TransGrid

Network Development Strategy 2014

A long term strategy for the development of the NSW transmission network

Contents

Executive Summary

This Network Development Strategy (NDS) provides an overview of the transmission network in NSW and the ACT, its history, expected trends and possible developments over the long term. It has been prepared to articulate how short-term transmission network developments are developed to be consistent with longer term expectations of electricity consumption and generation, and strategic plans for developing the transmission network. The strategy will also assist TransGrid to identify key future substation sites and line route segments that may need to be secured early to ensure that efficient development options are not precluded or rendered unfeasible.

Over the period spanned by this NDS, many of the assets that constitute the transmission network will reach the end of their serviceable lives. Effective management of assets throughout their life cycle is critical to achieving the required levels of security and reliability for the transmission system and to minimising asset life cycle costs.

The electricity supply industry worldwide will increasingly be subjected to changing conditions with regard to the level of greenhouse gas (GHG) emissions from power generation. There is little doubt that general community expectations will require reduced carbon emissions by all sectors of society. Accordingly the industry in NSW and Australia is expected to use a variety of measures to minimise future GHG emissions from electricity usage. Abatement strategies that reduce energy consumption may also result in reduced demand on the transmission network.

In addition, potential developments in new technology could, within the period of this NDS, have different influences on the development of the transmission network. Renewable generation technologies such as wind and solar are already having some effects on the transmission system. Emerging technologies like electric vehicles could also have significant effects on demand.

The function of the transmission network is to link major generation centres with major load centres. It is the enabler for the National Electricity Market (NEM), which services the eastern and southern Australian states. The NSW electricity demand on the one hand, and the locations from which it is generated, on the other, will determine the future development of the NSW transmission network. The increasingly distributed nature of generation sources and the potential controllability of some components of demand may also impact on the nature of transmission developments in the future.

In this NDS, the long term expectations of electricity demand and potential generation development to meet that demand are considered, to identify where the development of the transmission network may be required within the next approximately 40 years. These developments will affect both the main interconnected network and regional areas of the network. Major network augmentations tend to have a long development period, from conception to completion, and the asset lives of major plant items can extend over decades. It is necessary to project forward some 40 years to allow network development plans to be adequately integrated with likely changes in energy technology, land use requirements and social developments across the state.

IT IS NECESSARY TO PROJECT FORWARD SOME 40 YEARS TO ALLOW NETWORK DEVELOPMENT PLANS TO BE ADEQUATELY INTEGRATED WITH LIKELY CHANGES IN ENERGY TECHNOLOGY, LAND USE REQUIREMENTS AND SOCIAL DEVELOPMENTS ACROSS THE STATE.

This document is structured as follows:

SECTION 1 – INTRODUCTION

This section gives an overview of the historical development of the NSW power system and an outline of expected future trends. It also provides the strategic context around which network development and asset management are undertaken by TransGrid in NSW.

TransGrid's network comprises assets that have been installed over the period from the 1950s. These assets thus range in age to about 60 years, although the average age is around 25 years.

This NDS covers a nominal period of 40 years and the existing assets will require careful management. A significant proportion may require refurbishment or replacement as they reach end of life condition.

SECTION 2 – DEMAND GROWTH IN NSW

TransGrid's demand projections used for planning the adequacy of the network are based on what is termed "native" demand, which includes all residential and commercial consumption, large industrial consumption, and transmission loss forecasts. The projections thus include small generators embedded within distribution networks such as solar photovoltaic (PV), which are netted from the load.

In recent years energy consumption and demand has fallen. Several factors are likely to have contributed to this change and these are reviewed in section 2.

TransGrid has considered three demand growth scenarios. These scenarios are the same as those used by the Australian Energy Market Operator (AEMO) and are as follows:

- A medium scenario of moderate sustained economic activity, leading to modest growth;
- A higher growth scenario based on high levels of economic activity and resource production, leading to sustained growth; and
- A low growth scenario, involving low levels of economic activity and resource production and slight decreases in long term demand.

Whilst these scenarios form the baseline for considering future transmission system developments, the NDS considers the possibility of demand growth in specific industries in regional areas (eg. mines).

Consideration has also been given to the possibility of reducing demand, in circumstances where customers disconnect from the grid.

SECTION 3 – NSW ELECTRICITY GENERATION DEVELOPMENT

The electricity supply system comprises the transmission network, distribution networks and generators. The transmission network spans the eastern states of Australia and provides bulk supply to regional areas. Bulk supply points throughout the state feed into the distribution networks that convey electricity to all but the largest customers' premises.

Generators may be connected to the supply system at different locations, to both the transmission and distribution networks. Smaller generators connected within the distribution networks act to reduce the demand at points of bulk supply from the transmission network.

This section 3 reviews potential generation developments to provide the energy needs of NSW over the period spanned by the NDS. It includes the consideration of:

- The future of the existing transmission connected coal fired generators;
- Large scale and remote generators connected to the transmission network; and
- Smaller generation developments located within distribution networks.

SECTION 4 – DEVELOPMENTS TO MEET STRATEGIC CHALLENGES AND FUTURE DEMAND

From the perspective of the development of the transmission network, it is the exchange of energy between the generators connected to that network and the net demand presented at bulk supply points that determines the required capability of the transmission network. The alternative demand growth and generation development scenarios are combined to develop a range of likely developments of the transmission network.

Demand management is likely to play an important role in mitigating demand growth in some situations, enabling the deferral or avoidance of augmentation of the transmission network.

Section 4 sets out the development strategies for:

- Interstate interconnections;
- The "core" transmission network;
- Supply to regional areas; and
- Demand management (DM).

1.0

Introduction

As with the development of electricity networks in other Australian states, the NSW transmission network was originally planned and designed by a vertically integrated organisation which managed the development of both generation and transmission capacity.

Introduction

The primary aim of transmission network development was to provide reliable and cost effective connections between the major power stations and load centres in NSW. Construction of the present main transmission system commenced in the mid 1950s, with the development of a 330 kV network to transfer the NSW and ACT (Australian Capital Territory) allocation of Snowy power towards Sydney, supplying the Yass/Canberra/Wagga area on the way.

Almost sixty years on, the "core" transmission network has been developed at voltages of 500 and 330 kV to exchange energy between:

- the major generators;
- the major NSW load centres of Sydney, Newcastle and Wollongong; and
- the states of Victoria, South Australia and Queensland.

The network has also been developed at 330 and 132 kV to provide reliable supplies to the regional areas of NSW. Over this extended period, the electricity demand in NSW has increased by a factor of about seven.

The formation of the National Electricity Market (NEM) in 1998 has significantly changed the role of the NSW transmission network. This has led to generation scheduling and consequential power flows on the NSW network that have been quite different from those for which it was originally planned and designed.

In response to these developments, the network has been fine-tuned to maximise the utilisation of its capacity. This work has included line uprating, extensive voltage support installations and the application of system protection schemes. Little scope exists for further fine tuning of capacity in many parts of the network and demand growth could cause constraints to emerge. Consequently, future requirements for additional network capacity are likely to require the construction of additional major new transmission lines and substations.

The electricity supply industry worldwide is increasingly being subjected to changing conditions with regard to the level of greenhouse gas (GHG) emissions from power generation. There is little doubt that general community expectations require reduced carbon emissions by all sectors of future society. Accordingly the industry in NSW and Australia is expected to continue to use a variety of measures to minimise future GHG emissions from electricity usage.

Such measures include:

- significant Demand Management (DM) measures as a result of community education initiatives and commercial incentives;
- improved end use and supply efficiencies such as incentives to promote energy efficient electrical appliances and improved power generation efficiencies;
- increased focus on the reduction of transmission losses;
- continued development of renewable power generation technologies such as solar, wind, biomass, wave, tidal and geothermal;
- fuel substitution for less GHG intensive fuels such as natural gas; and
- carbon sequestration and carbon capture technologies.

Load reduction measures are expected to continue to mitigate the rate of growth of electrical energy usage from the previous long term trends. This expectation has been factored into the load forecasts detailed in TransGrid's Transmission Annual Planning Report (TAPR) and in this report.

Worldwide, there is significant attention to the control of power systems, generators and loads utilising modern communication systems or "Smart Grid" technology. TransGrid will develop and adopt Smart Grid approaches where they provide economic benefits to the community.

TransGrid's plans for the future development of the transmission network in NSW are detailed in its TAPR, which is issued in June each year. This Network Development Strategy attempts to provide an understanding of how those short term network developments are consistent with longer term probable trends in electricity consumption and strategic plans for network development. It will also assist TransGrid to identify key future substation sites and line route segments which may need to be secured early so that efficient developments are not precluded.

The ACT network is treated as being part of the NSW network as it is fully embedded in the NSW network and has no major local generation. All network developments, population estimates and load growth assumptions applied to "NSW" include those factors attributed to the ACT.

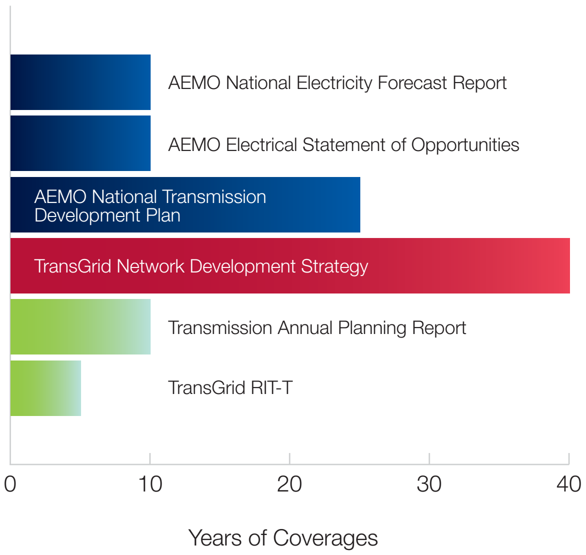
1.1 PURPOSE OF THIS DOCUMENT

This document forms the Network Development Strategy (NDS) for TransGrid. It is intended to define the strategic actions, objectives and approach to the development of the electricity transmission network assets.

The relationship of the NDS to related Australian Energy Market Operator (AEMO) and TransGrid forecasting and planning documents is shown in Figure 1.1. This document covers the development of the transmission network over a longer planning horizon than AEMO's National Transmission Network Development Plan (NTNDP) and TransGrid's TAPR. Individual projects are the subject of the Regulatory Investment Test for Transmission (RIT–T), which requires TransGrid to demonstrate the project provides a net benefit to electricity consumers or that it is necessary to meet statutory requirements and is being done at minimum cost. With the exception of TransGrid's NDS, all of these documents are specified by the National Electricity Rules (the Rules).

FIGURE 1.1

RELATIONSHIP BETWEEN PLANNING DOCUMENTS



This document forms part of a suite of documents and procedures that TransGrid has developed to establish asset management practices that represent good industry practice. The NDS addresses the "plan" lifecycle stage of asset management.

TransGrid's planning to develop the network takes place at a number of different stages:

- This NDS, spanning a period of approximately 40 years;
- The TAPR, which is founded on internal regional area plans, covering a nominal period of 10 years and with greater detail of the forthcoming five year period; and
- Individual project plans and RIT–T analysis. The timing of project plans can vary but, generally, the RIT–T must be completed before significant resources are deployed on a project.

As the time for a development draws near, the uncertainty associated with forecasts lessens and planning is refined from concept outline plans to more detailed designs for obtaining environmental/development approval.

A principal objective of this document is to demonstrate a clear "line of sight" that links TransGrid's corporate mission and vision through to the planning policies and decision making processes that go into the development of this long term NDS. To this end, Figure 1.2 illustrates the interdependencies between these elements and their location within this document.

1.2 REGULATORY CONTEXT

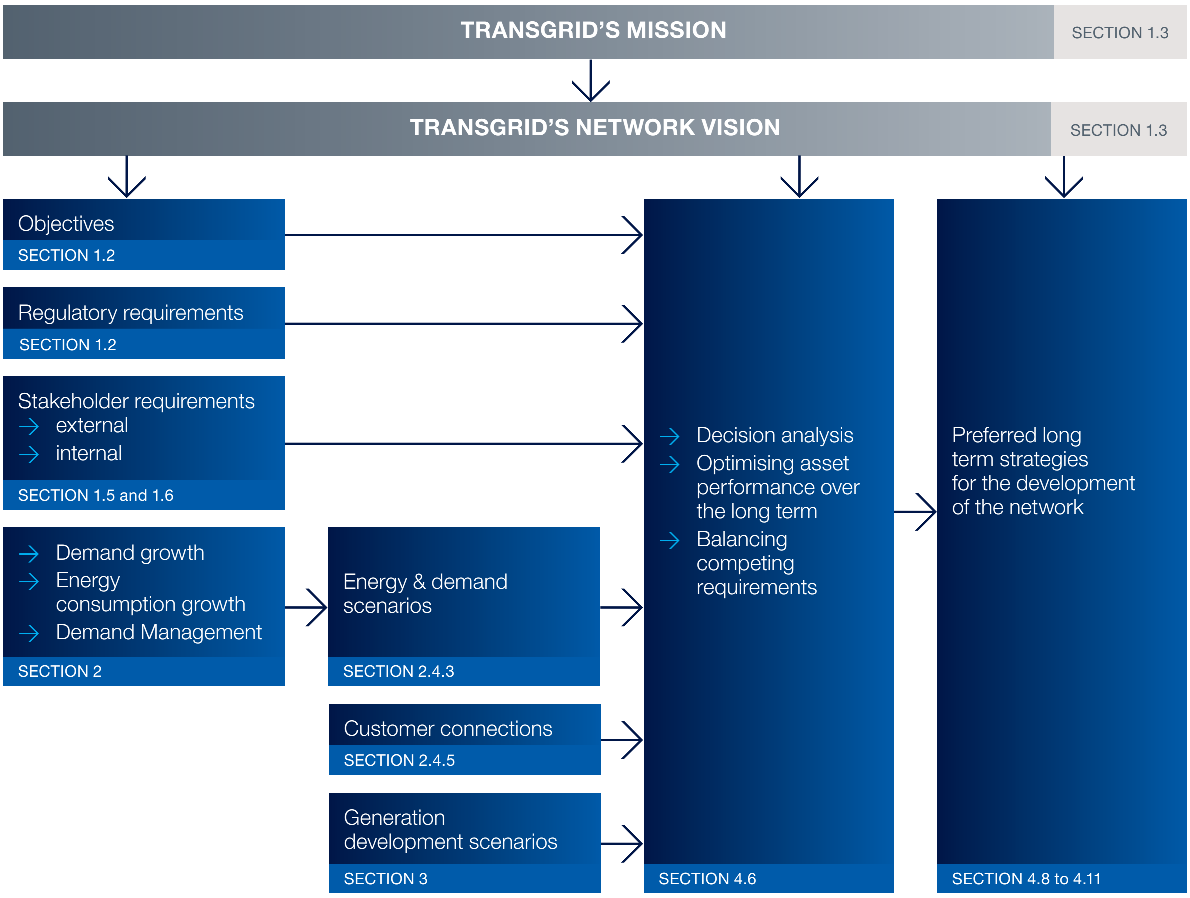
TransGrid is a regulated business that provides high voltage electricity transmission services in NSW as part of the NEM. It is within this framework that TransGrid is required to plan, design, build, operate, maintain and renew its electricity transmission network. TransGrid provides transmission network services directly to electricity distributors in NSW and the ACT, as well as to the large customers and generators directly connected to its network. It is also required to provide services in support of a secure national transmission grid and an effective wholesale electricity market.

