applies to water discharges, vegetation clearance and other work requiring chemical handling or which generates industrial or hazardous waste.

Therefore, to reduce any potential impact on the environment, TransGrid substations are designed and sited to minimise their impact. All sites have environmental response systems and emergency response plans designed to ensure that, in the event of equipment failure, the surrounding environment is unaffected. Major oil-filled plant, such as transformers, are located within bunds. Secondary, and on some sites tertiary oil containment systems are installed, to prevent the escape of oil from the substation to the surrounding environment.

Noise emissions from transformers are reduced by construction of suitable enclosures or walls where necessary. In recent years, air-blast circuit breakers have been replaced with quieter SF_6 circuit breakers.

To reduce any potential impact on the environment by works programs at a substation or premises TransGrid substation staff are trained to TransGrid's Environmental Rules for Premises. These rules require that an environmental impact assessment (EIA) for maintenance activities to be undertaken before any work takes place. The EIA takes into account all possible matters that could or are likely to affect the environment by reason of that activity.

Environmental Aspects of Transmission Line Easements and Access Tracks

Before construction of a new transmission line, extensive community consultation takes place.

An environmental impact assessment is prepared, which assesses all the known possible environmental impacts of the construction and the operation of the line following construction. The assessment is publicly exhibited and submissions from interested parties are encouraged. A program for managing construction and maintenance of the line following construction is then implemented, based on the findings of the environmental impact assessment and submissions received.

For any existing transmission line, any work activity proposed to take place on the transmission lines, easements, and their associated access tracks could potentially affect the environment. This particularly applies to easement vegetation control, access track maintenance, erosion works and other work requiring excavation or soil disturbance.

To reduce any potential impact on the environment by works programs associated with a transmission line, its easement or associated access tracks TransGrid mains and easement staff plus TransGrid vegetation management and access track maintenance contractors are trained to TransGrid's Environmental Rules for Easements, Underground Cables and Access Tracks.

Procedures for maintenance of transmission line easements have been developed with the aim of minimising environmental impacts and a series of 13 brochures have been developed in conjunction with Greening Australia 'Easement Planting with Native Birds in Mind' identifying low growing native species to assist land holders around the state to select plants for safe and environmentally suitable revegetation of electricity transmission line easements.

TransGrid has also designed Geographical Information System databases to maintain all relevant environmental information about each easement, including the location of rare and threatened flora and fauna species and habitats, protected lands and rivers, archaeological relics, heritage sites and property owner requirements.

4.3 Asset Disposal Strategies

4.3.1 Introduction

Assets are of operational value to TransGrid only in so much as they continue to effectively support the delivery of the required service. Once these assets no longer provide the required level of service their worth lies only in the benefits to be gained from their disposal.

Asset disposal is therefore the final stage in the asset life cycle and its proper planning and management is an integral part of TransGrid's Network Management Plan.

TransGrid's asset disposal strategies mainly encompass two broad types of assets. The first involves real property holdings and the second involves general assets such as buildings, structures, plant and equipment.

Although real property assets normally have high values and their disposal often involves more complex planning and financial issues, the general disposal processes followed within TransGrid are very similar to the disposal of all other asset types. Therefore this section of the Network Management Plan outlines these general disposal strategies.

4.3.2 Asset Disposal Planning

TransGrid's asset disposal planning involves a detailed assessment of those assets identified in the planning/capital investment strategies and asset management strategies that are no longer required, or no longer effectively meet their service delivery outputs at the lowest long term cost to TransGrid. This allows TransGrid to cull redundant assets that might otherwise reduce efficient and effective service delivery.

Disposal planning incorporates two separate elements:

- → The detailed assessment of assets identified as surplus; and
- → The analysis and implementation of the physical disposal of the assets.

An asset is identified as surplus when one of the following occurs:

- → The asset is not required for the delivery of service, either currently or over the longer planning time frame;
- → The asset becomes uneconomical to maintain or operate which could be due to advances in technology, social expectations, changing demographic patterns or the economies of scale made possible by new service capacity; or
- → The asset wears out or becomes uneconomical to repair or refurbish.

Once an asset is identified as surplus, its physical disposal will depend on one or more of the following:

- → Whether or not there are net disposal benefits to TransGrid, either in financial or other terms such as management, supervision and storage;
- → Whether or not there are secondary (non-core) service obligations associated with the asset which dictate its retention, for example heritage, open space or other social environmental considerations;
- → Whether or not disposal can be carried out without adverse impacts on the physical environment;
- → Compliance with any legislative requirements or Chemical Control Orders such as for Asbestos and Polychlorinated Biphenyls (PCBs); or
- → Whenever it is considered likely that under-utilised or surplus assets may be of significant value to other agencies such as NSW DNSPs, such agencies are advised of the asset's availability.

4.3.3 Asset Disposal Strategy Process

TransGrid's asset disposal strategy process is a structured and systematic process aimed at ensuring the asset portfolio comprises only assets that effectively meet their service delivery requirements at the lowest long term cost. The processes involved are therefore directly linked with TransGrid's service delivery strategies, TransGrid's planning/capital investment strategies and TransGrid's asset management strategies.

The disposal strategy has five discrete stages, the main aspects of which as are follows:

Stage 1 – Assessment in detail of those assets identified by the planning/capital investment and asset management strategies as being surplus to service delivery requirements.

Stage 2 – Assessment of the advantages or otherwise to TransGrid, TransGrid's shareholders or the community in divesting the surplus assets.

Stage 3 – Identifying any opportunities for increasing asset value.

Stage 4 – Identifying related disposal requirements (auction, tender, private treaty or scrap) and processes including probity requirements.

Stage 5 – Preparing and implementing an appropriate disposal plan that satisfies all safety and environmental requirements.

The majority of TransGrid's aged surplus assets are normally scrapped or sold for material salvage and depending on the materials used in the design and construction of the assets a number of procedures have been established to facilitate this process. Many of these processes are contained within TransGrid's waste management procedure.

4.3.4 Waste Management

TransGrid's Waste Management procedure has been established in accordance with both NSW and Australian legislation requirements and is closely related to the NSW Waste Avoidance and Resource Recovery Act, 2001. This involves the appropriate disposal methods for various waste and materials, the licensing of TransGrid sites and facilities and direct dealings with the Environmental Protection Authority.

All potentially hazardous waste is required to be tested and classified before disposal is undertaken.

Within TransGrid, specific asset disposal strategies concerning certain types of materials include the following:

Disposal of Polychlorinated Biphenyls (PCB)

The NSW PCB Chemical Control Order 1997 requires that:

i) Owners of PCB contaminated materials must carry out a survey by 1st January 1999 to identify items of equipment and articles containing PCB. TransGrid has completed this task.

ii) Concentrated PCB material (i.e. PCB greater than 10%) must be removed from priority areas within two years of completing the survey, and from other than priority areas within five years of completing the survey. TransGrid completed the removal and destruction of all concentrated PCB materials (1,155 tonnes) by January 1999.

iii) Scheduled PCB material (i.e. PCB greater than 50 ppm) must be removed from service, or processed in-situ to reduce the PCB concentration below 50 ppm, within five years of identification. TransGrid has completed the removal and destruction of all scheduled PCB materials as identified in the survey undertaken in accordance with the Chemical Control Order. However, isolated cases of plant that could not be sampled without destruction have subsequently been identified as scheduled PCB waste. In concurrence with the Department of Environment, Climate Change and Water (EPA) these


newly identified items are scheduled for priority removal in accordance with the disposal process within the Chemical Control Order.

iv) Non-scheduled PCB materials (i.e. PCB less than 50 ppm) are not required to be removed from service within any legislative time-frame. However once removed from service appropriate disposal methods are required.

TransGrid maintains a number of contracts for the disposal of PCB contaminated oil and solid waste of varying contaminations.

Disposal of Chemical Fluid Dow C4

One of the non-PCB fluids introduced for power capacitors in 1980 was the chemical "Dow C4" and within TransGrid 23 capacitor banks contain this fluid (total of 763MVAr). This fluid is considered a hazardous waste and appropriate handling and disposal methods are used to manage the associated risks.

At present, failed capacitor cans are being stockpiled and disposed when the quantity becomes viable.

A number of Dow C4 contaminated capacitor banks are planned for replacement over the period of this Plan for condition reasons, and their disposal will be incorporated into the replacement project.

TransGrid has developed a specific Waste Management Work Instruction for the disposal of Dow C4 contaminated equipment.

Disposal of Batteries

TransGrid has quantities of large station and communication batteries that comprise Lead Acid or Ni-Cad. These batteries have a normal life span of approximately 20 years and their retirement is determined by the asset management strategy and battery maintenance procedures.

Disposal of Ni-Cad batteries is a requirement of TransGrid's procurement specification for batteries and thus forms part of the contract. The old Ni-Cad cells are returned to Australian manufacturer's works for shipment overseas for recycling. The entire process is carried out in accordance with the relevant dangerous goods and environmental regulations.

Similarly, return of lead acid type batteries is included in the procurement specification, although the recycling is carried out in Australia. Where a requirement for disposal cannot be aligned with a replacement, a one-off order will be placed subject to the same controls.

TransGrid has developed a specific Waste Management Work Instruction for the disposal of Lead Acid and Ni-Cad batteries.

Disposal of Chemically Treated Wood Poles

TransGrid has a large number of wood poles as part of its transmission network. The pole butts have been treated with preservative chemicals to reduce the impact of rot and termites on pole strength. When wood poles are replaced, the disposal of this treated wood needs to be carefully managed as some of these chemicals are considered hazardous under the NSW Scheduled chemical wastes chemical control order 2004 (e.g. DDT, dieldrin, heptachlor, alderin, benzo-a-pyrene have been used in previous times).

The wood poles can be recycled into timber building products. TransGrid maintains a contract for the disposal of wood poles including contaminated pole butts of varying contaminates. TransGrid is responsible for testing and classifying the contaminated pole butts before they are removed from site and sent for disposal.

TransGrid has developed a specific Waste Management Work Instruction for the disposal of redundant wood poles.

Other Waste Materials

For all other waste materials generated as a result of any asset disposal process, the relevant TransGrid Waste Management Work Instruction must be followed. This procedure provides staff with a simple way of identifying the specific processes required for the storage, transportation and disposal of waste in a manner compliant with environmental legislation. The information provided applies to all TransGrid workplaces where waste is generated, stored, handled or transported.

Chapter 2: Customer Installation Safety

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1. Introduction

TransGrid's transmission network is connected to electricity distributors, other transmission network operators, generators and direct connected customers.

This Chapter of the Network Management Plan describes requirements for direct connected customers with a nominal voltage level below 132 kV. TransGrid has three direct connected end use customers, being:

- Tomago Aluminium Company at Tomago – 330 kV;
- Norske Skog Paper Mills at Albury – 132 kV; and
- Visy Pulp & Paper Pty Limited at Gadara – 132 kV and 11 kV.

Of these, only one of the connections to Visy Pulp & Paper Pty Limited at Gadara is connected at a nominal voltage level below 132 kV.

All direct connected customers have current connection agreements with TransGrid. The agreements specify TransGrid's and the Customer's obligations to maintain the equipment in an appropriate state for safe operation.

2. Design, Construction and Maintenance Standards

All connections to TransGrid's network must comply with the National Electricity Rules. In addition, Gadara substation was originally constructed by TransGrid, and therefore was designed according to TransGrid's design standards.

TransGrid connection agreements specify that equipment must be maintained in a manner and to a standard consistent with good electricity industry practice, as defined in the National Electricity Rules. Both TransGrid and direct connected customers must retain maintenance records that may be audited.

Records of testing, outage plans and operating procedures are also maintained.

3. Testing, Connection and Notification Criteria

All equipment to be connected to TransGrid's high voltage network is commissioned in accordance with TransGrid procedure Network Alterations – Operational Requirements – GD SO G2 001. This procedure provides guidelines, checklists, notification requirements and responsibilities for customers and TransGrid to ensure the safe initial connection of equipment.

4. Inspection Regime and Procedures to Remedy Faulty Work

Upon identifying a deficiency in the performance within the customer's site, as measured against the minimum performance specified in the connection agreement, TransGrid may require corrective action to be taken by the customer within a specified timeframe. There are provisions in the connection agreement to consider whether suspension is required (such as when there is risk of damage, loss of injury to persons or property) or whether longer-term corrective action is required, and to reach agreement on the terms of the corrective action.

5. Reporting Defective Installation Work

The connection agreement is a binding legal document and sets down the process for dealing with disputes in the event that this is necessary.

The agreement considers appropriate timeframes for resolution, the provision for expert determinations, and the binding nature of the determinations.

Chapter 3:
Public Electrical Safety Awareness

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1. Introduction

TransGrid transmits electricity through an extensive transmission network in New South Wales. The transmission lines that comprise this network cross private and public property along corridors which TransGrid has an obligation to maintain in a condition that allows the safe operation of the transmission lines.

The objective of TransGrid's Public Electrical Safety Awareness Plan is to make the public aware of the hazards associated with electricity, in particular high voltage transmission lines, cables and substations owned and/or operated by TransGrid.

2. Background

There have been no electrical incidents resulting in injury to members of the public from TransGrid's assets since TransGrid was formed on 1 February 1995. However, a risk assessment undertaken to assist in the development of strategies for public electrical safety awareness highlighted a number areas where there may be a potential for an increased risk for TransGrid in relation to public electrical safety.

The identified risks are:

- → Unauthorised access in substations (eg. adventurous children, vandals, thieves);
- → Unauthorised climbing of transmission towers;
- → High machinery and extendable plant operating under transmission lines;
- → Excavators and earth moving machinery in vicinity of high voltage cables;
- → Logging contractors felling trees in vicinity of transmission lines;
- → Kite flying and model planes in proximity to transmission lines;
- → Fires under, or in proximity to, transmission lines;
- → Aircraft flying in proximity of transmission lines eg. Crop dusting, gliders, etc;
- → Navigable waters under transmission lines; and
- → Potentially hazardous electrical conditions around TransGrid transmission lines and substations.

This Plan has been developed to ensure these risks are eliminated or controlled so as to minimise any impact on the public.

3. Action Plans

Action Plans are developed on an annual basis to address each of the identified public electrical safety risks. These are reviewed regularly to ensure the identified issues and associated strategies remain relevant and effective.

The current Action Plan is focused on three specific areas:

1. Relationship management with
   i) Property owners;
   ii) Emergency services; and
   iii) External organisations.
2. Site specific issues – related to individual transmission line structures, cables and substations.
3. Community interaction – schools, residents, general community, etc.

Strategies to address these areas are included in the Action Plans based on assessed priorities. Some strategies are ongoing as part of everyday business, and others are more specific to target particular items identified for improvement. One area for improvement over the past few years was the installation of aerial marker balls on transmission lines to more effectively identify the location of transmission lines from the air to minimise likelihood of aircraft coming in contact with the lines. Progress with implementation of Action Plans is monitored to ensure compliance.

3.1 Relationship Management

For those areas impacted by its assets, TransGrid maintains personal relationships with respective property owners and conducts routine patrols. This provides an opportunity to inform property owners of issues of importance to TransGrid, including:

- → Electrical safety in general and as appropriate in relation to specific assets.
- → The importance of our assets in supplying electricity to the community and to report any suspicious activities around our assets to either TransGrid or the Police.

Contact is also maintained on a regular basis with relevant property owners when any work on TransGrid assets may have an impact on them or in their vicinity.

Police, Fire Brigades, Rural Fire Services and State Emergency Services are important for response to emergencies that may occur on TransGrid assets. These services have attended briefings and/or inductions at various substations, specifically those that have been assessed as having an increased exposure for public safety. Experience of briefings with fire brigades indicates a good understanding of the hazards associated with substations, which is included in their training. Specific initiatives are therefore aimed at Police, Rural Fire Service (RFS) and State Emergency Services (SES).

Community consultation is mandatory with new projects and construction that may impact on the public. TransGrid has a formal community consultation process that ensures the issue of public safety is addressed.

Supervision and consultation is also maintained with TransGrid's contractors and sub-contractors to ensure responsibilities in relation to personal and public safety are understood and implemented appropriately. Risk assessments and Safety Management Plans are developed for new construction projects to identify and manage safety risks.

Activities undertaken by others in association with property owners may also impact on TransGrid assets e.g. construction, logging and aerial activities. TransGrid has nominated officers to respond to inquiries and requests for information to assist these organisations to safely carry out their work in the vicinity of our assets.

Dial Before You Dig is a service to which TransGrid remains a participating member. This service provides information on the location of underground services for organisations external to TransGrid for specific work activities (e.g. excavation work). Before any work that involves ground disturbance, *Dial Before You Dig* must be contacted by phone on 1100 or on the internet at www.1100.com.au. TransGrid has officers who receive the enquiries and action each enquiry by providing appropriate information to the enquirer of any of TransGrid's underground assets in the vicinity of the proposed work.

3.2 Site Specific Issues

Any public safety issues identified for specific transmission lines, cables or substations are assessed and appropriate strategies developed to control the risks. These are incorporated into the Network Management Plan as appropriate.

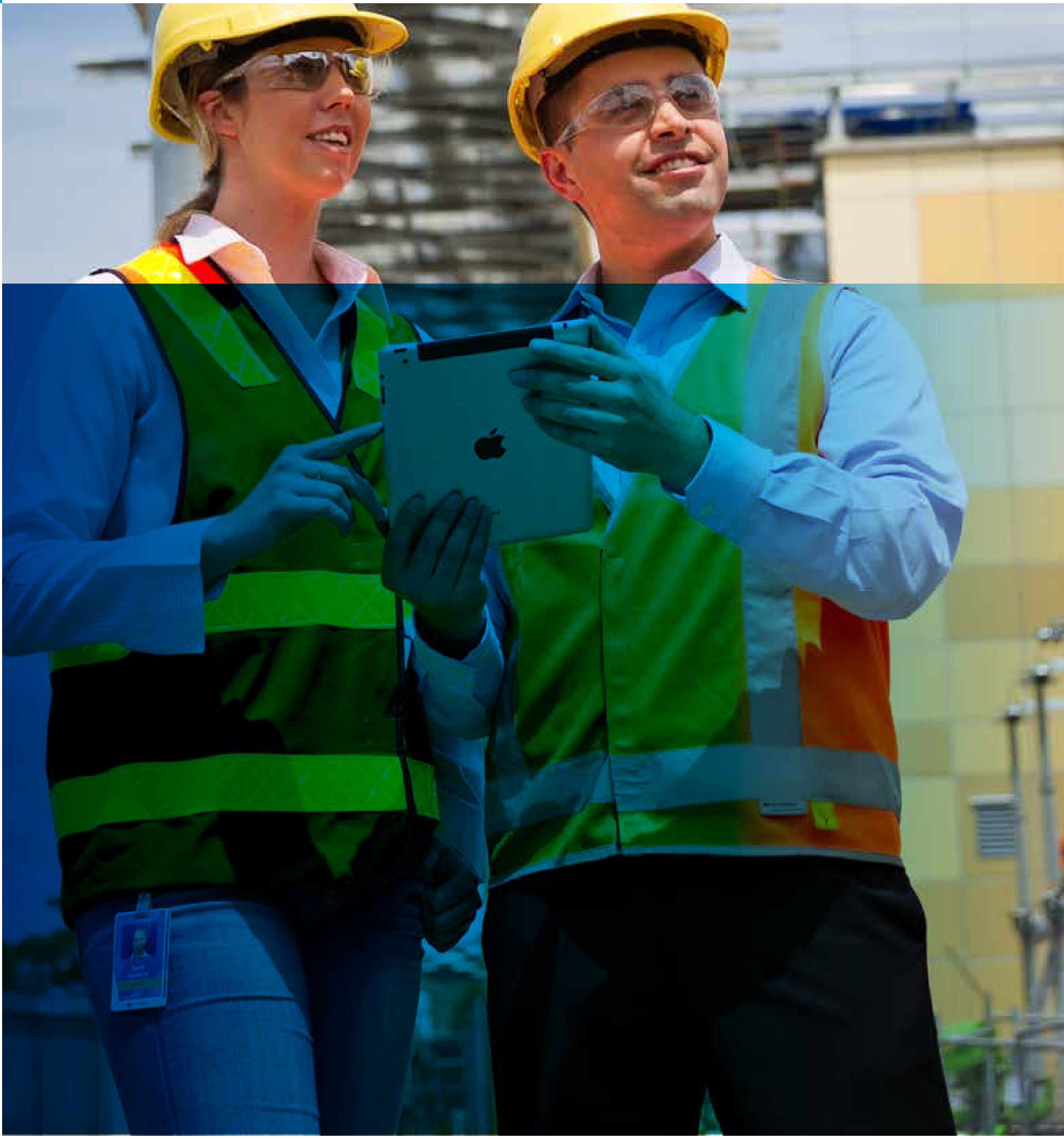
3.3 Community Interaction

In addition to responding to enquiries, TransGrid is involved in community consultation in relation to specific projects. Information is also made available to various community groups with regard to electrical safety and the reporting of suspicious activities in the vicinity of TransGrid's assets to TransGrid or the Police. This information may be included in:

- Publications/brochures;
- TransGrid's Web site;
- Newspaper articles; and
- Liaison with individual community groups, organisations, etc.