The regulatory framework that TransGrid operates within is defined in two critical pieces of legislation, namely, at the:

- National level, the National Electricity Law which sets out the national electricity objective; and
- NSW level, the *Energy Services Corporations Act 1995 No 95* which sets out TransGrid's principal objectives and functions.

These regulatory obligations are outlined in sections 1.2.1 and 1.2.2.

FIGURE 1.2
LINE OF SIGHT



1.2.1 NATIONAL ELECTRICITY OBJECTIVE

The National Electricity Objective that TransGrid is required to achieve, as stated in the National Electricity Law, is:

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

1.2.2 TRANSGRID'S PRINCIPAL OBJECTIVES

The Rules impose an extensive set of service obligations on TransGrid. In delivering transmission services TransGrid is also required to meet the principal objectives of its enabling legislation, the *Energy Services Corporations Act, 1995*. This Act defines the principal objectives of an energy transmission operator in section 6B as:

1. The principal objectives of an energy transmission operator are as follows:
   a. to be a successful business and, to this end:
      i. to operate at least as efficiently as any comparable businesses,
      ii. to maximise the net worth of the State's investment in it,
      iii. to exhibit a sense of social responsibility by having regard to the interests of the community in which it operates,
   b. to protect the environment by conducting its operations in compliance with the principles of ecologically sustainable development contained in section 6 (2) of the *Protection of the Environment Administration Act, 1991,*
   c. to exhibit a sense of responsibility towards regional development and decentralisation in the way in which it operates,
   d. to operate efficient, safe and reliable facilities for the transmission of electricity and other forms of energy,
   e. to promote effective access to those transmission facilities.
2. Each of the principal objectives of an energy transmission operator is of equal importance.
3. Without limiting subsection (1)(b), in implementing the principal objectives set out in subsection (1), an energy transmission operator has the special objective of

OPERATING AT VOLTAGES UP TO

500kV

ASSET AGE IS UP TO

60 YEARS

minimising the environmental impact on land of activities authorised by easements for transmission facilities created in favour of the energy transmission authority. In implementing this special objective, the transmission operator is bound by all relevant laws (such as those concerning native vegetation, soil conservation and easement management) applying at the time.

Finally, regulations under the *Electricity Supply Act, 1995* also impose obligations upon TransGrid to construct, operate, repair and maintain its electricity network with the aim of promoting the efficient, safe, reliable and environmentally responsible production and use of electricity. Specifically, TransGrid is obliged to meet the transmission planning standards set by the NSW Government under these regulations.

1.3 TRANSGRID'S VISION AND MISSION

TransGrid develops its Corporate Plan in accordance with guidance provided from NSW Treasury, within the context of the forecast growth and development of the NSW economy and to deliver on stakeholder requirements. TransGrid's Corporate Plan is refreshed on an annual basis. The vision and mission are stated in TransGrid's Corporate Plan for 2013 to 2018, as follows:

TransGrid's Vision Statement

Excellence in all we do

TransGrid's Mission

To provide safe, reliable and efficient transmission services to NSW, the ACT and the National Electricity Market

TransGrid has developed a Network Vision in order to meet the challenges. TransGrid's Network Vision has identified six key objectives for its network of the future:

1. Deliver safe, secure, environmentally responsible and cost-effective electricity transmission services;
2. Meaningfully engage stakeholders and the community to align expectations with our ability to deliver;
3. Optimise the network in anticipation of future requirements to ensure value is being delivered;
4. Adaptively plan the network to match demand requirements and the changing mix of generation sources;
5. Leverage technology and innovation to optimise the capability and capacity of the network; and
6. Implement flexible and tailored connection solutions.

1.4 ASSET MANAGEMENT GOOD PRACTICE ALIGNMENT

This document has been developed based on good practice guidance from internationally recognised sources, including the Global Forum on Maintenance and Asset Management (GFMAM) and the Institute of Asset Management (IAM). It has been developed to comply with the relevant clauses of BSI PAS 55:2008 (specifically clause 4.3) and the emerging requirements of ISO 55001.

TransGrid is focused on delivering electricity transmission network services of the required level of performance at efficient costs, over the complete lifecycle of the network assets. This includes optimising asset performance. In doing this, TransGrid assesses the incremental costs of delivering an incremental change in network service and performance to customers, relative to the incremental benefits accruing to customers from the delivery of that enhanced network service and performance.

Where the delivery of certain outputs is a function of external obligations placed upon the business (eg. planning standards, legislation stipulating network safety requirements) a different approach is undertaken. More specifically, TransGrid adopts a cost effectiveness (least cost) analysis to ensure that the output is delivered at least cost over the asset lifecycle.

This asset management strategy therefore ensures that all decisions to replace, reuse, operate, maintain, augment or dispose of network assets are justified on economic grounds. The benefits being a function of the explicit customer value proposition, or their proxy via the adoption of minimum performance standards stipulated in legislation or other statutory or regulatory instruments.

Following consideration of relevant asset management good practice TransGrid has also included the documentation of Asset Management Objectives within this Asset Management Strategy document.

This NDS should be read in conjunction with the:

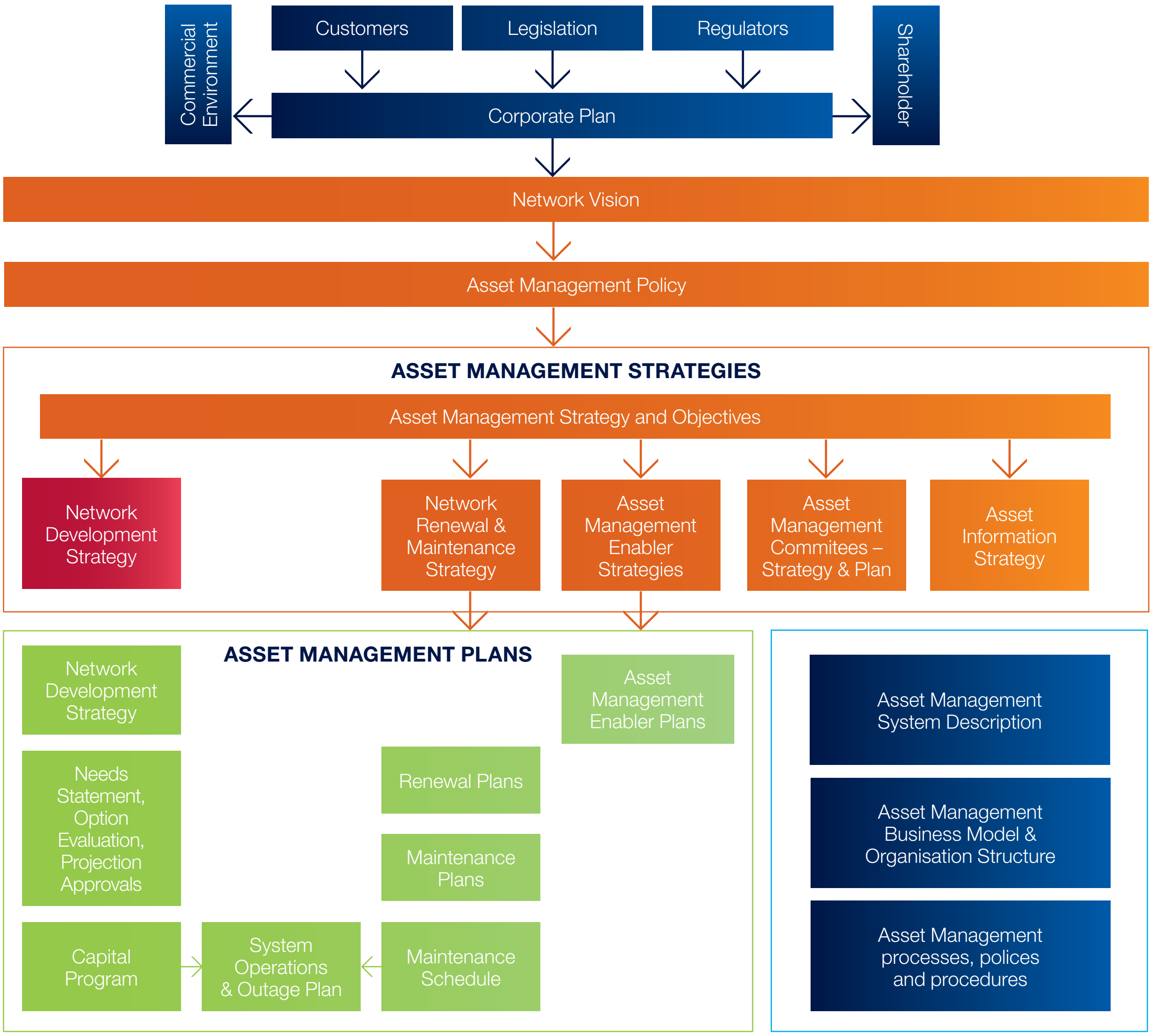
- Asset Management System Description which summarises, in PAS 55 terminology, TransGrid's asset management system, comprising an asset management framework and a document hierarchy. This strategy is one of the components of the asset management system; and
- Asset Management Strategy and Objectives document which sets out the broad asset management strategies for the electricity transmission network.

This document's role within TransGrid's overall Asset Management System is shown in Figure 1.3. The NDS is shown within the red box.

The core asset management documents in Figure 1.3 provide the asset management direction for the optimal combination of lifecycle activities to be applied across TransGrid's portfolio of network asset and asset management systems in accordance with their criticality to the network, condition and performance. This top down connective thread to the Corporate Plan via these documents is a key feature of the asset management system ie. the clear "line of sight" from the organisation's direction and goals down to individual day-to-day activities.

FIGURE 1.3

ASSET MANAGEMENT SYSTEM DOCUMENT HIERARCHY



96
SUBSTATIONS

MORE THAN
12,900km
OF LINES

The latest version of these core asset management system documents is available for all staff and contractors on TransGrid's intranet, called The Wire. These documents are integrated into TransGrid's quality, environment, and health and safety management systems to form an effective and integrated management system.

1.5 EXTERNAL ENVIRONMENT: STAKEHOLDERS AND OTHER REQUIREMENTS

TransGrid's Network Vision identifies the external stakeholders and describes their requirements. These and other requirements arising from the external environment are summarised below:

- **NSW Government:** The NSW Government is the business owner and establishes overarching policies and legislation. The NSW Government currently sets the network reliability standards. TransGrid has a legislative obligation to maximise the commercial value of its business.
- **NSW electricity consumers:** For all but large customers, the transmission price is a small proportion of their energy bill. Nevertheless, recent large electricity price increases in NSW have increased the pressure on TransGrid to contain costs.
- **Climate change and emission reductions:** Whichever approach is adopted by governments to pursue the development of low emission sources of energy and end use energy efficiencies, it will contribute to increases in the price of electricity over at least the next several years. The progressive shift away from existing coal fired generation towards low emission sources may have significant implications for the development of the transmission network particularly if generation is developed in new locations or the output of that generation is intermittent.
- **Industry efficiency and productivity:** A number of recent reviews and proposed changes to the Rules are in response to increased electricity prices. Their aim is to drive regulated network prices and revenues down and extend the role of benchmarking as a tool to improve industry productivity.
- **Economic policy and reform:** The secure and reliable supply of energy at minimum cost underpins the Australian economy. This is the driver for the Australian Government's wide ranging review of the energy industry through its Energy White Paper.[1] The review is aimed at identifying policy and regulatory reforms to improve energy efficiency and productivity and thereby enhancing Australia's international competitive position.
- **Review of national transmission arrangements:** There is ongoing debate over the "right" level of interconnection between the states to enable the sharing of generation resources, and also whether investment by generation proponents and transmission networks can be better "co-optimised". This review has recommended "optional firm access" to the network, contestable connection arrangements and new planning arrangements.
- **Changing attitudes to network reliability standards:** A review of network reliability standards by the AEMC has recently been completed. That review may lead to changes in the way that reliability standards are set. Revised reliability standards would most probably impact on existing methods of managing the transmission network.
- **New connections:** Whilst small customers and generators are connected to distribution networks, the largest will seek connection to the transmission network. TransGrid must manage connection enquiries from prospective major end-use customers and generators, including an increased number of renewable generators like wind, that are not always located close to the existing network.
- **Community resistance to transmission projects:** TransGrid will respond to increasing electricity demand by implementing the most cost effective solution, which may be a non-network option. Often lower cost options which meet the need for a relatively short period are available. When these options are exhausted, it must construct new transmission lines, cables and substations to meet its statutory obligations. All such developments are subject to environmental approval processes and consultation with affected communities.
- **An uncertain future:** The future growth in electricity demand is becoming more uncertain. This adds to the challenge of forecasting capital expenditure needs and justifying these needs in the context of a revenue cap application covering regulatory control periods of generally five years. Key factors contributing to this uncertainty include uncertain future economic conditions, government policies on GHG emission reduction, the market response to rising electricity prices and consumers' uptake of new technologies for managing electricity use.

1 Department of Industry, Energy White Paper – Issues Paper, December 2013.

OVER THE PAST TWO YEARS TRANSGRID HAS ALSO INCREASED ITS FOCUS ON DEVELOPING, RECOGNISING, VALUING AND EMPOWERING ITS PEOPLE AND HAS IDENTIFIED SPECIFIC OPPORTUNITIES TO INCREASE THE LEVEL OF EMPLOYEE ENGAGEMENT.