4. Annual Review and Report

Each of the Specific Initiatives is implemented, monitored and reviewed to ensure applicability and effectiveness. Performance Indicators are evaluated and reported to Trade & Investment NSW as part of annual reporting requirements.



Chapter 4: Bush Fire Risk Management

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3. Strategies for Bush Fire Risk Management 74


1. Introduction

Bushfires pose an ever present risk to life, property and the environment throughout rural and urban areas in New South Wales.

Bushfires can be caused by a variety of factors, including lightning strikes, sparks from farm machinery and incinerators, vehicle crashes, and electrical incidents such as fallen powerlines.

TransGrid's strategies, policies and procedures are based on the principles of risk management, and bush fire risk management forms an integral part of TransGrid's overall asset management system. These systems have been developed over many years, and changes and improvements have been made taking into account system performance during bush fires.

These systems have proven effective in previous major bush fire events, such as those in 2001-2003. In the period since then, there have been no major bush fire events that have impacted on TransGrid's transmission lines or infrastructure.

TransGrid reviews its processes and the performance of the network for bush fire emergencies. These reviews continue to find that the operating protocols are effective, the network performs very reliably, and communications protocols with emergency services organisations are effective.

The policies, procedures and work instructions required for the implementation of the Bush Fire Risk Management plan are distributed to the relevant staff via TransGrid's intranet, *The Wire.*

2. Objectives

This Chapter is intended to demonstrate the responsible management of TransGrid's network assets in relation to bush fire risk and meets the requirements of clause 12 (1) of the *Electricity Supply (Safety and Network Management) Regulation 2008 – Objectives of a Bush Fire Risk Management Plan.*

The objectives required by the Regulation ***[in italics below]*** have been expanded to better represent TransGrid's existing asset management policies and standards:

a) To ensure public safety.

i. To proactively manage public, employee and contractor safety.

ii. To protect the environment from harm.

b) To establish standards that must be observed when electricity lines operate near vegetation.

i. To establish design and maintenance standards that ensure bush fires are not initiated due to the normal operation of transmission lines.

c) To reduce interruptions to electricity supply that are related to vegetation.

i. Minimise the likelihood of interruption of the electricity supply due to faults on the network as a result of vegetation approaching too close to transmission lines.

ii. To minimise interruptions to electricity supply as a result of bush fire initiated outages of the network.

d) To minimise the possibility of fire ignition by electricity lines.

i. Minimise the likelihood that bush fires initiated by the operation, mal-operation or failure of transmission lines or electricity substation plant associated with transmission lines.

ii. To minimise the likelihood of fire ignition by electricity lines under lightning induced fault conditions, or severe storm events.

3. Strategies for Bush Fire Risk Management

3.1 General

TransGrid's risk approach to asset management is to minimise the likelihood that an asset will initiate a fire, irrespective of the location of that asset.

TransGrid is required to protect the environment by conducting its operations in compliance with the principles of ecologically sustainable development, and to operate efficient, safe and reliable facilities for the transmission of electricity.

The asset management and operational strategies therefore encompass all these issues including bush fire risk management.

3.2 Specific Strategies

The following strategies are the elements of TransGrid's asset management and operational strategies specific to bush fire risk management. These elements include policies, standards, processes and procedures that together meet the objectives of this plan that were outlined in section 2.

a) To identify:

→ **bush fire prone areas within the TransGrid supply area;**

→ **network assets capable of initiating bush fires; and**

→ **a system to ensure that this information is kept up to date.**

Transmission Lines

TransGrid's transmission line assets traverse the state and are generally located in rural and semi–rural areas. All of these areas have periods of high fire danger during the year and many of the transmission line corridors in these areas have sections of dense vegetation at risk of bush fire. TransGrid's risk approach to asset management assumes that every transmission line has the potential to be impacted by fire, or to initiate fire, including bush fire.

Each line's maintenance frequencies are determined taking into account the following factors:

→ Vegetation density and growth patterns and associated bush fire initiation risks;

→ Condition of the line;

→ Public safety and easement encroachment considerations; and

→ Local environmental conditions e.g. high corrosion or high termite activity areas.

The allocated maintenance frequencies are reviewed annually. TransGrid has recently carried out a review of the bush fire risk ranking of each transmission line. This review has taken into account the surrounding terrain, a vegetation classification, and propagation factors relating to the lines. The proximity of the line to populated areas is reviewed to assist in assessing the impact of a fire started in the vicinity of the line. This information will be used in the next annual review of the Maintenance Policy to address the assessment of the line conditions and target issues that may increase bushfire risk.

The schedule of lines and their maintenance frequencies are listed in the Transmission Line Maintenance Policy.

Applicable Asset Management Standards:

- Transmission Line Maintenance Policy – GM AS L1 001.

Protection Equipment

Protection equipment is provided to detect electrical faults on overhead lines and / or power system abnormalities so as to mitigate the undesirable effects of such faults or abnormalities by the timely and correct operation of these devices.

This equipment will operate to de-energise transmission lines when flame or dense smoke reaches the HV conductors and causes an electrical arc. It is essential that this equipment operates correctly to ensure minimal system disturbance and supply interruption.

Protection equipment forms a system made up of relays that detect the fault and circuit breakers that electrically isolate the fault by de–energising the line. The frequency of maintenance of protection equipment is governed by TransGrid's Protection Maintenance Policy. This standard also specifies in service auto-reclose checks that verify the complete protection scheme including intertrips and the mechanical operation of the circuit breakers.

The frequency of maintenance of circuit breakers is governed by TransGrid's Substation Maintenance Policies.

Applicable Asset Management Standards:

- Protection Maintenance Policy – GM AS P1 001.
- Substation Maintenance Policy – GM AS S1 001.

Substations

TransGrid's approach to the management of its substation assets takes into consideration:

- The risk that a fire may be initiated by an ignition source from within a substation, and
- The risk to equipment that may be posed by a fire external to a substation.

The activities required to eliminate these risks are set out in the Substation Maintenance Policy and the Fire Protection Manual Operations and Maintenance and include:

- Routine inspection of fire fighting equipment;
- Routine inspection of transformer fire protection systems;
- Routine inspection of control room fire protection systems;
- Routine inspection of switchyards and inspection of oil containment systems;
- Grass cutting and weed control on the substation site;
- Routine inspection for any rubbish that may present a potential fire hazard, clean up and disposal of rubbish;
- Routine inspection of perimeter firebreaks and rectification of any perimeter bush fire hazards;
- Routine inspections of control room gutters and removal of any combustible material;
- Control of vegetation and weeds within the switchyard; and
- Removal of grass and or weeds near cable entries.

Applicable TransGrid Standards:

- Substation Maintenance Policy – GM AS S1 001.
- Fire Protection Manual Operations & Maintenance.

Radio Repeater Sites

The Telecommunication Maintenance Policy covers property maintenance and includes all cleaning, mowing, clearing, internal or external building remediation work and general repairs to:

- Communication rooms;
- Radio repeater buildings;
- Fences;
- Compounds;
- Buffer zones; and
- Access roads.

This maintenance is performed to ensure Telecommunication Assets are adequately protected from deterioration, the effects of weather, vandalism or bush fire.

Applicable TransGrid Standard:

- Telecommunication Maintenance Policy – GM AS C1 001

b) To ensure that the identified network assets located in bush fire prone areas are inspected, tested and maintained in accordance with a suitable maintenance schedule.

The inspection and maintenance frequencies for all lines and protection equipment are established in accordance with the maintenance policies and are scheduled in TransGrid's ERP system, Ellipse. Inspection and maintenance includes testing where required.

The maintenance achievement and any variances from targets are reviewed each month and corrective action initiated if required.

Technical Performance Assessments (TPAs) are carried out by the Asset Performance Group annually in each of TransGrid's three Regions to ensure that maintenance is being carried out in accordance with Asset Management Standards.

Applicable Asset Management Standards:

- Network Asset Management – GD AS G2 003.
- Technical Performance Assessment Process – GM AS G2 005.

TransGrid has established maintenance practices that ensure adequate conductor to vegetation clearances are maintained, to minimise the likelihood of bush fire initiation due to arcing. These standards provide sufficient clearances to prevent flashover under all environmental conditions and under all line loadings.

TransGrid has commenced a strategy to transition towards a routine maintenance regime for its easements based upon a return frequency governed by known vegetation issues and growth patterns. Annual aerial inspections of all lines combined with routine ground inspections provide regular checks for any defect vegetation requiring action outside the routine maintenance program. The aim is to remove all tall growing species whose mature height is expected to impact on safe and reliable clearance to the high voltage conductors.

Applicable Asset Management Standards:

- Transmission Line Maintenance Policy – GM AS L1 001.
- Easements and Access Track Maintenance Policy – GM AS L1 002.
- Asset Management Strategy – Transmission Line Easements – GM AS L5 002.

c) To review equipment types or construction methods known in their operation or design to have bush fire ignition potential, and develop mitigation strategies in relation to their use.

Transmission Lines

TransGrid transmission lines do not have any known design or construction flaws that would initiate bush fires provided they are maintained and operated in accordance with TransGrid's standards and procedures. TransGrid's asset management process ensures that all incidents are reviewed in the TPA, QAPR and Quality Audit processes (refer to Chapter 1 of this Plan for the detail of these processes). These reviews include design and construction matters.

The focus therefore is to reduce the risk that the design and construction are not compromised by inadequate maintenance or inappropriate operation. Mechanical failure of a transmission line (eg dropped conductor), or failure of a transmission line to operate correctly under fault conditions (eg faulty earthing at times of lightning strike), can initiate fire under specific conditions.

Assessment of line inspection frequencies in response to the recently prepared bush fire risk ranking review will be carried out as part of the next Maintenance Policy issue.

The Asset Management Standard Transmission Line Maintenance Policy – GM AS L1 001 governs the policy for maintenance of transmission lines to ensure failures do not occur and to ensure earthing systems perform adequately during lightning and other fault conditions.

Protection equipment

An uncleared fault, or a fault which is not cleared with minimal delay, could lead to consequential mechanical failure of a transmission line (eg dropped conductor due to insulator failure, or conductor separation due to arc or heat damage).

TransGrid's asset management process ensures that the performance, testing and maintenance of these devices are reviewed in the TPA, QAPR and Quality Audit process (refer to Chapter 1 of this Plan). These reviews also include any design matters arising from performance issues.

Applicable Asset Management Standards:

- Substation Maintenance Policy – GM AS S1 001.
- Protection Maintenance Policy – GM AS P1 001.

d) To inform customers with private overhead lines of the dangers of trees coming into contact with those lines.

TransGrid's customers are:

- The Distribution Network Service Providers (DNSPs) that distribute power to the majority of end users (ActewAGL, Country Energy, Energy Australia and Integral Energy);
- Connected generators (Delta Electricity, Eraring Energy, Macquarie Generation, Origin Energy and Snowy Hydro Limited); and
- Directly connected loads (Norske Skog, Tomago Aluminium and Visy Pulp & Paper).

The NSW DNSPs are required under the Regulation to lodge a Bush Fire Risk Management Plan separately.

The NSW generators are responsible for safe operation and maintenance of their lines to ensure vegetation does not create a bush fire risk.

Notifications will be sent to directly connected load customers during 2013/14, reminding them of their statutory responsibilities under the Electricity (Consumer Safety) Regulation 2006 and the Electricity (Consumer Safety) Act 2004, as well as informing them of the dangers of vegetation coming into contact with their privately owned lines.

e) To ensure that private overhead lines located in bush fire prone areas and capable of initiating a bush fire are inspected, tested and maintained in accordance with a suitable maintenance schedule and that appropriate standards are enforced by the network operator.

The NSW DNSPs are required to ensure their overhead lines located in bush fire prone areas and capable of initiating a bush fire are inspected, tested and maintained in accordance with a suitable maintenance schedule in accordance with a Bush Fire Risk Management Plan.

It is the responsibility of the NSW generators to implement suitable maintenance schedules and standards to ensure the safe operation and maintenance of their lines.

As part of the information provided to the direct connected load customers, discussions relating to the maintenance requirements of any overhead line assets they own are ongoing. Any items of risk identified with the customer's installation during routine or ad hoc inspections of TransGrid assets in the area will be communicated with the customer for remedial action.

f) To record any complaints in relation to bush fire risk management, and to ensure that appropriate investigations are made and remedial actions undertaken as required.

Each of TransGrid's Regional Centres handles enquiries and complaints from the public, and keeps records of these enquiries. Any matters brought to the attention of TransGrid by the public in relation to bush fire risk management will be investigated and remedial action undertaken if required by the Region.

Enquiries are normally from property owners where TransGrid has an easement or from other State authorities that manage the land over which the transmission lines traverse.

Communication channels and procedures are in place with these stakeholders for all maintenance matters. Members of the public can also contact the Regional centre or TransGrid headquarters using telephone numbers published in local telephone directories and on TransGrid's website www.transgrid.com.au. Free-call 1800 numbers are also provided to contact each Region in an emergency, and Email contact addresses are provided on TransGrid's website.

On occasions, some enquiries are redirected to TransGrid from Distributors or other authorities. Any bush fire risk enquiries will be forwarded to the maintenance team or local patrolman and will receive a high priority and will be followed up in accordance with Regional Centre processes.

Applicable Grid Standard:

- Administration of the Network Management Plan – GD AS G2 006.

g) To liaise and consult with the NSW Rural Fire Service, NSW Fire Brigades, councils for relevant local government and other relevant government departments.

TransGrid is represented on applicable local and regional bush fire committees, and is involved as required in local and regional emergency plans, their preparation and any exercises or testing of such plans. Representation generally consists of a corresponding member with at least an annual attendance at meetings for each applicable committee. Correspondence providing safety information and TransGrid's interests and requirements is sent to each applicable committee as required.

Each Regional Centre establishes and provides the required representation.

TransGrid maintains an Agreement with the National Parks and Wildlife Service of NSW for the maintenance of its infrastructure on Service areas. Amongst other matters this agreement implements protocols for vegetation management taking into account bush fire considerations. TransGrid is also in discussions with stakeholders and other bodies as required on bushfire related matters.

h) To provide information for the general public about the fire hazards associated with overhead power lines and vegetation, particularly during storms and conditions of high fire hazard.

The Network assets and the transmission line easements managed and maintained by TransGrid are designed to operate safely under all environmental conditions including storms and conditions of high fire hazard.

The transmission lines are generally covered by formal easements, and/or traverse land managed by State bodies such as the NSW National Parks and Wildlife Service, Forests NSW and the Sydney Catchment Authority. TransGrid Regional Centres keep in close contact with all stakeholders with land over which TransGrid lines traverse.

To maintain the integrity and safety of the Network as designed, the activities on easements that are permitted, controlled or not permitted are communicated in accordance with Chapter 3 of this Plan regarding Public Electrical Safety Awareness.

For the smaller landholdings, TransGrid regularly communicates through its patrol staff and provides information through documents such as TransGrid's Easement Guide. This document details the activities allowed within easements taking into account matters such as bush fire risk. Specifically, the following items are covered for prohibited activities within an easement:

- Storage of flammable liquids or explosives;
- Storage of garbage materials or fallen timber; and
- Planting or cultivation of trees or shrubs that will grow to a mature height exceeding four metres.

i) To ensure that special procedures and precautions are taken during conditions of very high fire danger, including work practices by staff, fault location procedures, automatic and manual reclosing of lines and protection settings.

Operating Procedures

Grid Operating Manual "Automatic and Manual Reclosure of Transmission Lines" governs the operation of transmission lines during events such as bush fire. The manual specifies actions to be taken during bush fires and includes instructions regarding when to make the auto re–close function on transmission lines "non–auto" and the conditions under which manual closure can be attempted.

Applicable Asset Management Standards:

- Automatic and Manual Reclosure of Transmission Lines – OM 686.
- Bushfire and Weather Hazards – OM 695.

Work within TransGrid Work Sites

TransGrid's Fire Protection Manual Operations & Maintenance sets the minimum standards for fire prevention and protection measures. The standard specifies:

- That each substation, depot, communication site and Regional centre is required to have in place a Local Fire Procedure Manual;
- The design requirements for fire–breaks around substation sites;
- The site requirements and emergency procedures for the management of contractors; and
- The requirements for "Hot Work", and the need to observe fire restrictions. "Hot Work" is an activity requiring particular hazard and risk assessments and control measures.

Hazard and Risk assessments are carried out for all work. These assessments will include the assessment of fire risk due to "Hot Work" such as angle grinding or drilling of steel cross–arms during maintenance, or the risk of fire ignition from vehicle exhaust in long grass.

If a Total Fire Ban with a 'Catastrophic' rating is declared by the NSW RFS no "Hot Work" is to be undertaken. If a Total Fire Ban with a rating less than 'Catastrophic' is declared by the NSW RFS no high fire risk "Hot Work" is to be undertaken. Moderate fire risk "Hot Work" may still be undertaken on these days in accordance with the control measures documented on a 'Fire Risk Assessment and Control Measures' form.

Applicable TransGrid Standards:

- Fire Protection Manual Operations & Maintenance – GD HS G2 001.
- Management System Document – Hot Work.

j) To maintain a schedule of reports to be made to the Director–General in relation to the control of the risk of bush fire resulting from the transmission system.

These reports are provided as outlined in Chapter 1, section 1.7 of this Plan. Copies of these reports will be retained in TransGrid's records.

k) To review and report on the performance of the network during bush fires emergencies and implement improvement recommendations.

Formal reviews are carried out for all major incidents involving Network assets. These reviews are conducted under terms of reference set by the relevant Executive General Manager or the Executive.

TransGrid has carried out reviews of the major bush fire emergencies that have impacted the NSW network in the last decade. These reports are:

- Review of Network Performance During Bush Fires in December 2001 – January 2002.
- Investigation into the Impact of Bush Fires on TransGrid's Network on 4th–6th December 2002.
- Investigation into the impact of the Canberra fires on TransGrid's Network in January 2003.

These reports covered:

- An assessment of system plant and performance.
- A review of operating practices, emergency response procedures, and design and maintenance standards; and
- The identification of strategies with respect to easement or site management to enhance reliability of the network in future or similar bush fires.

Generally the reports concluded that the network exhibited excellent performance during these emergencies. A number of improvements have been implemented as a result of these reviews, which will further enhance network reliability.

Minor damage to lines during bush fire events is reviewed where necessary as part of normal asset failure scenarios. The fire events in early 2013 only damaged one pole of a two pole wood structure near Yass. Due to the intensity of this fire in the location, the fire damage of one pole is considered very minor. Other lines impacted by fires around the state in the various fire events were not damaged. These issues have not led to any proposed changes to maintenance practices or asset renewals.

Appendix A
Corporate Policies

Health and Safety Policy 80
Environment Policy 80

Health and Safety Policy

TransGrid's Health and Safety principles are:

- Safety is our first priority;
- All accidents are preventable;
- Working safely is a condition of employment;
- Everyone can demonstrate leadership in health and safety; and
- We are committed to protecting the health and safety of employees, contractors, visitors and the public.

To achieve our health and safety principles, TransGrid will:

- Provide a safe and healthy work place for our staff and contractors;
- Apply standards that meet relevant health and safety legislation, regulations and codes of practice;
- Identify and assess health and safety risks prior to commencing all activities and projects and work to eliminate or control risk;
- Regularly monitor and review the health and safety management system;
- Continually improve our health and safety performance through establishing measureable performance objectives and actions;
- Respond to all incidents and provide timely and effective injury management that promotes early and sustainable return to duties;
- Engage in open communication and consultation with staff, contractors and agency workers on issues that have the potential to affect their health or safety;
- Ensure everyone in TransGrid understand their health and safety responsibilities; and
- Foster a positive safety culture that enables health and safety to be a part of all decisions in the organisation.

Environment Policy

TransGrid is committed to conducting its activities and services in a manner that minimises pollution and complies with relevant legislation, industry standards and codes of practice.

The Environment Policy covers all activities and services undertaken by TransGrid including the planning, building and operation of infrastructure, ongoing management of these assets and their decommissioning.

We aim to enhance our systems and processes in a manner that promotes continuous improvement in environmental management and which will lead to the achievement of industry best practice.