1.6 INTERNAL ENVIRONMENT

1.6.1 CORPORATE STRATEGIC THEMES

TransGrid's Corporate Planning process is undertaken annually and currently focuses on a five year period. The Corporate Plan for 2013-2018 sets out TransGrid's Vision and Mission as outlined in section 1.3 and focuses on four strategic themes, as shown in Figure 1.4.

FIGURE 1.4

CORPORATE STRATEGIC THEMES

TRANSGRID'S VISION STATEMENT
Excellence in all we do

TRANSGRID'S MISSION To provide safe, reliable and efficient transmission services to NSW, the ACT and the National Electricity Market

SERVICE THE MARKET

- Customer connection experience enhanced
- Transmission constraints efficiently managed
- Information provided to National Electricity Market participants and intending participants enhanced

IMPROVE AND INNOVATE

- Reliability at an efficient price
- A safe and healthy workplace
- A responsive and flexible program delivery process
- An innovative and responsive workplace

CONTRIBUTE TO OUR COMMUNITY

- Confidence of Government
- Positive relationships with stakeholders including customers, consumers and communities
- Public safety ensured
- Environmentally responsible

INCREASE BUSINESS VALUE

- Profitability
- A successful Revenue Determination
- A commercially sound regulatory framework
- Spend as if we own the business

FOSTER A PERFORMANCE CULTURE

THE REFURBISHMENT AND, WHERE APPROPRIATE, REPLACEMENT OF ASSETS REACHING THE END OF THEIR SERVICEABLE LIVES IS THEREFORE AN IMPORTANT ASPECT OF TRANSGRID'S ASSET MANAGEMENT STRATEGY.

These corporate strategic themes are used as a key input to the review and update of the Asset Management Strategies.

Internal stakeholders and their needs are also identified in the Network Vision statement and are summarised below:

- **People:** The organisation has always had a strong focus on keeping employees, contractors and the public safe. Over the past two years it has also increased its focus on developing, recognising, valuing and empowering TransGrid's people and has identified specific opportunities to increase the level of employee engagement.
- **Efficiency and productivity:** As already noted, the external focus on the efficiency of electricity network businesses is intensifying and will need to be addressed, with particular emphasis on drawing on the knowledge of employees to contribute to improved outcomes.
- **Service reliability performance:** The economic and social consequences of major transmission service failures can be so significant that they are generally not considered acceptable by communities in developed countries. TransGrid's transmission network reliability exceeds 99.999%, which reflects the importance consumers place on maintaining a reliable supply of electricity. There is an ongoing need to keep the risk of major transmission service failures very low.
- **Delivering the capital works program:** Timely delivery of the capital works program is vital to TransGrid in meeting its obligations to provide a reliable transmission network. It is also essential to maintaining TransGrid's credibility with key stakeholders. Future demand growth is becoming more uncertain, which poses challenges for the timing and delivery of some long lead time transmission developments.

1.6.2 ASSET MANAGEMENT DRIVERS

ASSET AGEING

The age of an asset does not directly drive the need for its refurbishment or replacement. However, it is usually a factor affecting its serviceability. Prudent asset management will maintain assets in service, where it is economically efficient to do so, with each individual asset being subject to separate consideration. Nevertheless, transmission assets do have finite lives and the generally accepted life span of asset classes is shown in Table 1.1.

This strategy covers the development of the transmission network over a period of 40 years, by which time a significant proportion of the assets currently in service will have been in service for periods exceeding those in Table 1.1. The refurbishment and, where appropriate, replacement of assets reaching the end of their serviceable lives is therefore an important aspect of TransGrid's asset management strategy.

Details of TransGrid's refurbishment and replacement strategies are set out in the Renewal and Maintenance Strategy document.

TransGrid's planning processes integrate development and asset condition needs, allowing any synergies or economies to be captured.

DEMAND GROWTH

The average annual growth rates from AEMO's 2013 forecasts for the NSW region of the NEM are shown in Table 1.2.

Demand growth is discussed further in section 2 of this document.

TABLE 1.1

LIFE SPAN OF TRANSMISSION ASSETS

Asset class	Life (years)
Transmission line (steel tower)	50 – 70
Transmission line (concrete pole)	40 – 50
Transmission line (wood pole)	35 – 40
Power transformers	35 – 50
GIS switchgear	30 – 40
Substation equipment	35 – 50
Secondary equipment (communications, protection and control)	15 – 20

TABLE 1.2

ENERGY AND MAXIMUM DEMAND GROWTH RATES

	Actual/estimated 2005/06 to 2012/13	Projected 2013/14 to 2022/23	Projected 2013/14 to 2032/33		
Energy Sent Out	-0.9%	0.6%	0.4%		
	Actual 2005/06 to 2012/13	Projected 50% POE 2013/14 to 2022/23	Projected 50% POE 2013/14 to 2032/33	Projected 10% POE 2013/14 to 2022/23	Projected 10% POE 2013/14 to 2032/33
Summer Peak Demand	0.6%	0.9%	0.7%	1.0%	0.7%
	Actual 2006 to 2012	Projected 50% POE 2013 to 2022	Projected 50% POE 2013 to 2032	Projected 10% POE 2013 to 2022	Projected 10% POE 2013 to 2032
Winter Peak Demand	-1.1%	1.0%	0.9%	1.1%	0.9%

POE: Probability of exceedence
Source: AEMO 2013

ADVANCES IN TECHNOLOGY

Advances in technology are enabling a broader range of solutions to network constraints to be considered by Transmission Network Service Providers (TNSPs). The consideration of demand side solutions and smart network initiatives are two areas where stakeholders can exploit new technology.

The current focus on energy efficiencies and climate change policy are fuelling advances in the efficiency of energy generation and usage. This includes new gas fired generation (at a macro and micro level), gas fired air conditioning and more efficient co-generation and tri-generation solutions. The Australian Government's incentives will encourage clean energy technologies. In this regard, the Government's Energy White Paper is currently canvassing ways in which the uptake of low emissions intensity generation may be progressed.[2]

The benefits of advances in technology in primary asset classes include:

- Increasing reliability through the use of fewer components and improved materials;
- Increasing availability of online condition monitoring equipment;
- Provision of improved information to support condition based maintenance; and
- Aggregation of previously discrete primary assets.

The dominant trend in secondary systems is toward the application of digital technology devices and systems with in-built intelligence and integrated functionality. These digital technology platforms add value by:

- Increasing functionality, reliability and availability through the use of microprocessors, solid state devices, digital technology and optic fibre based communication systems;
- Lowering per function capital costs whilst increasing performance capability;
- Embedding intelligent diagnostic software that optimises operation and improves asset management;
- Rationalising equipment via functional integration and multiple signal processing capability; and
- Providing remote management facilities for network elements based on real time data communications.

2 Department of Industry, Energy White Paper – Issues Paper, December 2013, p. 37.

THE CURRENT FOCUS ON ENERGY EFFICIENCIES AND CLIMATE CHANGE POLICY ARE FUELLING ADVANCES IN THE EFFICIENCY OF ENERGY GENERATION AND USAGE

CLIMATE CHANGE

Climate change has been identified as a driver of change in TransGrid's operating environment, affecting:

- Consumers' demand for electricity (eg. growth in the use of air conditioners, increased use of rooftop solar panels to generate electricity). This aspect is addressed in this NDS through the range of forecast demands that have been considered.
- The weather events to which the transmission network is exposed, with potential greater prevalence of extreme events such as storms and flooding and incidence of bushfires. This consideration could influence the design and specification of equipment and TransGrid's operational response to events, but is unlikely to lead to changes in the manner in which the transmission network is developed.

There is currently some uncertainty about the way in which climate change will be addressed through Government policies. Regardless of the mechanism adopted by government (carbon tax, emissions trading, or direct action) climate change is still expected to cause gradual changes that will affect the development of the transmission network.

GOVERNMENT INITIATIVES

TransGrid will be required to respond to Government initiatives that could potentially impact on the development of the transmission network. The Solar Cities program closed on 13 June 2013 and was principally directed at showcasing energy efficiency. The Smart Grid Smart City program focuses on energy efficiency enablement technologies and the development of the distribution network.[3] If programs such as these lead to the broader adoption of enabling technologies, they have the potential to result in altered energy consumption and demand at the transmission level.

The Coalition Government's Direct Action Plan commits funding to a number of initiatives supporting renewable energy including a study into high voltage connections to remote renewable generation.[4] Should such an initiative prove viable, it is likely to influence the way in which the transmission network is developed.

RESOURCING

Retaining and developing TransGrid's long term established and experienced personnel is critical to the successful future of the organisation. Knowledge sharing and skills transfer are critical objectives. Programs designed to promote behaviours and activities consistent with TransGrid's values facilitate these objectives.

More immediately, the industry faces skill shortages through retirement of an aging workforce. The employee retirement profile is driving the increasing demand for knowledge management, skills transfer, training and recruitment.

SUPPLY CHAIN

TransGrid relies heavily on external workforces for the delivery of capital and maintenance programs. As such, significant time and effort is taken to build and maintain relationships with external contractors, specifically the primary service providers.

3 Department of the Environment, Water, Heritage and the Arts, Smart Grid, Smart City – A new direction for a new energy era, 2009.

4 Department of Environment & Climate Change, The Coalition's Direct Action Plan, 17 June 2010, p. 25.

2.0

Demand Growth in NSW

This section highlights issues and assumptions associated with forecasting electricity load growth in NSW over the long term.

Demand Growth in NSW

AEMO has assumed the responsibility for producing aggregate energy and demand projections for NSW (the NSW region includes the ACT). These NSW region load growth forecasts are used by TransGrid for NSW transmission planning and by AEMO in preparing the annual Electricity Statement of Opportunities (ESoO) and the NTNDP. These forecasts extend for a period of 20 years.

TransGrid also co-ordinates the publication of "Bulk Supply Point" load forecasts in NSW which are provided by the NSW/ACT Distribution Network Service Providers (DNSPs): Ausgrid, Endeavour Energy, Essential Energy and ActewAGL. Those forecasts are used by TransGrid when jointly planning the parts of the transmission network which serve those DNSPs.

The load forecasts used in this report are consistent with the NSW region load forecasts detailed in TransGrid's 2013 TAPR as supplied by AEMO in the 2013 National Electricity Forecasting Report. AEMO's longer term load forecasts are detailed in Section 2.4.3.

Future demand growth will be strongly influenced by developments in various sectors of the economy. Whilst the above forecasts form the "base-line" for planning future developments, it is possible that some sectors may grow more strongly in the global economy, where Australia has an advantage. Deloitte Access Economics has identified gas, agribusiness, tourism and wealth management as potential opportunities. These sectors taken together have the potential to contribute as much to the Australian economy as mining.[5] Deloitte Access Economics has commented that NSW's portfolio of industries is better suited to the sectoral growth drivers of the next two decades.[6]

Another perspective considers the possibility of decreasing electricity demand due to factors such as further closure of manufacturing or consumers going off grid.

There are thus uncertainties associated with demand growth forecasts at both a state wide and local level. Thus a forecast scenario approach is taken in considering the development of demand and generation and the potential flow on impacts on the transmission system. The transmission network underpins the economic development of the State and TransGrid will respond by developing the network to provide a secure and reliable system to match the state's requirements.

2.1 KEY CHARACTERISTICS OF ELECTRICAL DEMAND

In order to maintain a satisfactory supply of electricity to consumers it is important to respond to the peak demand for electricity.

Peak demand is the greatest instantaneous demand (rate of electrical energy consumption) used in a summer or winter season. Summer peaks generally occur during mid afternoons and winter peaks in early evenings as evident from the daily load profiles given in Figure 2.1.

Energy consumption is the total quantity of electricity consumed. The area beneath each demand curve in Figure 2.1 represents the energy consumed on those days.

At any one time the total electricity generated on a power supply system is equal to the combined requirements of all the end use electrical devices that are operating plus power station internal power requirements, transfers to and from energy storage, transmission network losses and distribution network losses.

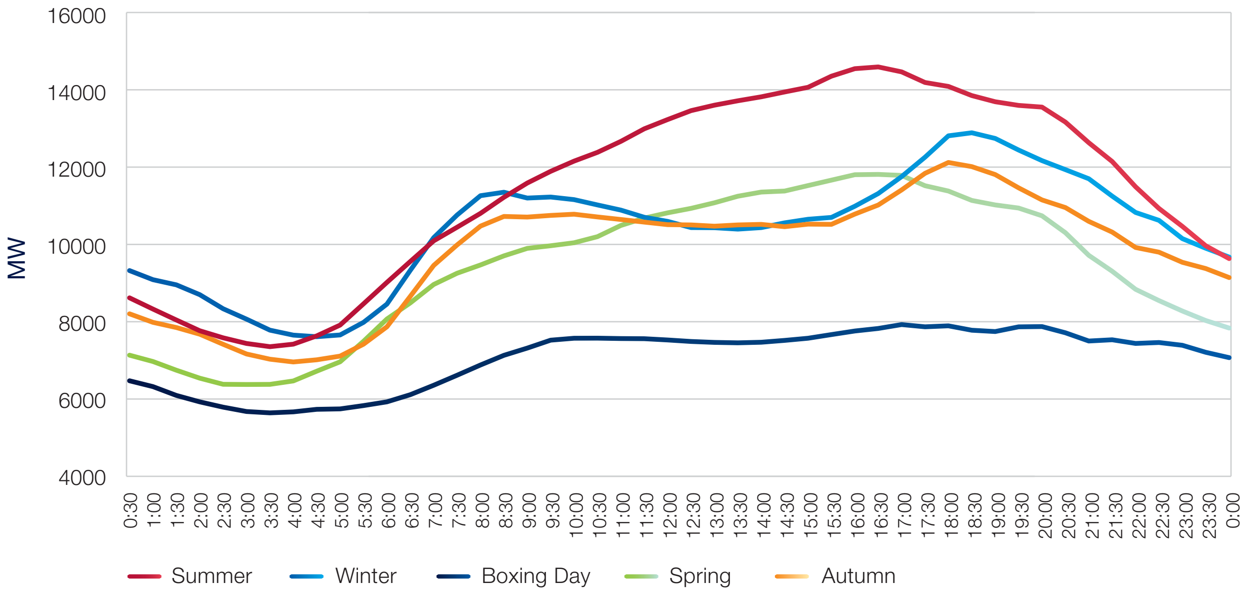
Whilst the usage of any single device usually varies as a function of time many common devices tend to be used in a similar manner leading to characteristic patterns of electricity consumption. For example lighting device usage patterns depend on seasonal variations in daylight while heating and cooling device usage patterns depend on the weather. The extent of intra-day and interseasonal variations in the NSW electrical demand are illustrated by the half-hourly demand curves for typical days in Figure 2.1.