In meeting these commitments, TransGrid:

- Maintains an Environmental Management System that provides the framework for setting and reviewing our environmental objectives and targets, including the implementation, monitoring and review of these objectives and targets;
- Continues to develop systems that recognise sensitive environmental and cultural sites on or near our infrastructure, and provides processes to manage and minimise our potential impacts;
- Integrates environmental management considerations into the planning, design, siting, construction, maintenance, operation, decommissioning and disposal of all TransGrid assets;
- Provides environmental training, assessment and authorisation under our Environmental Rules to employees and contractors to enable them to perform their duties in an environmentally sensitive manner;
- Engages with the community, customers, employees, government and other stakeholders regarding potential environmental or cultural impacts associated with our plans and activities; and
- Pursues opportunities to maximise resource efficiencies and reduce the generation of waste through reduction, reuse and recycling programs.

Appendix B
Asset Inventory

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Circuit Breakers	88
Transmission Lines and Underground Cables	91

Schedule of Substations and Switching Stations

500 kV SITES	COMM YEAR	SYSTEM VOLTAGE (kV)
Bannaby	2010	500/330
Bayswater	2009	500/330
	1984	330
Eraring	1984	500/330
Mt Piper 500	2009	500/330
	1986	330/132
Kemps Creek	1984	500/330
	1989	330/16
Wollar	2009	500/330
Total Sites at 500 kV = 6		

220KV SITES	COMM YEAR	SYSTEM VOLTAGE (kV)
Balranald	2001	220/22
Broken Hill	1979	220/22
Buronga	1988	220
Total Sites at 220 kV = 3		

330 kV SITES	COMM YEAR	SYSTEM VOLTAGE (kV)
Armidale	1972	330/132
	1969	132/66
Avon	1974	330
Beaconsfield West	1979	330/132
Canberra	1967	330/132
Capital Wind Farm	2009	330
Coffs Harbour	2006	330/132
	1979	132/66
Dapto	1962	330/132
Darlington Point	1988	330/220
		330/132
Dumaresq	2000	330
Haymarket	2004	330/132
Ingleburn	1984	330/66
Jindera	1979	330/132
Kangaroo Valley	1976	330
Liddell	1970	330
Lismore	1992	330/132
Liverpool	1985	330/132
Lower Tumut	1972	330
Macarthur	2009	330/132
		330/66
Marulan	1992	330/132

132 kV SITES	COMM YEAR	SYSTEM VOLTAGE (kV)
Albury	1958	132
A.N.M.	1981	132
Beryl	1976	132/66
Boambee South	2010	132
Burrinjuck	1950	132
Coleambally	1993	132
Cooma	1954	132/66/11
Cowra	1960	132/66
Deniliquin	1971	132/66
Finley	1991	132/66
Forbes	1969	132/66
Gadara	2000	132/11
Glen Innes	2007	132/66
Griffith	1964	132/33
Gunnedah	1985	132/66
Guthega	1970	132
Hume	1957	132
Inverell	1984	132/66
Kempsey	1967	132/33
		66/33
Koolkhan	1963	132/66
Macksville	2010	132
Manildra	2012	132

330 kV SITES	COMM YEAR	SYSTEM VOLTAGE (kV)
Munmorah	1967	330/132
Murray	1967	330/132
Muswellbrook	1983	330/132
Newcastle	1969	330/132
Regentville	1997	330/132
Sydney East	1976	330/132
Sydney North	1963	330/132
Sydney South	1961	330/132
Sydney West	1965	330/132
Tamworth 330	1968	330/132
Tomago	1983	330/132
Tuggerah	1986	330/132
Upper Tumut	1969	330
Vales Point	1962	330/132
Vineyard	1994	330/132
Wagga 330	1973	330/132
Wallerawang 330	1975	330/132
Waratah West	1992	330/132
Wellington	1984	330/132
Williamsdale	2012	330/132
Yass	2006	330/132
	1965	132/66
Total Sites at 330 kV = 40		

132 kV SITES	COMM YEAR	SYSTEM VOLTAGE (kV)
Molong	2001	132/66
Moree	1984	132/66
Mt Piper 132	1988	132/66
Munyang	1989	132/33
Murrumburrah	1985	132/66
Nambucca	2001	132/66
Narrabri	1965	132/66
Orange	1954	132/66
Orange North	2012	132
Panorama	1979	132/66
Parkes	1993	132/66
Port Macquarie	1979	132/33
Queanbeyan	2010	132/66
Raleigh	2009	132
Tamworth 132	1961	132/66
Taree	1958	132/66/33
Tenterfield	1970	132/22
Tumut	1967	132/66
Uranquinty	2007	132
Wagga 132	1955	132/66
Wagga North	2009	132/66
Wallerawang 132	1953	132/66
Yanco	1969	132/33
Total Sites at 132kV = 45		
Total Sites at all voltages = 94		

TransGrid System Transformers

SUBSTATIONS	VOLTAGE (kV)	MVA	PHASE	MANUFACTURER	CONTRACT	DATE	QTY
ARMIDALE	132	60	3	ABB	1122	2006	2
ARMIDALE	330	375	3	ELIN VATECH	1056B	2007	2
ARMIDALE PST	132	200	3	TOSHIBA	1199	2009	1
ARMIDALE SVC	330	302	3	ALSTOM	1020	2001	1
BALRANALD	220	30	3	ABB	1023	2000	1
BANNABY	500	500	1	TOSHIBA	1156	2009	6
BAYSWATER	500	500	1	TOSHIBA	1156	2009	6
BEACONSFIELD	330	375	3	TYREE	2520	1979	2
BERYL	132	120	3	TYREE	2976/4	1983	2
BROKEN HILL	220	100	3	TYREE	2770	1979	2
CANBERRA	330	133	1	JEUM SCHNEID	1549	1967	6
CANBERRA	330	375	3	TYREE	3529	1987	1
CANBERRA	330	375	3	ABB	1016	2002	1
COFFS HARBOUR	330	375	3	AREVA	1056A	2006	1
COFFS HARBOUR	132	120	3	ABB	1189A	2009	2
COOMA	132	27.5	3	BRE	XRLY	1959	2
COOMA	132	30	3	ACEC	724/1	1959	1
COWRA	132	60	3	WILSON	1238	2010	2
DAPTO	330	375	3	TYREE	2520	1979	1
DAPTO	330	375	3	TYREE	2875/2	1982	2
DARLINGTON PT	330	280	3	TYREE	2875/2	1983	1
DARLINGTON PT	330	200	3	TYREE	3631	1988	2
DARLINGTON PT	330	280	3	TYREE	3631/1	1988	1
DENILIQUIN	132	60	3	TYREE	3735/1	1989	2
ERARING	500	400	1	FUJI	3004	1982	3
FINLEY	132	60	3	WILSON	1183	2010	2
FORBES	132	60	3	TYREE	1670	1969	2
GADARA	132	35	3	ABB	GADARA	2000	1
GLEN INNES	132	60	3	ABB	1122	2006	2
GRIFFITH	132	45	3	ACEC	209	1956	2
GRIFFITH	132	45	3	ACEC	382	1960	1
GUNNEDAH	132	60	3	TYREE	3485	1985	2
HAYMARKET	330	133	1	TOSHIBA	1050	2003	9
INGLEBURN	330	250	3	TYREE	2875/1	1983	2
INVERELL	132	120	3	TYREE	2976/6	1983	2
JINDERA	330	375	3	TYREE	2520	1981	1
JINDERA	330	375	3	TYREE	2875/2	1981	1
KEMPS CK	500	400	1	FUJI	3004	1983	6

SUBSTATIONS	VOLTAGE (kV)	MVA	PHASE	MANUFACTURER	CONTRACT	DATE	QTY
KEMPSEY	66	15	3	ENG ELECTRIC	772/1	1959	1
KEMPSEY	132	60	3	AREVA	1185	2008	2
KOOLKHAN	132	60	3	TYREE	3485	1984	1
KOOLKHAN	132	60	3	WILSON	1041C	2003	1
KOOLKHAN	132	60	3	WILSON	1225	2010	1
LISMORE	330	375	3	ASEA	4005/1A	1992	1
LISMORE	330	375	3	ASEA	4005/1B	1992	1
LISMORE SVC	132	180	3	ABB	1014	2000	1
LIVERPOOL	330	375	3	TYREE	3529	1985	2
LIVERPOOL	330	375	3	ALSTOM	1056A	2004	1
MACARTHUR	330	250	3	AREVA	1120B	2009	1
MACARTHUR	330	375	3	AREVA	1120B	2009	1
MARULAN	330	160	3	HITACHI	974	1962	1
MOLONG	132	30	3	ENG ELECTRIC	724/2	1961	1
MOREE	132	60	3	TYREE	2976/2	1983	2
MT PIPER	132	120	3	TYREE	2976/7	1984	2
MT PIPER	330	375	3	TYREE	3631/1	1989	1
MT PIPER	500	500	1	TOSHIBA	1156	2009	6
MUNMORAH	330	375	3	ABB	1016	2000	1
MUNYANG	132	30	3	ACEC	60/2	1955	1
MUNYANG	132	60	3	MITSUBISHI	C1280	2012	1
MURRAY	330	40	3	AEG	81/23415	1967	2
MURRUMBURRAH	132	60	3	TYREE	3485	1984	1
MURRUMBURRAH	132	60	3	WILSON	1041C	2002	1
MUSWELLBROOK	330	375	3	TYREE	2875/2	1983	2
NAMBUCCA	132	60	3	ABB	1041B	2001	1
NAMBUCCA	132	60	3	AREVA	1185	2009	1
NARRABRI	132	30	3	ELIN	E60	1955	1
NARRABRI	132	30	3	AEI	1393A	1965	2
NEWCASTLE	330	133	1	MITSUBISHI	1712	1969	6
NEWCASTLE	330	375	3	AREVA	1056A	2005	1
ORANGE	132	60	3	TYREE	1670	2007	1
ORANGE	132	60	3	AREVA	1226	2009	1
ORANGE	132	60	3	WILSON	1225	2010	1
PANORAMA	132	120	3	TYREE	2976/3	1981	2
PARKES	132	60	3	ABB	3999/2	1993	1
PARKES	132	60	3	AREVA	1182	2008	1
PT MACQUARIE	132	60	3	ABB	1122	2006	2