5 Deloitte Access Economics, Positioning for Prosperity? Catching the next wave, 2013, pp. 11, 19.

6 Deloitte Access Economics, Business Outlook, September 2013, p. 94.



FIGURE 2.1
DAILY LOAD PROFILES



Source: AEMO

Some characteristic features of these demand curves are that:

- the highest demands occur on hot summer afternoons and cold winter evenings;
- in colder weather a morning and evening peak is evident but in warmer weather the demand builds up gradually towards an afternoon peak;
- the minimum demand for the entire year typically occurs on Boxing Day; and
- the lowest daily demands occur in the early hours of the morning at all times of the year.

2.2 GROWTH OF ELECTRICITY CONSUMPTION IN NSW

HISTORICAL ENERGY GROWTH

Over the past half a century, growth in electricity consumption in NSW has primarily been driven by:

- Population growth; and
- An increase in electricity consumption per capita.

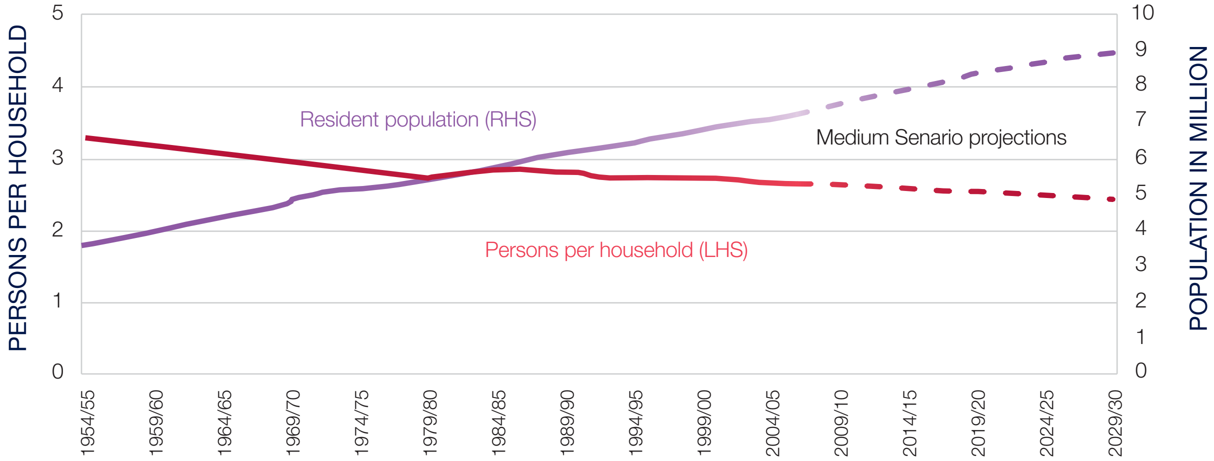
The population of NSW has grown from around three and a half million in the mid–1950s to nearly eight million in 2013. By the year 2031 it is forecast to reach almost nine million based on NIEIR/ABS (National Institute of Economic and Industry Research/Australian Bureau of Statistics) projections. At the same time, the number of households has grown at a slightly higher rate, reflecting a decrease in the average number of persons per household. Figure 2.2 shows historical and forecast trends of population and persons per household in NSW region.

Until about 2008/09, the general trend of fewer people living in each household has led to increasing electricity consumption per person. Secondary drivers of increasing electricity consumption per person include growing real incomes, the increasing use of energy in production and (until recent years) more or less stable real electricity prices.

The Global Financial Crisis (GFC) marked a turning point in this trend of increasing electricity consumption per capita. Although past trends in population and households are expected to continue, electricity consumption per capita is expected to decline. The reasons for this are discussed in the following.

FIGURE 2.2

TRENDS IN NSW/ACT POPULATION AND HOUSEHOLDS



Source: ABS demographic statistics and NIEIR population projections

FACTORS AFFECTING ENERGY CONSUMPTION

The historical and projected growths in residential and commercial electrical energy consumption per capita are shown in Figure 2.3. The chart shows a sharp fall in electricity usage per capita in the aftermath of the GFC

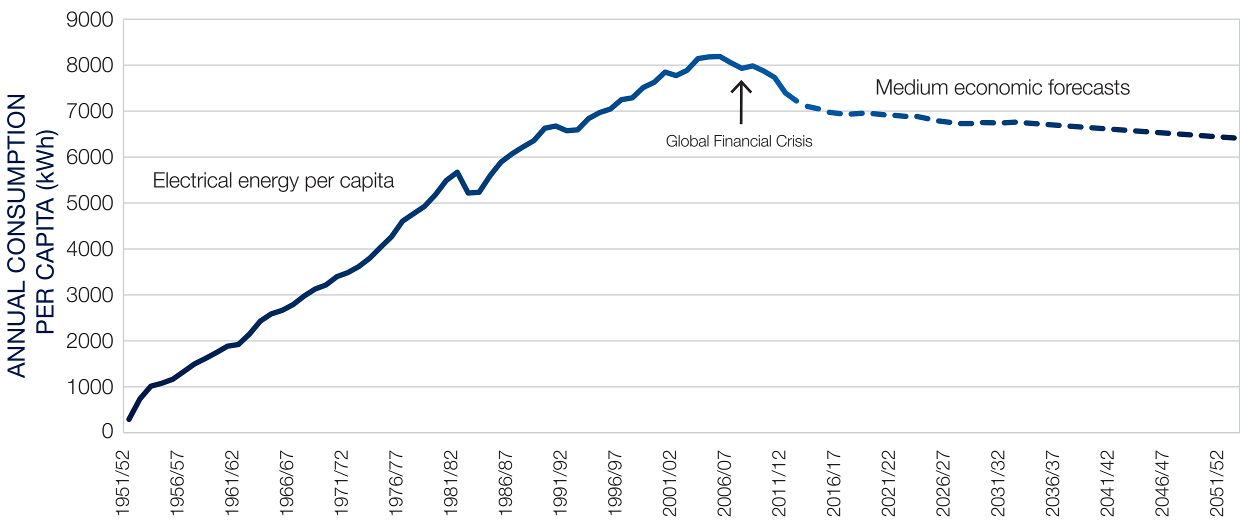
It is likely that overall energy consumption will revert back to a positive rate of growth in the years to come, however, energy per capita is expected to continue to decline due to a combination of factors mentioned above.

The recent sharp fall may be attributed to:

- Apparent changes in weather patterns;
- A downward revision of economic growth;
- Sharp rises in electricity price;
- Depressed consumer sentiments and their cautious spending behaviour;
- Rising Australian dollar;
- Fuel substitution; and
- Energy efficiency initiatives and increased installation of solar photovoltaic (PV).

FIGURE 2.3

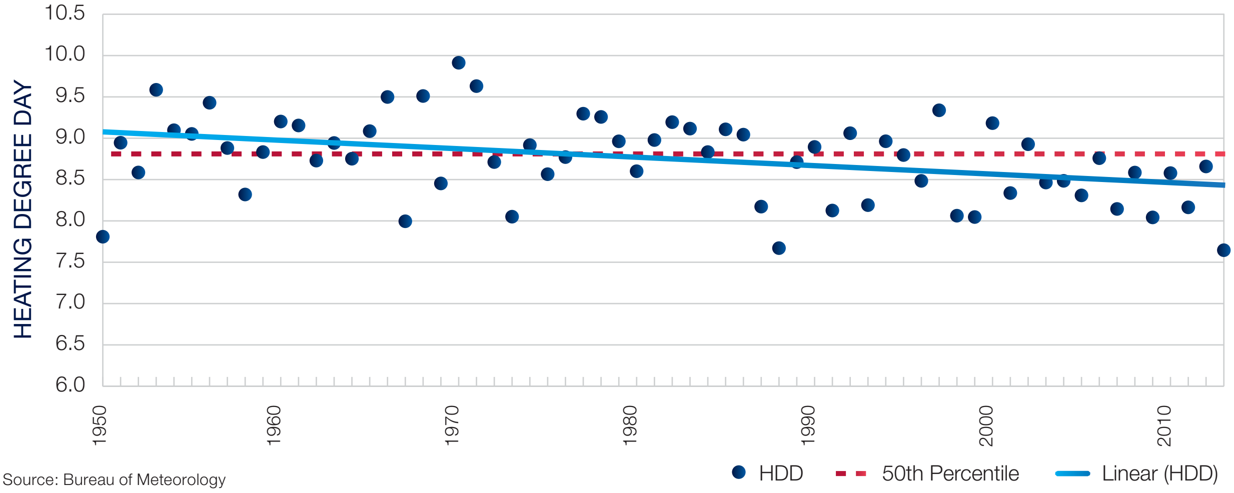
RESIDENTIAL AND COMMERCIAL ELECTRICAL ENERGY CONSUMPTION PER CAPITA



Source: AEMO, ABS, NIEIR

FIGURE 2.4

TRENDS IN AVERAGE WINTER HEATING DEGREE DAYS



Source: Bureau of Meteorology

These factors are discussed below.

APPARENT CHANGES IN WEATHER PATTERNS

Figure 2.4 shows trends in average heating degree days during the winter months in the past few decades. Heating degree days are constructed as deviations from a particular threshold temperature during the winter months (a high number represents a cold winter and a low number points to a mild winter). It is evident from the chart that winters in NSW have become milder particularly so in the last few years which would have contributed to lower electricity maximum demand and energy consumption. However, average cooling degree days during summer months do not show any trend though the past few summers have been milder than average.

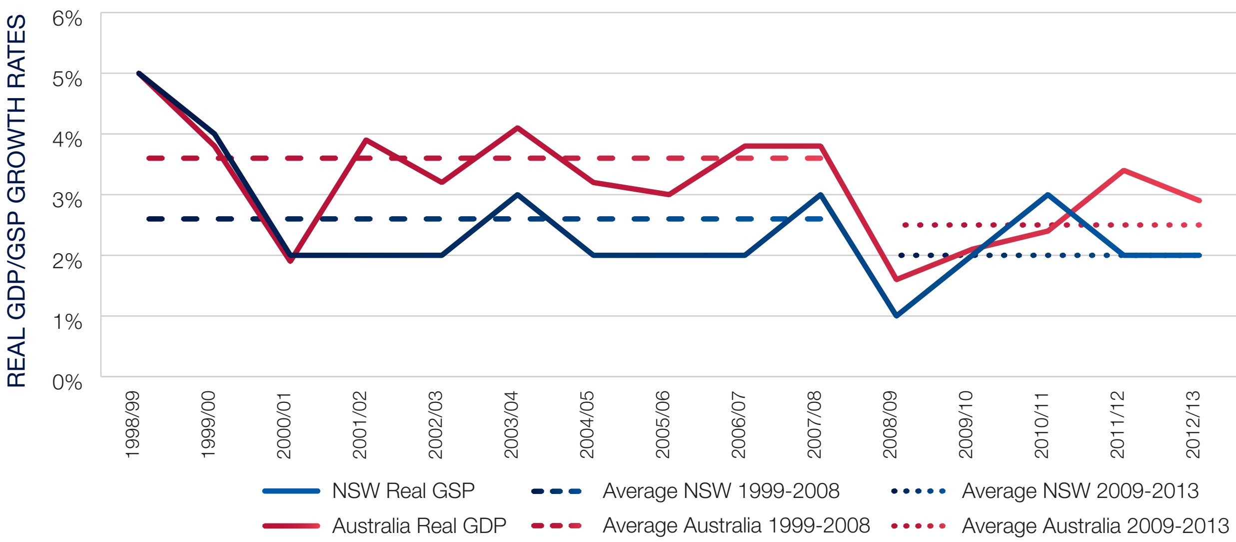
Many climate scientists believe that climate change will increase the duration, frequency and severity of future extreme weather events. Such events may increase the loading on the network and/or affect its ability to serve that load, such as through causing damage to parts of the network.

A DOWNWARD REVISION OF ECONOMIC GROWTH

For most of the period between 1998/99 and 2007/08, the Australian and NSW economies have grown at an average rate of 3.6 and 2.6% respectively, which have been close to their historical trend rates of growth. However, there has been a sharp decline in the average rates of growth after the GFC. Figure 2.5 shows those changes in economic growth rates pre and post GFC. To the extent that energy consumption is correlated with economic growth, deceleration in economic growth is likely to contribute to a decline in energy consumption.

FIGURE 2.5

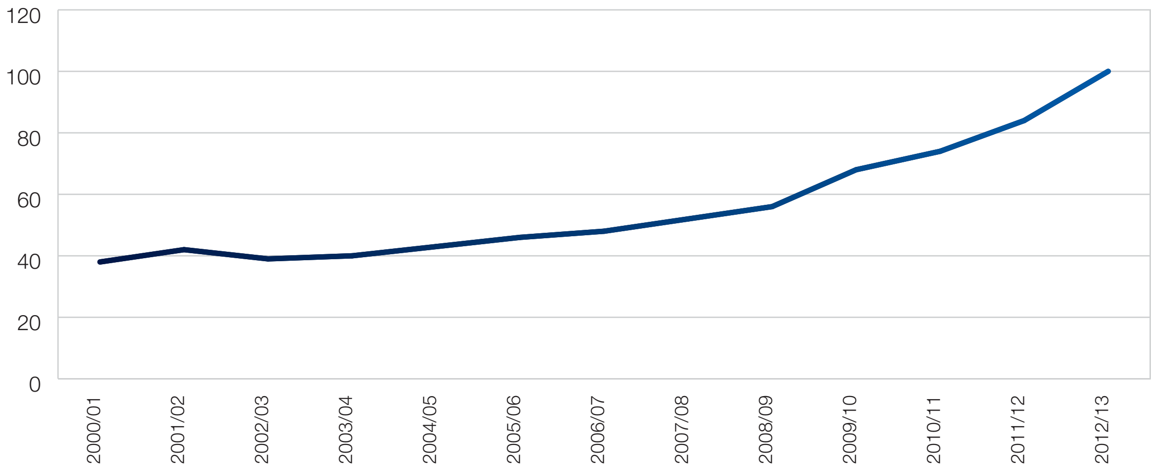
AUSTRALIA AND NSW ECONOMIC GROWTH



Source: ABS, Deloitte Access Economics

FIGURE 2.6

RESIDENTIAL AND COMMERCIAL ELECTRICITY PRICES IN NSW (REAL $2012/13)



Source: AEMO, NIEIR

SHARP RISE IN ELECTRICITY PRICE

The increases in electricity prices over recent years (refer to Figure 2.6) are likely to have had an impact on electricity usage. As customers pay for energy used over an extended period (such as one or three months), the focus may have been on electricity usage in general, rather than usage at times of maximum demand. Nonetheless, changes in energy usage would probably have had some effect on maximum demands.