SUBSTATIONS	VOLTAGE (kV)	MVA	PHASE	MANUFACTURER	CONTRACT	DATE	QTY
PT MACQUARIE	132	60	3	ABB	1180	2007	1
QUEANBEYAN	132	120	3	WILSON	1189B	2010	2
REGENTVILLE	330	375	3	TYREE	2875/2	1984	1
REGENTVILLE	330	375	3	ABB	4005	1994	1
SYDNEY EAST	330	133	1	TYREE	2231	1974	9
SYDNEY NORTH	330	375	3	TYREE	2875/2	1981	3
SYDNEY NORTH	330	375	3	TYREE	2875/2	1982	1
SYDNEY NORTH	330	375	3	TOSHIBA	1229	2011	1
SYDNEY SOUTH	330	375	3	ALSTOM	1056A	2003	2
SYDNEY SOUTH	330	375	3	AREVA/ALSTOM	1056A	2004	1
SYDNEY SOUTH	330	375	3	AREVA	1120B	2008	1
SYDNEY SOUTH	330	375	3	SIEMENS	1120A	2008	1
SYDNEY SOUTH	330	375	3	AREVA	1120B	2012	1
SYDNEY WEST	330	375	3	ABB	1016	2000	1
SYDNEY WEST	330	375	3	ELIN	1056B	2005	1
SYDNEY WEST	330	375	3	ELIN VATECH	1056B	2006	1
SYDNEY WEST	330	375	3	AREVA	1120B	2007	1
SYDNEY WEST	330	375	3	ELIN VATECH	1056B	2007	1
SYDNEY WEST SVC	330	294	3	ABB	1065	2004	1
TAMWORTH	330	150	3	PARSON PEEBLE	1517/2	1968	2
TAMWORTH	132	60	3	TYREE	1670	1969	2
TAMWORTH	132	60	3	TYREE	2105	1971	1
TAMWORTH	330	200	3	ABB	1016	2000	1
TAREE	132	60	3	TYREE	3666/1	1988	2
TAREE	132	60	3	WILSON	1100	2004	2
TENTERFIELD	132	15	3	ENG ELECTRIC	1849	1970	2
TOMAGO	330	375	3	AREVA	1120B	2010	1
TOMAGO	330	375	3	TOSHIBA	1229	2010	1
TUGGERAH	330	375	3	AREVA	1120B	2009	2
TUMUT	132	60	3	TYREE	3485	1985	1
TUMUT	132	60	3	WILSON	1041A	2001	1
VALES POINT	330	200	3	ABB	4381	1995	1
VALES POINT	330	200	3	ABB	1016	2001	1
VINEYARD	330	375	3	AREVA/ALSTOM	1056A	2004	1
VINEYARD	330	375	3	ELIN	1056B	2005	1
VINEYARD	330	375	3	TOSHIBA	1229	2011	1
WAGGA	132	60	3	TYREE	1670	1968	1
WAGGA	132	60	3	TYREE	2105	1975	1
WAGGA	132	60	3	TYREE	3735	1991	1

SUBSTATIONS	VOLTAGE (kV)	MVA	PHASE	MANUFACTURER	CONTRACT	DATE	QTY
WAGGA	330	375	3	AREVA	1120B	2009	2
WAGGA NTH	132	60	3	AREVA	1226	2009	1
WALLERAWANG	132	60	3	GEC	2179	1971	2
WALLERAWANG	330	375	3	AREVA	C1120B	2011	2
WALLERAWANG	330	200	3	ABB	1016	2000	1
WARATAH WEST	330	375	3	ELIN VATECH	1056B/1	2004	1
WARATAH WEST	330	375	3	TOSHIBA	1229	2010	1
WELLINGTON	330	375	3	AREVA	1056A	2006	1
WELLINGTON	330	375	3	ELIN VATECH	1056B	2006	1
WOLLAR	500	500	1	TOSHIBA	1156	2009	3
YANCO	132	45	3	ACEC	382	1960	1
YANCO	132	45	3	HACKBRIDGE	1419/1	1969	1
YASS	132	30	3	ELIN	262-1/23	1962	1
YASS	330	200	3	ABB	4381	1995	1
YASS	330	200	3	ELIN VATECH	1056B	2003	1
						Total =	**220**

Circuit Breakers

TYPE	MANUFACTURER	TYPE	VOLTAGE (kV)	QTY	FIRST INSTALL DATE	LAST INSTALL DATE
SMALL OIL	ASEA	HLC72	66	57	1978	1982
SMALL OIL	ASEA	HLD145	132	42	1968	1981
SMALL OIL	ASEA	HLR145	132	97	1980	1992
SMALL OIL	ASEA	HLR170	132	1	1972	1972
SMALL OIL	ASEA	HLR84	66	17	1983	1984
SMALL OIL	DELLE	HPGE9	66	45	1970	1977
SMALL OIL	MAGRINI	12MG500	11	4	1983	1989
SMALL OIL	MAGRINI	38MGE	33	16	1989	1995
SMALL OIL	SPRECHER	HPF509K	66	1	1979	1979
SMALL OIL	SPRECHER	HPF512N	132	4	1980	1980
SMALL OIL	SPRECHER	HPF515C	330	2	1981	1981
SF_6	ABB	EDF-33	33	2	2003	2003
SF_6	ABB	EDF-66	66	3	1998	2001
SF_6	ABB	EDS	66	19	1996	2000
SF_6	ABB	HPL145	132	54	1992	2003
SF_6	ABB	HPL245	330	5	1992	1992
SF_6	ABB	HPL362	330	23	1994	2006
SF_6	ABB	HPL420	330	5	1995	1995
SF_6	ABB	LTB145	132	69	1996	2002
SF_6	ABB	LTB170	132	21	2004	2011
SF_6	ABB	LTB420	330	3	2009	2009
SF_6	ALSTOM	FXT15	220	1	2001	2001
SF_6	ALSTOM	FXT15	330	61	2000	2008
SF_6	ALSTOM	FXT16	330	5	2001	2001
SF_6	ALSTOM	FXT22D	500	1	2000	2000
SF_6	ALSTOM	GL309F1	66	13	2005	2007
SF_6	ALSTOM	S1145	132	4	2001	2001
SF_6	ALSTOM	S1145F1	132	84	2000	2012
SF_6	ALSTOM	S172	66	29	2000	2008
SF_6	AREVA	DT1145	132	9	2002	2012
SF_6	AREVA	DT172.5-DT	66	6	2009	2009
SF_6	AREVA	GL309F1	66	10	2010	2012
SF_6	AREVA	GL312	132	7	2009	2012
SF_6	AREVA	GL315	330	83	2005	2011
SF_6	AREVA	S1145	132	3	2012	2012
SF_6	ASEA	ECKS132	132	54	1979	1986

TYPE	MANUFACTURER	TYPE	VOLTAGE (kV)	QTY	FIRST INSTALL DATE	LAST INSTALL DATE
SF_6	ASEA	HB24/16	22	4	1986	1986
SF_6	ASEA	HB36/12	33	3	1988	1990
SF_6	ASEA	HPL145	132	2	1990	1991
SF_6	ASEA	HPL170	132	1	1987	1987
SF_6	ASEA	HPL245	220	12	1986	1988
SF_6	ASEA	HPL362	330	6	1994	1996
SF_6	GEC	FXT15	330	68	1997	2006
SF_6	GEC	FXT9	66	2	1995	1996
SF_6	MAGRINI	36GB20	33	2	1984	1984
SF_6	MAGRINI	36GI	22	5	1998	1998
SF_6	MAGRINI	36GI	33	8	1996	1996
SF_6	MERLIN GERIN	FA2	330	48	1980	1985
SF_6	MERLIN GERIN	FA4	500	11	1984	1984
SF_6	MERLIN GERIN	PFA1	66	3	1970	1986
SF_6	MITSBISH	132DT	132	12	2009	2010
SF_6	MITSBISH	66DT	66	13	2009	2010
SF_6	SIEMENS	3AP1-132	132	31	2000	2011
SF_6	SIEMENS	3AP1-66	66	20	2004	2012
SF_6	SIEMENS	3AP1DT-132	132	6	2009	2010
SF_6	SIEMENS	3AP1-DT-132	132	89	2005	2012
SF_6	SIEMENS	3AP1-DT-66	66	41	2005	2012
SF_6	SIEMENS	3AP2-330	330	17	2009	2010
SF_6	SIEMENS	3AP2-500	500	9	2009	2010
SF_6	SIEMENS	3AP3-500	500	17	2009	2010
SF_6	SIEMENS	3AQ2	330	36	1990	1994
SF_6	SIEMENS	3AS2	330	39	1983	1986
SF_6	SIEMENS	SPS2145-DT	132	8	2001	2006
SF_6	SIEMENS	SPS272-DT	66	9	2001	2006
SF_6	SIEMENS	8DN8	132	23	2005	2005
SF_6	SIEMENS	8DQ1	330	4	2005	2005
SF_6	SPRECHER	112/1	132	4	1990	1993
SF_6	SPRECHER	FXT9	66	7	1993	1995
SF_6	SPRECHER	HGF112	132	23	1987	1996
SF_6	SPRECHER	HGF215	330	40	1985	1994
SF_6	SPRECHER	HGF309	66	4	1991	1991
SF_6	SPRECHER	HGF312	132	20	1993	2006

TYPE	MANUFACTURER	TYPE	VOLTAGE (kV)	QTY	FIRST INSTALL DATE	LAST INSTALL DATE
BULK OIL	REYROLLE	LMT/X6	11	17	1967	1972
BULK OIL	REYROLLE	LMT/X8	11	3	1970	1970
VACUUM	ALSTOM	OX36	33	45	2000	2007
VACUUM	ALSTOM	WBS	22	3	2001	2001
VACUUM	AREVA	OX36	33	6	2011	2011
VACUUM	AREVA	VOX36-DT	33	1	2012	2012
VACUUM	JOSELYN	VBU4	220	2	1979	1979