There may have been interactions between factors, for example economic uncertainty may have heightened consumer awareness of price increases and amplified responses.

CONSUMER BEHAVIOUR

In recent years household savings have returned to levels not seen since the 1980s (refer to Figure 2.7). The re-emergence of the so called "cautious consumer" is likely to have influenced the purchase and usage of energy consuming devices, as are other factors such as energy efficiency programs.

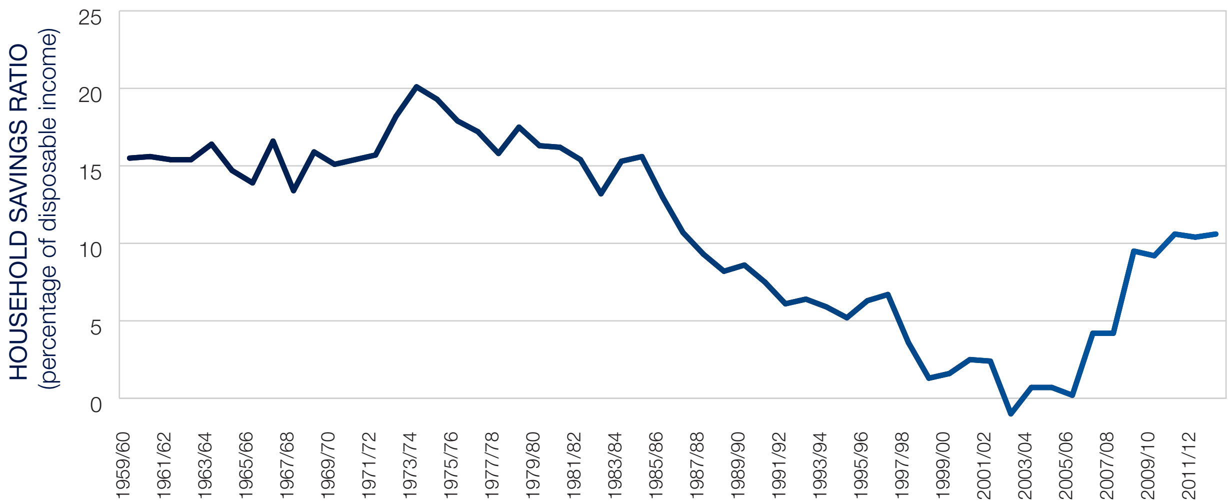
CONSUMER SENTIMENT INDEX

The GFC started in 2008/09 with the United States and some European countries being particularly affected. Fortunately, Australia has fared better than many other countries.

Figure 2.8 shows the Westpac Melbourne Institute index of Australian consumer sentiment. There was a sharp decline in Consumer Sentiment in the immediate aftermath of the GFC. The average level of the consumer sentiment index has been lower post GFC compared to the pre GFC period. A lower consumer sentiment index generally would have some effect on consumer spending habits.

FIGURE 2.7

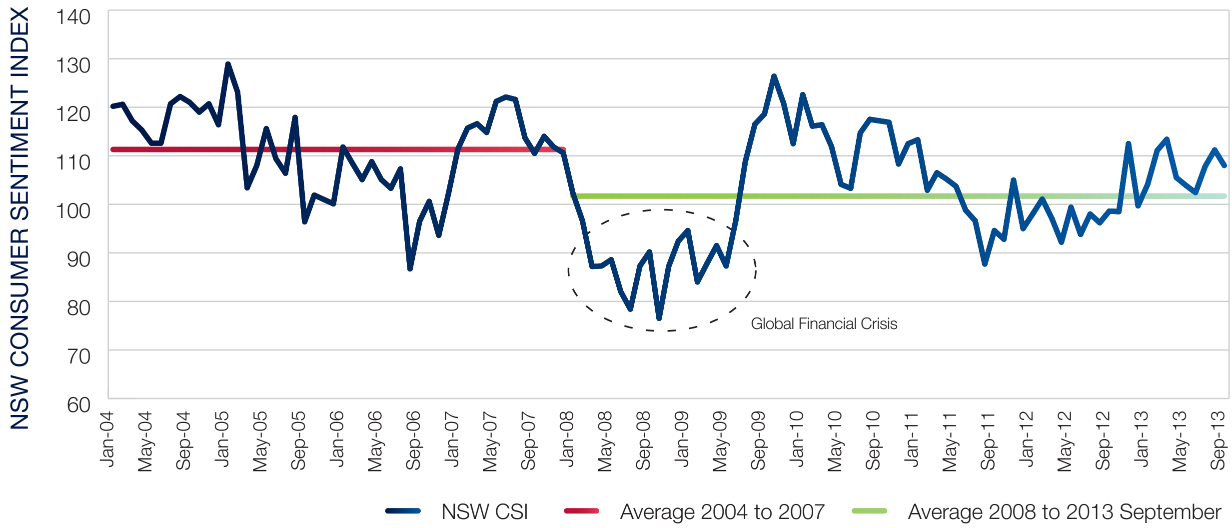
HOUSEHOLD SAVINGS RATIO



Source: ABS

FIGURE 2.8

CONSUMER SENTIMENT INDEX FOR NSW



Source: Westpac Melbourne Institute

EFFECTS OF RISING AUSTRALIAN DOLLAR

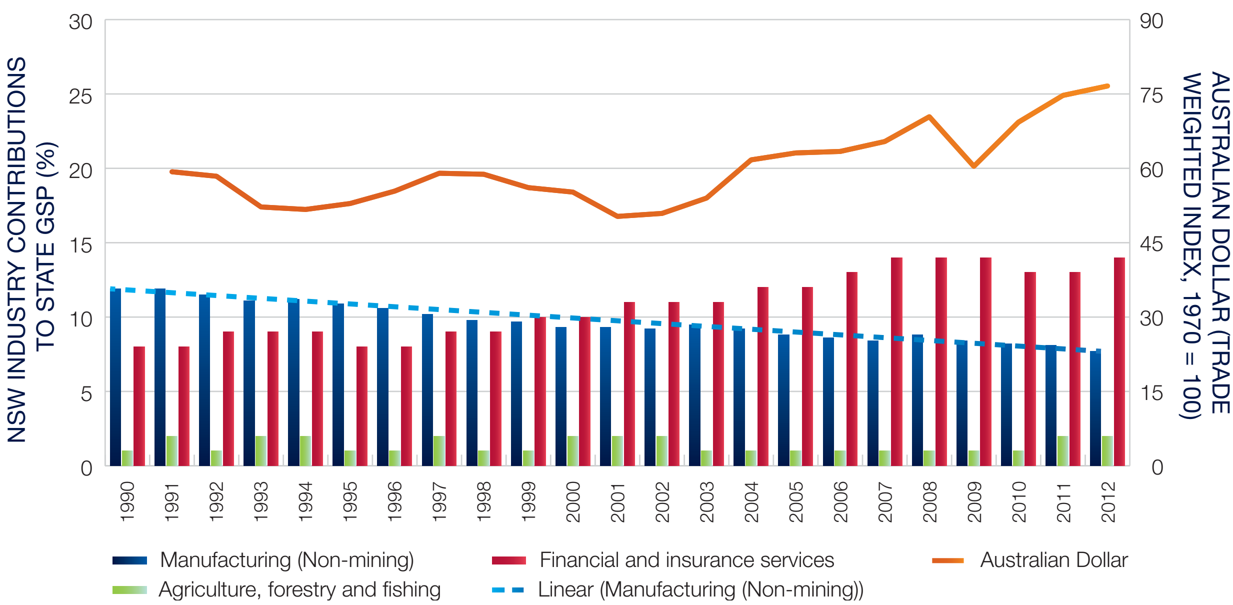
Over the last twenty years, NSW has continued to witness a period of deindustrialisation. The share of non-mining manufacturing has shrunk from 12% of state GSP in 1990 to around 8% of state GSP in 2012. One contributing factor for this would be the rise in the value of the Australian dollar against the US dollar over about the last decade, which renders Australian and NSW manufacturing less competitive in the international market and imports cheaper into Australia and NSW.

Also, the rising cost structures of manufacturing in NSW could be another factor contributing to the decline in manufacturing.

Anecdotal evidence is that in recent years many small businesses have closed down or relocated manufacturing overseas. Some larger businesses in the automobile and textile sectors have also done the same. The closure of the Kurri Kurri Aluminium Smelter has resulted in a step decline in total industrial energy consumption in NSW. Trends in the NSW manufacturing share and the Australian dollar are shown in Figure 2.9.

FIGURE 2.9

TRENDS IN NSW MANUFACTURING SHARE AND AUSTRALIAN DOLLAR



Source: ABS

SOLAR PV CAN REDUCE THE ENERGY CONSUMED THROUGH THE ELECTRICITY NETWORK BY ALLOWING RESIDENCES TO GENERATE THEIR OWN ELECTRICITY DURING THE DAY, OFFSETTING THEIR OWN CONSUMPTION AND EXPORTING EXCESS ENERGY BACK INTO THE DISTRIBUTION NETWORK

FUEL SUBSTITUTION

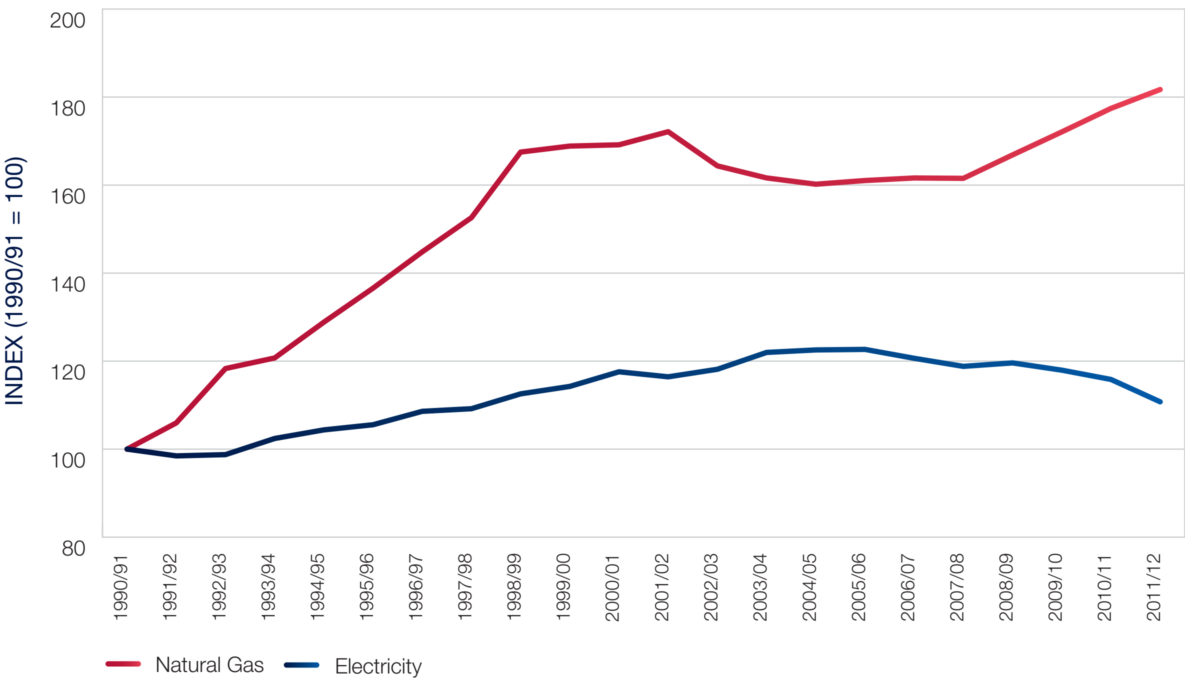
Historically, electricity and natural gas usage have increased in per capita terms. Figure 2.10 shows the per capita growth in residential and commercial electricity and residential gas consumption in NSW from 1991 to 2012. Whilst per capita growth in electricity consumption has declined after the GFC, per capita gas consumption has continued to show a very strong growth. There appears to be a fuel substitution effect from electricity to gas, especially in the last five years, coinciding with the increase in electricity prices and in response to government initiatives. There is also anecdotal evidence of a greater number of gas connections to new residences, replacement of electric water heaters with gas heaters and substitution of electric cooking and space heating appliances with their gas counterparts. There is the potential for future shifts in fuel substitution, depending on factors such as the development of new gas production facilities and future opportunities for the export of gas.

ENERGY EFFICIENCY INITIATIVES AND INCREASED INSTALLATION OF SOLAR PV

NSW has seen a change in annual energy usage and maximum demand patterns due to the increased penetration of solar PV systems and energy efficiency measures amongst other factors. Solar PV can reduce the energy consumed through the electricity network by allowing residences to generate their own electricity during the day, offsetting their own consumption and exporting excess energy back into the distribution network. Energy efficiency measures allow users to achieve the same final demand (for lighting, heating, cooling, etc.) using less electricity. Government initiatives such as energy efficient standards for appliances, standards for new building designs and schemes to encourage industrial users to replace equipment with energy efficient alternatives have contributed to this effect. A discussion on solar PV and Energy Efficiency estimates is presented in Section 2.4.4.