Transmission Lines and Underground Cables

CIRCUIT NO.	FROM (SITE 1)	TO (SITE 2)	LENGTH (km)	PREDOMINANT CONSTRUCTION
Assets Constructed at Rated Voltage: 500 kV in Service at 500 kV				
5A1	Eraring	Kemps Creek	143.3	Double Circuit Steel Tower
5A1/1	Eraring	Field Terminated	2.5	Double Circuit Steel Tower
5A2	Eraring	Kemps Creek	143.3	Double Circuit Steel Tower
5A2/1	Eraring	Field Terminated	2.5	Double Circuit Steel Tower
5A3	Bayswater	Mount Piper	224.4	Double Circuit Steel Tower
5A4	Bayswater	Wollar	111.8	Double Circuit Steel Tower
5A5	Wollar	Mount Piper	112.6	Double Circuit Steel Tower
5A6	Mount Piper	Bannaby	141.3	Double Circuit Steel Tower
5A7	Mount Piper	Bannaby	141.3	Double Circuit Steel Tower
Assets Constructed at Rated Voltage: 500 kV in Service at 330 kV				
5	BANNABY	MARULAN	19.7	Double Circuit Steel Tower
36	BANNABY	MARULAN	19.7	Double Circuit Steel Tower
Assets Constructed at Rated Voltage: 330 kV in Service at 330 kV				
01	CANBERRA	UPPER TUMUT	99.9	Single Circuit Steel Tower
2	UPPER TUMUT	YASS	148.9	Single Circuit Steel Tower
3	LOWER TUMUT	YASS	128.9	Single Circuit Steel Tower
4	MARULAN	YASS	113.8	Single Circuit Steel Tower
5	MARULAN	YASS	118.1	Single Circuit Steel Tower
6	CANBERRA	CAPITAL WIND FARM	59.9	Single Circuit Steel Tower
07	CANBERRA	LOWER TUMUT	98.8	Single Circuit Steel Tower
8	DAPTO	MARULAN	70.8	Single Circuit Steel Tower
9	CANBERRA	YASS	42.2	Single Circuit Steel Tower
10	DAPTO	AVON	10.9	Single Circuit Steel Tower
11	DAPTO	SYDNEY SOUTH	68.0	Single Circuit Steel Tower
12	LIVERPOOL	SYDNEY SOUTH	18.3	Double Circuit Steel Pole
13	KEMPS CREEK	SYDNEY SOUTH	24.1	Single Circuit Steel Tower
14	KEMPS CREEK	SYDNEY NORTH	49.8	Single Circuit Steel Tower
16	AVON	MARULAN	70.6	Single Circuit Steel Tower
17	AVON	MACARTHUR	41.1	Single Circuit Steel Tower
18	DAPTO	KANGAROO VALLEY	42.7	Single Circuit Steel Tower
20	SYDNEY NORTH	SYDNEY WEST	33.2	Single Circuit Steel Tower
21	TUGGERAH	SYDNEY NORTH	64.4	Single Circuit Steel Tower
22	SYDNEY NORTH	VALES PT	86.1	Single Circuit Steel Tower
23	MUNMORAH	VALES PT	7.2	Single Circuit Steel Tower

CIRCUIT NO.	FROM (SITE 1)	TO (SITE 2)	LENGTH (km)	PREDOMINANT CONSTRUCTION
24	VALES PT	ERARING	25.2	Single Circuit Steel Tower
25	ERARING	VINEYARD	109.4	Double Circuit Steel Tower
26	MUNMORAH	SYDNEY WEST	124.1	Double Circuit Steel Tower
27	SYDNEY NORTH	SYDNEY EAST	21.9	Single Circuit Steel Tower
28	SYDNEY NORTH	SYDNEY EAST	22.3	Single Circuit Steel Tower
29	VINEYARD	SYDNEY WEST	20.7	Double Circuit Steel Tower
2M	MUNMORAH	TUGGERAH	39.8	Single Circuit Steel Tower
30	LIVERPOOL	SYDNEY WEST	16.6	Single Circuit Steel Tower
31	BAYSWATER	REGENTVILLE	171.0	Double Circuit Steel Tower
32	BAYSWATER	SYDNEY WEST	188.5	Double Circuit Steel Tower
33	BAYSWATER	LIDDELL	6.0	Double Circuit Steel Tower
34	BAYSWATER	LIDDELL	6.0	Double Circuit Steel Tower
35	BANNABY	MARULAN	0.6	Double Circuit Steel Tower
36	BANNABY	MARULAN	0.6	Double Circuit Steel Tower
37	MACARTHUR	KEMPS CREEK	23.2	Single Circuit Steel Tower
38	REGENTVILLE	SYDNEY WEST	17.5	Double Circuit Steel Tower
39	BANNABY	SYDNEY WEST	114.1	Single Circuit Steel Tower
3W	CAPITAL WIND FM	KANGAROO VALLEY	129.0	Single Circuit Steel Tower
41	SYDNEY SOUTH	BEACONSFIELD WEST	19.7	Underground Cable
42	SYDNEY SOUTH	HAYMARKET	27.5	Underground Cable
051	LOWER TUMUT	WAGGA	100.3	Single Circuit Steel Tower
060	JINDERA	WODONGA TS	42.4	Single Circuit Steel Tower
61	YASS	BANNABY	124.2	Single Circuit Steel Tower
62	JINDERA	WAGGA	99.6	Single Circuit Steel Tower
63	WAGGA	DARLINGTON PT	151.7	Single Circuit Steel Tower
64	LOWER TUMUT	UPPER TUMUT	40.6	Single Circuit Steel Tower
65	MURRAY	UPPER TUMUT	45.5	Single Circuit Steel Tower
66	LOWER TUMUT	MURRAY	73.0	Single Circuit Steel Tower
70	MT PIPER	WALLERAWANG	7.9	Double Circuit Steel Tower
71	MT PIPER	WALLERAWANG	7.9	Double Circuit Steel Tower
72	MT PIPER	WELLINGTON	171.0	Single Circuit Steel Tower
76	WALLERAWANG	SYDNEY SOUTH	142.8	Double Circuit Steel Tower
77	WALLERAWANG	INGLEBURN	121.4	Double Circuit Steel Tower
78	INGLEBURN	SYDNEY SOUTH	21.1	Double Circuit Steel Tower
79	WOLLAR	WELLINGTON	117.1	Single Circuit Steel Tower
81	LIDDELL	NEWCASTLE	100.8	Single Circuit Steel Tower
82	LIDDELL	TOMAGO	114.9	Single Circuit Steel Tower
83	LIDDELL	MUSWELLBROOK	17.7	Single Circuit Steel Tower
84	LIDDELL	TAMWORTH 330	139.5	Single Circuit Steel Tower

CIRCUIT NO.	FROM (SITE 1)	TO (SITE 2)	LENGTH (km)	PREDOMINANT CONSTRUCTION
85	TAMWORTH 330	ARMIDALE	103.7	Single Circuit Steel Tower
86	TAMWORTH 330	ARMIDALE	110.9	Single Circuit Wood Pole
87	ARMIDALE	COFFS HARBOUR	137.0	Single Circuit Steel Tower
88	MUSWELLBROOK	TAMWORTH 330	126.9	Single Circuit Steel Tower
89	COFFS HBR	LISMORE	174.3	Single Circuit Steel Tower
8C	ARMIDALE	DUMARESQ	172.0	Double Circuit Steel Tower
8E	ARMIDALE	DUMARESQ	172.0	Double Circuit Steel Tower
8L	DUMARESQ	BULLI CK	49.3	Double Circuit Steel Tower
8M	DUMARESQ	BULLI CK	49.3	Double Circuit Steel Tower
90	ERARING	NEWCASTLE	21.2	Single Circuit Steel Tower
92	NEWCASTLE	VALES PT	35.9	Double Circuit Steel Tower
93	ERARING	NEWCASTLE	20.7	Double Circuit Steel Tower
94	NEWCASTLE	TOMAGO	24.3	Double Circuit Steel Tower
95	NEWCASTLE	TOMAGO	25.4	Double Circuit Steel Tower
96	NEWCASTLE	WARATAH WEST	17.8	Double Circuit Steel Tower
9W	TOMAGO	WARATAH WEST	8.8	Single Circuit Steel Tower
L1	LOWER TUMUT	TUMUT 3	0.6	Single Circuit Steel Tower
L3	LOWER TUMUT	TUMUT 3	0.6	Single Circuit Steel Tower
L5	LOWER TUMUT	TUMUT 3	0.5	Single Circuit Steel Tower
M1	MURRAY	MURRAY 1	4.7	Single Circuit Steel Tower
M3	MURRAY	MURRAY 1	4.7	Single Circuit Steel Tower
M5	MURRAY	MURRAY 1	4.8	Single Circuit Steel Tower
M7	MURRAY	MURRAY 1	4.8	Single Circuit Steel Tower
M9	MURRAY	MURRAY 1	4.8	Single Circuit Steel Tower
M11	MURRAY	MURRAY 2	2.2	Single Circuit Steel Tower
M13	MURRAY	MURRAY 2	2.0	Single Circuit Steel Tower
U1	UPPER TUMUT	TUMUT 1	5.2	Single Circuit Steel Tower
U3	UPPER TUMUT	TUMUT 1	4.9	Single Circuit Steel Tower
U5	UPPER TUMUT	TUMUT 2	3.6	Single Circuit Steel Tower
U7	UPPER TUMUT	TUMUT 2	3.8	Single Circuit Steel Tower

Assets Constructed at Rated Voltage: 330 kV in Service at 132 kV

219	MAMRE ZONE	MT DRUITT	5.9	Double Circuit Steel Tower
250	MT COLAH	SYDNEY NORTH	8.2	Double Circuit Steel Tower
92Z (1)	MT COLAH	SYDNEY EAST	12.6	Double Circuit Steel Tower
92Z (2)	MT COLAH	SYDNEY NORTH	10.5	Double Circuit Steel Tower
932	MT DRUITT	SYDNEY WEST	5.9	Double Circuit Steel Tower
947	ORANGE TEE	MT PIPER 132	23.8	Double Circuit Steel Tower
959	SYDNEY EAST	SYDNEY NORTH	23.1	Double Circuit Steel Tower


CIRCUIT NO.	FROM (SITE 1)	TO (SITE 2)	LENGTH (km)	PREDOMINANT CONSTRUCTION
968	TAMWORTH 330	TWR 13B	3.7	Double Circuit Steel Tower
978	CANBERRA	WILLIAMSDALE	48.5	Double Circuit Steel Tower
97D	CANBERRA	WILLIAMSDALE	48.5	Double Circuit Steel Tower

Assets Constructed at Rated Voltage: 220 kV in Service at 220 kV

CIRCUIT NO.	FROM (SITE 1)	TO (SITE 2)	LENGTH (km)	PREDOMINANT CONSTRUCTION
0X1	BURONGA	RED CLIFFS	23.9	Single Circuit Steel Tower
X2	BURONGA	BROKEN HILL	259.5	Single Circuit Steel Tower
X5/1	DARLINGTON PT	BALRANALD	249.8	Single Circuit Steel Tower
X5/3	BALRANALD	BURONGA	148.0	Single Circuit Steel Tower