FIGURE 2.10

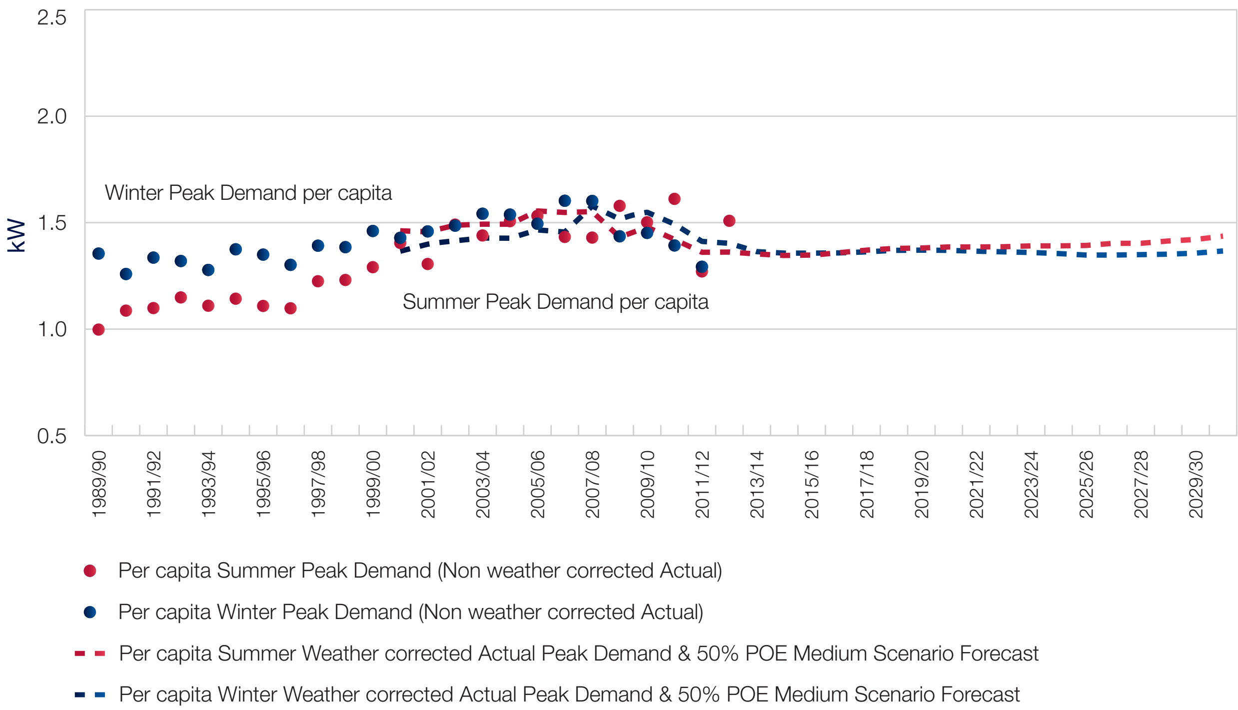
NSW RESIDENTIAL PER CAPITA CONSUMPTION INDEX OF NATURAL GAS AND ELECTRICITY



Source: TransGrid, AEMO, Bureau of Resources and Energy Economics (BREE)

FIGURE 2.11

RESIDENTIAL AND COMMERCIAL PER CAPITA PEAK DEMANDS



Source: AEMO, NIEIR, TransGrid

2.3 GROWTH OF PEAK DEMAND IN NSW

Per capita peak electricity demand in NSW has grown over the last 50 years in a manner that is consistent with electrical energy growth.

Historically peak demand in NSW has occurred during winter months. Winter peak demand occurs during the evening on a working day and is predominantly driven by heating loads that coincide with mealtimes.

Until the late 1980s summer peak demand in NSW was not significant because the peak demand during the "summer" months of November to March was exceeded by peak demands in either October (spring) or April (autumn) as well as the winter peak demand. However in recent years the growth in summer peak demand has accelerated to the point where in some years it has exceeded the preceding winter peak demand.

Both summer and winter peak demands are highly variable depending to a large extent on prevailing temperatures. The "peakiness" of summer demand (and to some extent winter demand) is related to air-conditioning ownership and use. As air-conditioners have become more common in new households and the cost of retrofitting split systems in existing buildings has decreased, air-conditioner ownership has accelerated in NSW. At some point, this trend is expected to largely conclude with the number of air-conditioners per household reaching equilibrium, although there is some evidence that households are tending to install a second air-conditioner. Replacement of old air-conditioners with new, more efficient units may also reduce demand.

Figure 2.11 above shows historical residential and commercial winter peak demand per capita (blue line) growing from around 1.35 kW per person in the late 1980s to a level of 1.6 kW in 2008 (though the demand has reduced in 2011/12 due to lower energy consumption compared to previous years). The growth in per capita consumption has been stabilising from the 1980s onwards due to the introduction of natural gas as an alternative fuel for household water heating, space heating and cooking. Historical summer peak demand has grown from around 1 kW in late 1980s to around 1.6 kW in 2010/11 and declined after that. According to PV estimates provided by AEMO the future growth in peak summer demand will be offset by rapid uptake of solar PV.

The recent real electricity price increases, policy measures to reduce peak demand and increase energy efficiency are expected to result in the tapering off in future peak demand growth compared to the historical trends.

2.4 NATIVE ENERGY AND DEMAND

Energy and demand projections used by TransGrid for planning purposes are based on "Native" quantities (demand and energy) rather than the underlying per capita quantities discussed above. Native energy and demand represent those loads supplied by "Scheduled" generators plus "Semi-Scheduled" and "Non-Scheduled" generators.

A rationalisation of the Australian aluminium industry led to the closure of the smelter at Kurri Kurri in 2012. The remaining large industrial load in the Newcastle area has combined energy consumption in the order of 8,500 GWh per annum or approximately 12 % of total NSW energy consumption. They have a combined peak in the order of 1,000 MW and together represent approximately 8% of NSW peak demand.

AEMO's demand and energy projections for NSW assume that the remaining large industrial loads will have little or no growth in the next 20 years.

2.4.1 EMBEDDED GENERATION DEVELOPMENTS

In some locations, embedded generation developments may reduce reliance on the transmission network by reducing or modifying the consumption of electricity.

Embedded generation developments may include generation or co-generation facilities. Energy sources for these developments may include but are not limited to:

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

2.4.2 DEMAND MANAGEMENT AND CONSIDERATION OF NON–NETWORK OPTIONS BY TRANSGRID

The primary drivers for investment in new assets on the NSW transmission network are:

- the need to replace ageing assets based on condition; and
- increases in peak demand.

As some critical system elements age their ratings are sometimes reduced. When equipment reaches the end of its serviceable life and is retired, the capability of the network can also decrease. System constraints can arise through increasing load, decreasing network capacity or both. Irrespective of what causes the constraint, both network and non-network options are potential solutions. Where cost effective, non-network options can reduce, defer or eliminate the need for new transmission investments thereby reducing expenditure as well as the environmental impacts associated with construction of new assets.

DEMAND MANAGEMENT

'Demand management' is a broad term used to refer to any deliberate change to the amount of electricity demanded from the network, and encompasses two distinct areas:

- **demand response,** 'a short run decision to reduce energy consumption in response to a specific event (for example, load shedding in response to a network constraint), and
- **energy efficiency,** referring to 'the use of less energy for the same activity or level of output, or increasing the level of output from the same amount of energy'[7].

Thoughtful application of demand management can reshape the demand profile and allow cost effective deferral or avoidance of investment in network capacity and in network measures to ensure reliability and security of supply. As a result, consumers generally can benefit from the consequent reduction in network costs in their electricity bills and even individually through participation in demand management themselves.

Demand management options for addressing network needs are particularly cost effective in a low demand growth environment where a small forecast growth in demand may be best met by a relatively cheap demand management solution rather than a higher capacity network solution.

Demand response in particular is increasingly used by network businesses where it offers a cost effective non-network option to meet a network need. For demand response to be effective as network support for the transmission network, it must be:

- In the right place. The response needs to occur in the area of network constraint, if support is to be provided at a suboptimal location its magnitude must be greater.
- At the right time. The response must occur at the time the network is under the most pressure to be effective; and
- Of a sufficiently large magnitude (megawatts).

7 P.11, CSIRO, 'Powering Sydney's Future – Energy efficiency'. This report will be released during the launch of TransGrid's engagement on the Powering Sydney's Future project, expected in May 2014.



TransGrid is committed to boosting demand management uptake in NSW, both through investigating demand management innovation and through procuring demand response as network support. In 2013, TransGrid and EnerNOC were awarded the Best Demand Response Project at the Energy Efficiency Industry Awards for a 35 MW procurement of demand response in the Sydney CBD.

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

- Load shifting, shifting peak electricity demand to off-peak periods by changing electricity usage patterns; and
- Load curtailment. Reduction in peak electricity demand at points of end-use through load curtailment incentives, energy storage systems, standby generators, power factor correction.

TransGrid considers non network options on an equal footing with network options when planning its network developments and applying the Australian Energy Regulator's (AER) 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 evaluation and analysis, it must be the most cost effective. It must also have a proponent who is committed to implement the option and accept the associated risks, responsibilities and accountabilities. It is expected that non-network options would emerge from joint planning with distributors, from the market or from other interested parties.

PROMOTION OF NON–NETWORK ALTERNATIVES BY TRANSGRID

TransGrid actively promotes non-network alternatives through:

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

TransGrid's joint planning with NSW distributors provides a further mechanism to identify opportunities for non-network options. Distributors follow a process for their networks defined in the Rules under their Distribution Annual Planning Review obligations including a requirement to develop strategies for the engagement with non-network providers and consideration of non-network options. These requirements provide another useful source of information for proponents of non-network options.

During 2012 and 2013, TransGrid hosted DM Innovation Forums in Sydney involving distributors, universities and advisors participating in the DM programs with TransGrid. At the Forums, progress reports on the joint projects were presented. The participants also discussed the ways in which DM can be further promoted in NSW. The Forums were very well received by all participants as a result of the open exchange of information.

2.4.3 FUTURE ENERGY AND DEMAND SCENARIOS

Energy consumption in NSW/ACT has largely been correlated with the growth of state income (represented by the gross state product). Price increases have been modest in the 1990s and the early part of 2000. As such, energy consumption grew at the rates of 2.8% between 1991 and 2000 and 1.7% between 2001 and 2008. After 2008, energy growth has largely been negative for a variety of reasons, including the onset of the GFC and the resulting depressed consumer confidence, sharp increases in electricity prices and the penetration of solar PV into the market.

The energy and maximum demand projections presented below were developed by AEMO for three economic scenarios as detailed in Table 2.1. For energy forecasting purposes, these scenarios have been designed to reflect different levels of economic growth, carbon price assumptions, small/medium industrial consumption, large industrial consumption, solar PV penetration, energy efficiency and small non-scheduled generation.

Annual electrical energy usage in NSW/ACT is projected to grow over the 20 year outlook period (2013/14 to 2032/33) at an annual average rate of 0.5% under the Medium Scenario (Planning), 0.6% under the High Scenario and 0.04% under the Low Scenario. Figure 2.12 shows the historical and projected annual energy usage under the three economic scenarios as given in Table 2.1.

Forecast rates of average annual energy growth for the next two decades are significantly lower than the past two decades. The GFC and other associated events have significantly reduced energy consumption growth rates in the recent past and any return toward past levels of consumption is expected to happen gradually over an extended period of time. Forecasts of annual energy usage reflect the penetration of solar PV systems and energy efficiency savings, which are expected to grow across the 20 year outlook period under the above scenarios.

TABLE 2.1

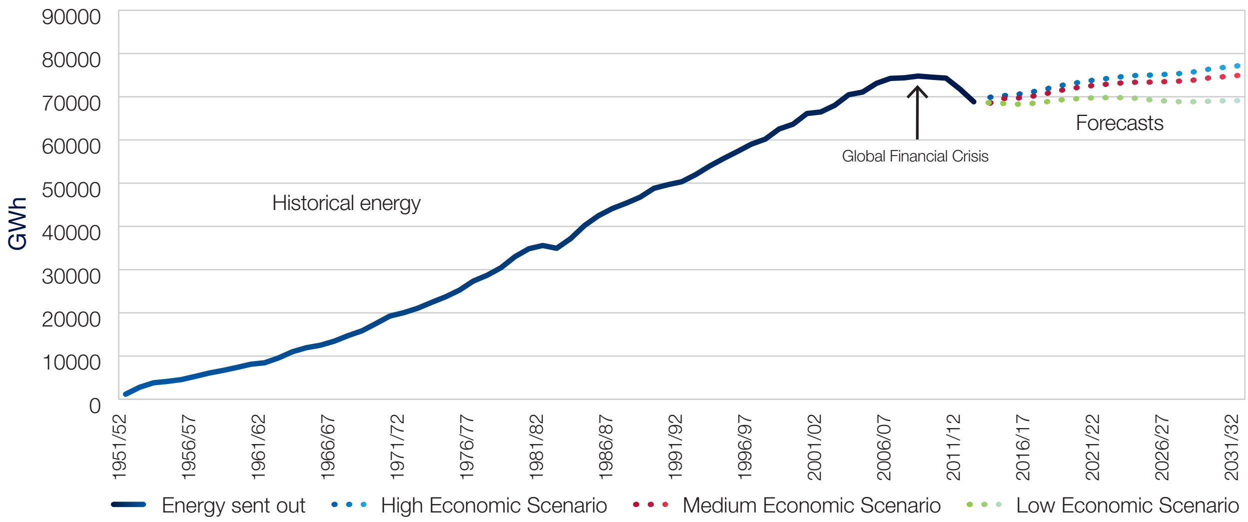
AEMO ECONOMIC SCENARIOS[8]

Parameter	Description	High	Medium (Planning)	Low
		HCO5	MCO5	LCO5
Global economy outlook and productivity assumptions	National and global economic growth	High	Medium	Low
	Productivity growth	High	Medium	Low
	Commodity prices	High	Medium	Low
Demographic assumptions	Population growth	High	Medium	Low
	Immigration rate	High	Medium	Low
	Fertility rate	High	Medium	Low
Carbon price assumptions	The Treasury – Strong Growth, Low Pollution, Modelling a Carbon Price report	The Treasury SGLP* scenario	The Treasury SGLP* scenario	The Treasury SGLP* scenario
	CO_2 emissions reduction target by 2020	5%	5%	5%
	CO_2 emissions reduction target by 2050	80%	80%	80%
Fuel Prices	International coal prices, East Coast gas prices	Stable	Stable	Stable
	LNG East Coast Production	High	Medium	Low

Source: AEMO, NIEIR. * Strong Growth, Low Pollution – Modelling a Carbon Price, Federal Treasury 2011

FIGURE 2.12

HISTORICAL AND PROJECTED NSW ANNUAL ENERGY USAGE

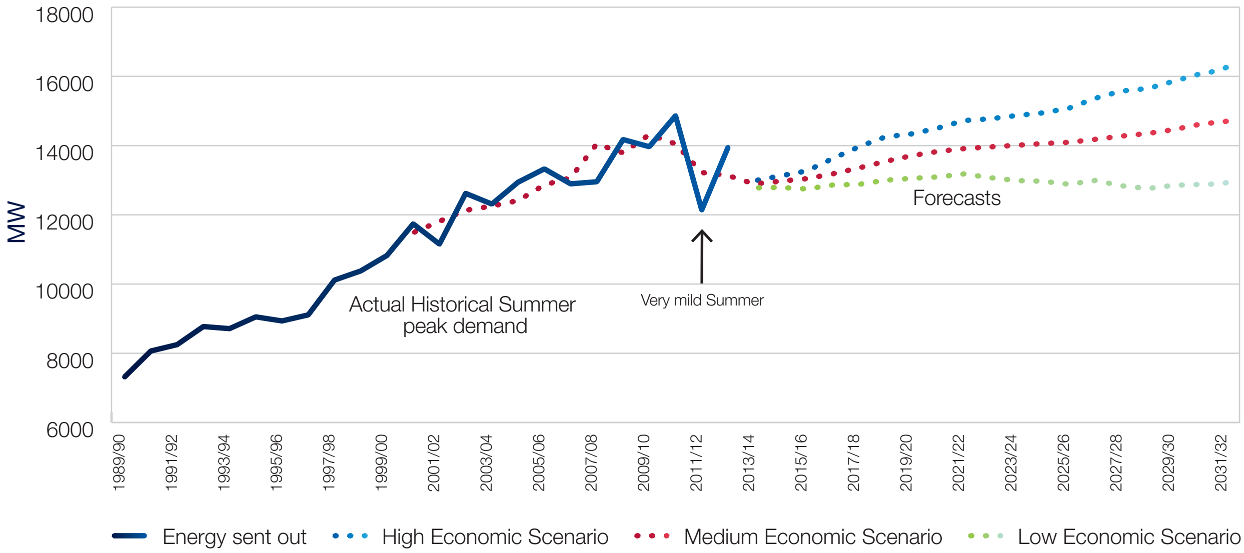


Source: AEMO, NIEIR, TransGrid

8 AEMO, National Electricity Forecasting Report for the National Electricity Market, 2013.

FIGURE 2.13

HISTORICAL AND PROJECTED PEAK SUMMER DEMANDS



Source: AEMO, NIEIR, TransGrid

Figure 2.13 shows actual summer peak demands, historical weather corrected 50% probability of exceedence (POE) peak demands and the 50% POE forecast summer peak demands for the three different economic scenarios.

The actual summer peak demand has grown at an average annual rate of 2.5% from 1990/91 to 2012/13. Historically summer maximum demand has been sensitive to weather variables and in recent years maximum demand has been quite volatile due to fluctuating weather conditions.

Peak Summer Demand in NSW/ACT is projected to grow over the 20 year outlook period (2013/14 to 2032/33) at an annual average rate of 0.7% under the Medium Scenario (Planning), and 1.2% under the High Scenario and 0.02% under the Low Scenario respectively.

Peak Winter Demand in NSW/ACT is projected to grow over the 20 year outlook period (2013 to 2032) at an annual average rate of 0.9% under the Medium Scenario (Planning), 1.4% under the High Scenario and 0.4% under the Low Scenario respectively.

Currently the maximum peak demand occurs during summer. Summer peak demand has grown in the past due to increasing penetration of air conditioners but in the future this is expected to be moderated by uptake of solar PV systems and energy efficiency measures thereby reducing the growth in summer peak demand.

Under the three economic scenarios mentioned above, the forecast growth rates of winter peak demand are higher than those of summer peak demand. This is because of the minimal impact of solar PV on winter peak demand which generally occurs around early evenings after the sun has set.

2.4.4 EFFECT OF SOLAR PV, ENERGY EFFICIENCY AND ELECTRIC VEHICLES

SOLAR PV

Historically, maximum demand in NSW has occurred on hot days in summer or cold days in winter. Summer maximum demand on the day typically occurs between 3.00pm and 5.00pm. At the time of summer peak demand, average solar PV generation as a percentage of installed capacity has ranged from 20% to 34%. At a typical peak demand time of 16:00 AEST (Australian Eastern Standard Time), systems have averaged 33% of their installed capacity. In order to forecast solar PV generation at times of maximum demand (based on sample data), AEMO has multiplied the average percentage derived (33.4%) by the installed capacity estimates.

According to AEMO's estimates, solar PV generation at the time of summer maximum demand will reach 843 MW in 2022/23 and 1,586 MW in 2032/33 under all three economic scenarios. These are the amounts by which the forecast summer peak demands have been reduced as a result of adjustment for the PV uptake. There is no impact of PV on winter maximum demands.

The AEMO 2013 National Electricity Forecasting Report estimates that solar PV will generate 3,059 GWh of energy in 2022/23 and 5,935 GWh in 2032/33.

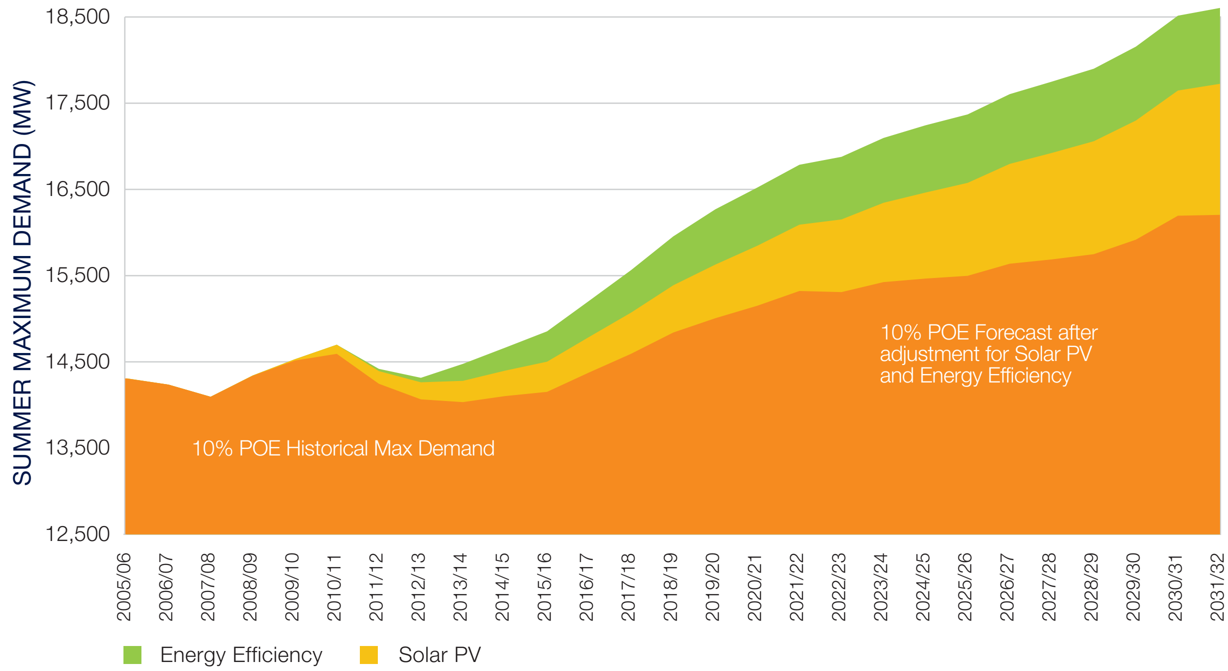
ENERGY EFFICIENCY

Energy efficiency refers to the use of less energy for the same activity or level of output, or increasing the level of output from the same amount of energy. Energy efficiency and emission reduction policies, coupled with rising energy prices in recent undertake energy efficiency measures. Energy efficiency through policy incentives, technological improvements and consumer behaviour change is expected to have an ongoing effect on annual energy usage and maximum demand in NSW/ACT.

WHILE ENERGY EFFICIENCY MEASURES ALSO HAVE THE POTENTIAL TO REDUCE PEAK DEMANDS, THEREBY REDUCING THE REQUIREMENT FOR NETWORK AUGMENTATION, THERE IS UNCERTAINTY ABOUT HOW REDUCTIONS IN OVERALL ELECTRICITY CONSUMPTION MAY "TRANSLATE" TO REDUCTION OF PEAK ELECTRICITY DEMAND.

FIGURE 2.14

SOLAR PV AND ENERGY EFFICIENCY ADJUSTMENTS AND SUMMER HISTORICAL AND PROJECTED PEAK DEMANDS



Source: AEMO NEFR forecast data

Policy incentives exist at both the state and federal levels, with potential overlap between the two. As such, to prevent double counting, AEMO has considered only federal schemes in its forecasts, consisting of Equipment Energy Efficiency (E3) programs and a number of building energy efficiency measures covering commercial and residential buildings. State based schemes such as the NSW Energy Savings Scheme (ESS) have not been included in the National Energy Forecasting Report (NEFR) 2013 estimates.

According to AEMO, energy efficiency policy summer maximum demand impacts reach 762 MW in 2022/23 and 893 MW in 2032/33 under all three scenarios. Figure 2.14 shows the forecast 10% POE Summer maximum demand adjusted for solar PV as well as energy efficiency estimates.

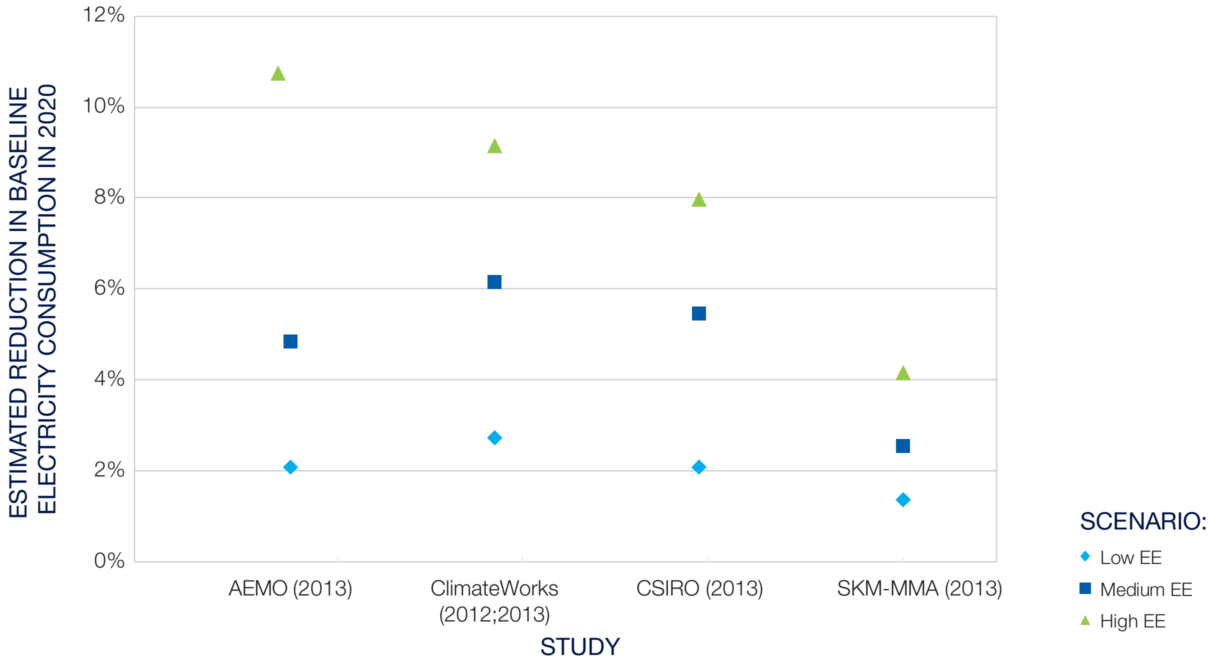
AEMO estimates that energy efficiency will cause a reduction in energy consumption above the historical trend of 4,528 GWh in 2022/23 and 5,568 GWh in 2032/33.

CSIRO[9] advises that energy efficiency is partly responsible for recent declines in annual energy consumption in NSW. Energy efficiency measures face barriers to uptake, with consumers lacking access to credible, relevant sources of information about the cost and effectiveness of various measures. Even so, CSIRO note that several policies appear to have improved energy efficiency uptake in NSW and Australia. Nationwide policies include the Energy Efficiency Opportunities program and the mandatory disclosure of the energy performance of commercial buildings; NSW specific policies include the NSW Building and Sustainability Index, which requires new residential dwellings to achieve at least a 40 percent reduction in greenhouse gas emissions relative to specified energy consumption levels.

9 Rai, A., Brinsmead, T., Reedman, L., Graham, P., Wall, J., and Cheng, J. (2014), TransGrid Powering Sydney's Future: Energy Efficiency, Report No. EP14312, CSIRO, Australia. This report will be made public by TransGrid in mid–2014 during consultation on the Powering Sydney's Future project.

FIGURE 2.15

POTENTIAL IMPACTS OF ENERGY EFFICIENCY (EE) ON SYDNEY'S OVERALL ELECTRICITY CONSUMPTION IN 2020



Source: Rai, A., Brinsmead, T., Reedman, L., Graham, P., Wall, J., and Cheng, J. (2014), TransGrid Powering Sydney's Future: Energy Efficiency, Report No. EP14312, CSIRO, Australia

There is potential for further uptake if certain proposed policies are implemented, such as phasing out of electric-resistance hot water systems. There also remains significant potential for energy efficiency in space heating and cooling in Sydney, both for the residential and commercial sectors.

CSIRO compare four studies that find there is potential for a reduction in Sydney's annual electricity consumption of between 3 and 6 percent (for the medium energy efficiency scenario), in the year 2020 (compared to the baseline). This is shown in Figure 2.15.

While energy efficiency measures also have the potential to reduce peak demands, thereby reducing the requirement for network augmentation, there is uncertainty about how reductions in overall electricity consumption may "translate" to reduction of peak electricity demand. As a result of uncertainty in the effects of energy efficiency measures on the peak demand and location of electricity use, there is considerable uncertainty regarding the likely impact of energy efficiency measures on transmission network requirements.

ELECTRIC VEHICLES

The charging loads from Electric Vehicles (EV), both fully electric and plug-in hybrids, could potentially be a significant new source of electricity consumption. At present the load from EVs remains small, due to their low penetration in Australia.