Assets Constructed at Rated Voltage: 132 kV in Service at 132 kV

CIRCUIT NO.	FROM (SITE 1)	TO (SITE 2)	LENGTH (km)	PREDOMINANT CONSTRUCTION
097B	BLOWERING	TUMUT 132	13.3	Single Circuit Wood Pole
219	MAMRE ZONE	MT DRUITT	2.4	Double Circuit Steel Tower
250	SYDNEY NORTH	MT COLAH	0.4	Double Circuit Steel Tower
92Z (2)	SYDNEY NORTH	MT COLAH	0.6	Single Circuit Wood Pole
932	SYDNEY WEST	MT DRUITT	1.4	Double Circuit Steel Tower
939	SYDNEY WEST	MAMRE ZONE	3.0	Double Circuit Steel Tower
944	WALLERAWANG	ORANGE	98.3	Single Circuit Wood Pole
945/1	MOLONG	945 TEE	60.2	Single Circuit Concrete Pole
945/2	945 TEE	WELLINGTON 330	6.2	Single Circuit Concrete Pole
947/2	BURRENDONG T	WELLINGTON 330	19.0	Single Circuit Wood Pole
947	ORANGE NTH	BURRENDONG TEE	65.6	Single Circuit Wood Pole
948	ORANGE	PANORAMA	44.8	Single Circuit Wood Pole
949	MT PIPER 132	ORANGE NORTH	70.1	Single Circuit Wood Pole
94B	BERYL	WELLINGTON 330	52.2	Single Circuit Wood Pole
94E	MT PIPER132	WALLERAWANG 132	9.0	Single Circuit Wood Pole
94K	PARKES 132	WELLINGTON 330	116.7	Single Circuit Wood Pole
94M	MUDGEE TEE	BERYL	29.6	Single Circuit Wood Pole
94M/1	ILFORD TEE	MUDGEE TEE	52.2	Single Circuit Wood Pole
94M/2	MT PIPER 132	ILFORD TEE	42.7	Single Circuit Wood Pole
94P	MOLONG	MANILDRA	26.6	Single Circuit Concrete Pole
94T	ORANGE	MOLONG	29.9	Single Circuit Concrete Pole
94U	FORBES	PARKES	30.3	Single Circuit Wood Pole
94X	PANORAMA	WALLERAWANG 132	57.5	Single Circuit Wood Pole
94Y	MT PIPER	MT PIPER 132	1.8	Single Circuit Wood Pole
959	SYDNEY NORTH	SYDNEY EAST	0.6	Double Circuit Steel Tower
962/2	WARABROOK	WARATAH WEST	1.6	Double Circuit Steel Tower
963	KARUAH	TAREE	105.6	Single Circuit Wood Pole
964	PT MACQUARIE	TAREE	66.0	Single Circuit Wood Pole

CIRCUIT NO.	FROM (SITE 1)	TO (SITE 2)	LENGTH (km)	PREDOMINANT CONSTRUCTION
965	ARMIDALE	KEMPSEY	138.7	Single Circuit Wood Pole
966	ARMIDALE	KOOLKHAN	177.0	Single Circuit Wood Pole
967	KOOLKHAN	LISMORE 330	90.2	Single Circuit Concrete Pole
968	TAMWORTH 330	NARRABRI	174.0	Single Circuit Wood Pole
969	TAMWORTH 330	GUNNEDAH	67.7	Single Circuit Wood Pole
96C/1 (A)	ARMIIDALE	DORRIGO TEE	99.8	Single Circuit Wood Pole
96C/1 (C)	COFFS HARBOUR	DORRIGO TEE	40.0	Single Circuit Wood Pole
96F	CLARENCETOWN	STROUD	31.5	Single Circuit Wood Pole
96G	KEMPSEY	PT MACQUARIE	43.1	Double Circuit Concrete Pole
96H	COFFS HARBOUR	KOOLKHAN	80.0	Single Circuit Wood Pole
96L	LISMORE	TENTERFIELD	125.4	Single Circuit Wood Pole
96M	MOREE	NARRABRI	107.2	Single Circuit Concrete Pole
96N	ARMIDALE	INVERELL	111.2	Single Circuit Wood Pole
96P	STROUD	TAREE	85.9	Single Circuit Wood Pole
96R	GLEN INNES	TENTERFIELD	80.3	Single Circuit Wood Pole
96T	ARMIDALE	GLEN INNES	96.0	Single Circuit Wood Pole
96X	WARABROOK	WARATAH WEST	1.6	Double Circuit Steel Tower
96Y	WARABROOK	WARATAH WEST	1.6	Double Circuit Steel Tower
970	YASS 330	BURRINJUCK	37.3	Single Circuit Wood Pole
973	YASS 330	COWRA 132	119.0	Single Circuit Wood Pole
975	QUEANBEYAN	ROYALLA	32.8	Single Circuit Wood Pole
976/1 (C)	CANBERRA	SPRING FLAT	27.4	Single Circuit Wood Pole
976/1 (Q)	QUEANBEYAN	SPRING FLAT	30.1	Single Circuit Wood Pole
976/2	MURRUMBATE T	SPRING FLAT	14.1	Single Circuit Wood Pole
976/2 (M)	MURRUMBATE T	MURRUMBATEMAN	0.2	Single Circuit Wood Pole
976/2 (Y)	MURRUMBATE T	YASS	22.9	Single Circuit Wood Pole
977/1	CANBERRA	SPRING FLAT	27.4	Single Circuit Wood Pole
977/3	QUEANBEYAN	SPRING FLAT	30.1	Single Circuit Wood Pole
978	WILLIAMSDALE	COOMA	74.1	Single Circuit Wood Pole
979	GUTHEGA	MUNYANG	0.5	Single Circuit Wood Pole
97A	TAMWORTH 132	TAMWORTH 330	3.0	Single Circuit Wood Pole
97B	TAMWORTH 132	TAMWORTH 330	3.0	Double Circuit Concrete Pole
97C	TAMWORTH 132	TAMWORTH 330	3.0	Single Circuit Wood Pole
97D	WILLIAMSDALE	COOMA	80.3	Single Circuit Wood Pole
97G/1	MURRAY	GEEHI TEE	18.9	Single Circuit Wood Pole
97G/2	GEEHI TEE	GEEHI DAM	0.5	Single Circuit Wood Pole
97G/3	GUTHEGA	GEEHI TEE	18.3	Single Circuit Wood Pole
97K/1	COOMA	SNOWY ADIT	66.0	Double Circuit Steel Tower
97K/2	SNOWY ADIT	MUNYANG	12.2	Double Circuit Steel Tower

CIRCUIT NO.	FROM (SITE 1)	TO (SITE 2)	LENGTH (km)	PREDOMINANT CONSTRUCTION
97L	GUTHEGA	JINDABYNE	20.8	Double Circuit Steel Tower
990	YASS 330	WAGGA 132	150.3	Single Circuit Concrete Pole
991	MURRUMBURRAH	WAGGA NORTH	114.9	Single Circuit Wood Pole
992	BURRINJUCK	TUMUT	52.7	Single Circuit Wood Pole
993	WAGGA 330	GADARA MILL	79.6	Single Circuit Wood Pole
994	WAGGA 330	YANCO	127.7	Single Circuit Concrete Pole
995	ALBURY	HUME PS	11.9	Single Circuit Wood Pole
996	WAGGA 330	A.N.M.	106.2	Single Circuit Concrete Pole
998	COWRA	FORBES	88.2	Single Circuit Concrete Pole
999	YASS 330	COWRA	114.5	Single Circuit Steel Tower
99A	URANQUINTY	FINLEY	169.0	Single Circuit Wood Pole
99B	ALBURY	JINDERA	17.0	Single Circuit Wood Pole
99D	DARLINGTON PT	YANCO	37.4	Single Circuit Wood Pole
99F	URANQUINTY	YANCO	109.0	Single Circuit Wood Pole
99H	A.N.M.	JINDERA	11.5	Single Circuit Wood Pole
99J	YANCO	GRIFFITH	45.9	Single Circuit Wood Pole
99K	DARLINGTON PT	GRIFFITH	59.7	Single Circuit Concrete Pole
99L	COLEAMBALLY	DENILIQUIN	152.7	Single Circuit Concrete Pole
99M	YASS 330	MURRUMBURRAH	71.9	Single Circuit Wood Pole
99P	GADARA MILL	TUMUT	8.2	Single Circuit Concrete Pole
99T	DARLINGTON PT	COLEAMBALLY	13.3	Single Circuit Concrete Pole
99W	WAGGA 132	WAGGA 330	9.8	Double Circuit Steel Tower
99X	WAGGA 132	WAGGA 330	10.3	Double Circuit Steel Tower
99Z	ALBURY	A.N.M.	9.7	Single Circuit Wood Pole
9R1	WAGGA 330	URANQUINTY	16.6	Single Circuit Concrete Pole
9R2	WAGGA 330	URANQUINTY	16.6	Single Circuit Concrete Pole
9R3	FINLEY	DENILIQUIN	46.6	Single Circuit Wood Pole
9R5	WAGGA 330	WAGGA NORTH	14.8	Double Circuit Steel Tower
9R6	WAGGA 132	WAGGA NORTH	10.3	Double Circuit Steel Tower
9U2	INVERELL	MOREE	143.0	Single Circuit Concrete Pole
9U3	GUNNEDAH	NARRABRI	98.9	Single Circuit Wood Pole
9U4	INVERELL	GLEN INNES	67	Single Circuit Concrete Pole
9U5	TAMWORTH 132	STR 16	14	Double Circuit Concrete Pole
9W2	KEMPSEY	RALEIGH	84.5	Double Circuit Concrete Pole
9W3	RALEIGH	COFFS HARBOUR	25.6	Double Circuit Concrete Pole
9W5	KEMPSEY	MACKSVILLE	52.5	Double Circuit Concrete Pole
9W6	MACKSVILLE	NAMBUCCA	13.3	Double Circuit Concrete Pole
9W7	NAMBUCA	BOAMBEE SOUTH	36.3	Double Circuit Concrete Pole
9W8	BOAMBEE SOUTH	COFFS HARBOUR	13.4	Double Circuit Concrete Pole
9W9	KEMPSEY	PT MACQUARIE	43.1	Double Circuit Concrete Pole

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