Currently, both plug-in hybrid and pure electric vehicles are considerably more expensive than internal combustion engine vehicles, largely due to electric vehicle battery costs. This cost premium for EVs is a significant barrier to consumer uptake.

In 2011 the AEMC (Australian Energy Market Commission) commissioned AECOM (a consulting company) to model the impact of EVs. Their central scenario estimate was for an additional energy consumption of 205 GWh in 2020 and 2,626 GWh in 2030 in the NSW region of the NEM. Longer range estimates to 2050 were performed by AEMO at a NEM wide level as part of their modelling of a 100% renewables study which line up with the NEM wide estimates from AECOM.

Neither study estimated the contribution of EVs to maximum demand as this would be heavily dependent on any smart recharge schemes or tariff structures employed.

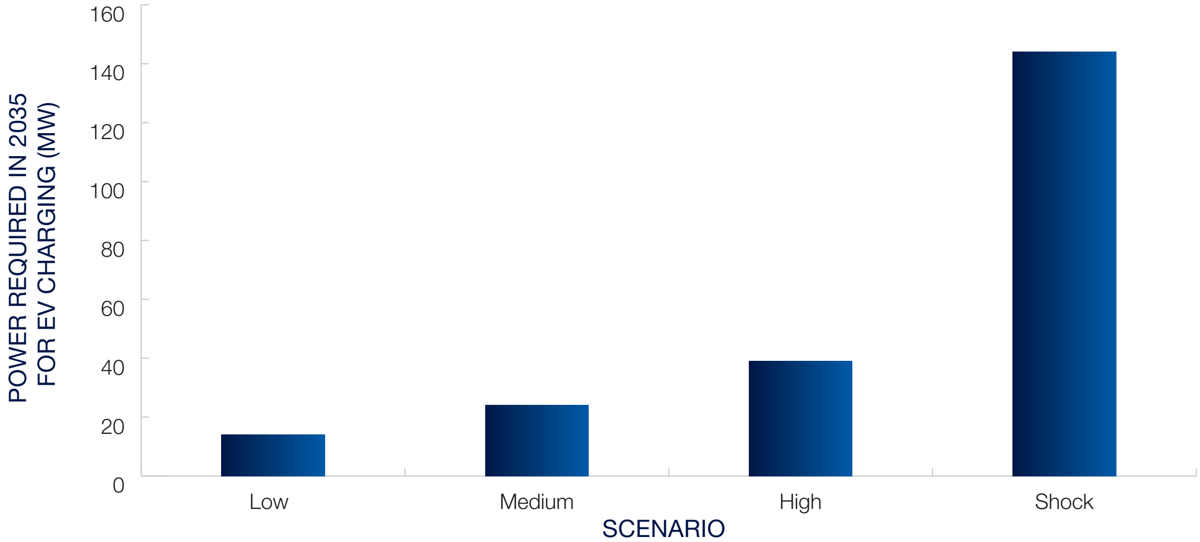
A study by the University of Sydney[10] finds that Australia is likely to be a 'slow follower' of EV uptake unless deliberate government incentives are developed and activated. The report estimates electricity demand in 2035 in the Sydney inner metropolitan area[11], in addition to 'normal' household electricity demand, to range from 14 MW (low uptake of EVs) to 144 MW (uptake due to a shock scenario) with demand for medium and high uptake scenarios estimated at 24 MW and 39 MW respectively, as shown in Figure 2.16.

10 Vassallo, Anthony M., Gomme, Philippe and Blik, John E. (2014) TransGrid Powering Sydney's Future – Electric Vehicles, USYD–CERC1–2014, Clean Energy Research Cluster, The University of Sydney, Australia. This report will be made public by TransGrid in mid–2014 during consultation on the Powering Sydney's Future project.

11 For the purpose of discussing this study, the "Sydney inner metropolitan area" refers to the primary study area of the report – specifically the local government areas of Woollahra, Waverley, Randwick, City of Sydney, Botany, Marrickville and Leichhardt.

FIGURE 2.16

ESTIMATE OF 2035 POWER REQUIRED FOR EV CHARGING IN THE SYDNEY INNER METROPOLITAN AREA



Source: Vassallo, Anthony M., Gomme, Philippe and Blik, John E. (2014) TransGrid Powering Sydney's Future – Electric Vehicles, USYD–CERC1–2014, Clean Energy Research Cluster, The University of Sydney, Australia.

The report also notes the potential to use EV battery energy to inject power back to the electricity grid. For example, EV battery energy could be used for demand response purposes. They estimate that under the medium uptake scenario there would be between 10 MW (at normal discharge of 3.6 kW) and 27 MW (with fast discharge of 10 MW) available in 2035. Under the shock scenario there is potential for almost 1000 MW (with fast discharge of 10 MW) to be available.

The findings under the shock scenario highlight the potentially large (although unlikely) demand implications for the transmission network in the extreme case of uncontrolled and unregulated charging of EV batteries, especially if uncontrolled charging occurs at the same time as network peaks. Given the low probability of the shock scenario and other analysis, the advice concludes that EVs are not likely to significantly impact electricity demand in the Sydney inner metropolitan area in the coming decades. However, these conclusions could be altered by future oil price rises, the rate of decline in EV battery costs, and any move by governments to incentivise EV uptake.

2.4.5 MAJOR LOAD CONNECTIONS

Major loads (such as mines or industries) are usually connected to the transmission network or, if connected to distribution networks, may require reinforcement of the transmission network.

The demand forecasts in the NDS do not contain projections of major load increases. TransGrid has identified some sites where the potential of major load increases does exist in the regional areas and these are discussed in section 4.11. In the event that a major load does seek connection to the network, the development of that section of the network would form part of the negotiation of the connection.

2.4.6 CSIRO FUTURE GRID SCENARIOS

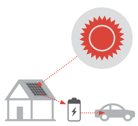
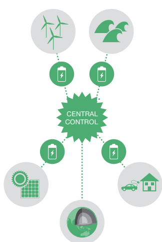
The CSIRO has established a Future Grid Forum of electricity industry and stakeholder representatives. Over a period of twelve to eighteen months, the Future Grid Forum will systematically evaluate the major options available for Australia's future electricity system from an end-to-end perspective to year 2050. The CSIRO initially released a report describing the evaluation process it intends to use and since has described the scenarios it proposes to consider.

Those scenarios are:

1. **Set and forget:** In response to electricity prices, consumers engage in significant levels of demand response, mainly on a centralised basis.
2. **Rise of the prosumer:** Increased penetration of small scale embedded generation, including cogeneration and trigeneration, which would supply about 50% of energy needs. Electric vehicles become popular.
3. **Leaving the grid:** Increasing electricity prices and the development of cost effective storage options drives consumers to leave the grid.
4. **Renewables thrive:** Reduced renewable generation costs lead to a greater proportion of renewables generation, the majority of it centralised.

These scenarios each have different implications for both the generation and demand connected to the transmission network. These potential effects on the development of the network are summarised in Table 2.2 for each scenario. It should be noted that elements from each of these different scenarios may well emerge in the future.

TABLE 2.2
EFFECT OF FUTURE GRID SCENARIOS

Future Grid scenario	Potential effects on transmission network development
Set and forget 	The advent of widespread centralised DM, on which this scenario is based, would contribute to stemming demand growth and potentially, to reducing the demand of major population centres on the network. This scenario does not specifically address energy consumption and the demand reduction is most likely to be achieved by "flattening" the energy consumption profile, which would increase the utilisation of existing network assets. In the absence of centralised energy storage, the demand reduction is unlikely to be accompanied by a proportional reduction in the energy consumed, particularly if the penetration of electric vehicles becomes significant. Transmission from existing and, potentially, new generation centres would thus remain a feature of this scenario and the transmission network would be developed to meet these requirements. TransGrid would thus maintain existing assets in service and refurbish or renew them as necessary to maintain the security and reliability of the power system. Rationalisation of those portions of the transmission network supplying major load centres would only become feasible if demand is reduced very significantly from current levels.
Rise of the prosumer 	The widespread development of small scale embedded generation would reduce the energy supplied by the transmission network. Dependent upon the particular generation technology, this would not necessarily result in a proportionate reduction in the demand on the network. Moreover, the penetration of electric vehicles would counteract this demand reduction. Whilst vehicle recharging may be mainly accommodated during periods of low network demand, a proportion would be charged rapidly during peak periods at charging stations. Overall, this scenario would result in significant changes to the pattern of utilisation of the network and the distribution of generation. The reduced reliance on centralised generation at the existing locations may result in opportunities to rationalise the transmission network in those localities. As the existing power station switchyards are integrated into the transmission network and in some cases provide supplies to regional loads, it is likely that a very limited number of assets would be made redundant or removed. The great majority of the existing transmission assets would be maintained in service and refurbished or renewed as necessary, to maintain secure supply.
Leaving the grid 	The development of small scale renewables generation and storage that form the basis of this scenario could see a reduction in the demand placed on the transmission network, if customers do indeed leave the grid permanently. This would require significant technology development, as most current renewable energy solutions rely on the grid to provide backup when the primary source of generation is not available or when storage is exhausted. The level of demand reduction would also depend on the penetration of the alternative energy solutions and their applicability for different types of consumers, including commercial and industrial premises of varying sizes. Should some assets not be fully utilised, it would be possible to: → relocate high voltage equipment to replace other equipment requiring replacement, avoiding the procurement cost of new equipment; → reuse or recycle other substation infrastructure; and → sell property or make it available for other infrastructure.
Renewables thrive 	Small scale renewable generation would be connected to distribution networks and would be manifested as a reduction in the overall energy delivered by the transmission network. If combined with small scale energy storage technology this is likely to result in a reduction in the demand on the transmission network. Without storage, demand reductions may be smaller and less certain. Centralised renewable generation (with the range of technologies described in sections 3.1.4 to 3.1.6) is likely to be developed in locations that are remote from major population centres and not close to the existing transmission network. This would require TransGrid to facilitate the connection of these generators, potentially using the Scale Efficient Network Extension (SENE) provisions of the Rules. TransGrid would also need to ensure that the remainder of the network is maintained and refurbished as required to be capable of transferring the energy flows from these generators to major population centres.

The impact of these scenarios has been considered in formulating development strategies for the network, described in section 4.6.

3.0

NSW electricity generation development

TransGrid's role is to manage and plan the transmission network for a range of likely generation development scenarios. TransGrid does not have a role in determining the type, timing or location of new generation developments. Consequently it must develop a range of scenarios that are considered to be probable or likely and use them in determining network development options.

NSW electricity generation development

Transmission in the NEM operates as an "open access" regime. Existing and new generators are entitled to be connected to the transmission network to a standard of performance and reliability which recognises the characteristics of each different connection.

Prior to the creation of the NEM the NSW power supply system was centrally planned to have sufficient generating plant and/or interconnection capacity to supply the maximum NSW demand together with a level of reserve capacity that would adequately manage the risk of supply interruptions should some generators not be available for service.

3.1 AEMO 2013 ESOO ASSESSMENT OF NSW GENERATION REQUIREMENTS

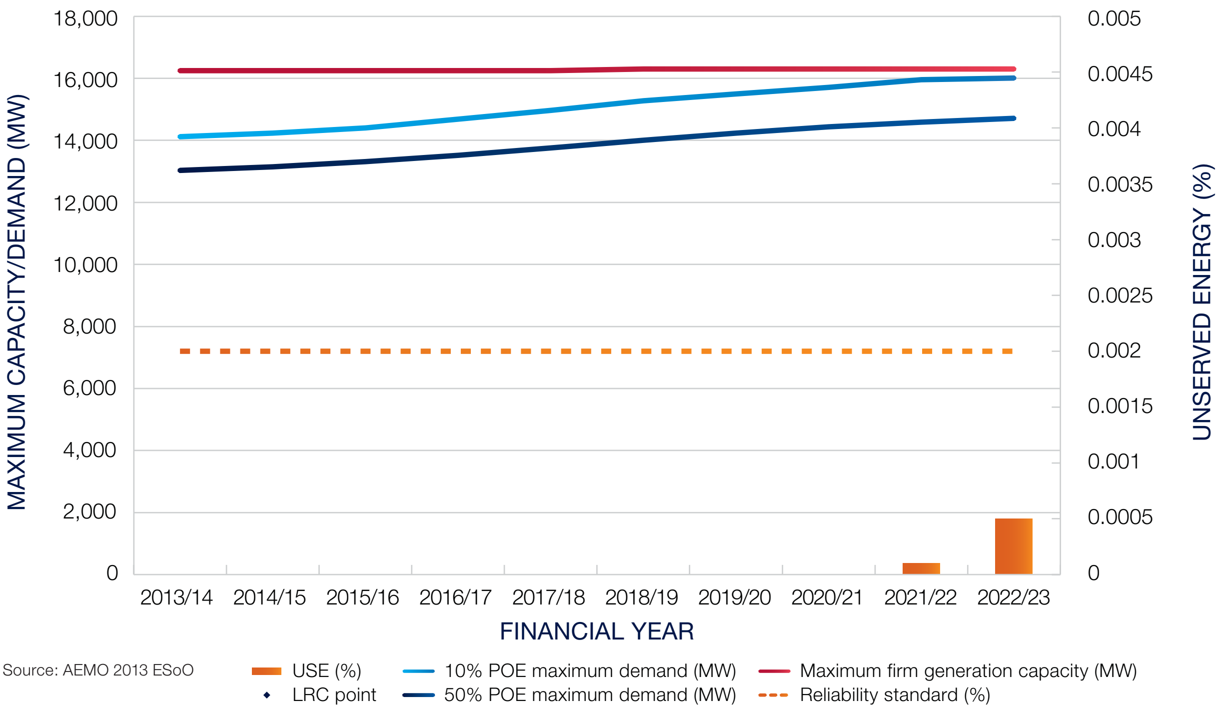
Since the formation of the NEM new power station developments must emerge in response to market conditions and commercial opportunities.

Each year, AEMO develops and issues the ESoO which includes an assessment of supply adequacy in each region of the NEM over the following ten years highlighting opportunities for generation and demand–side investment. Market modelling techniques are used to identify the magnitude of these supply shortfalls and to indicate when the Low Reserve Condition (LRC) points occur.

AEMO indicated in its 2013 ESoO that it expected the NSW LRC point to be beyond 2022/23 as indicated in Figure 3.1.

FIGURE 3.1

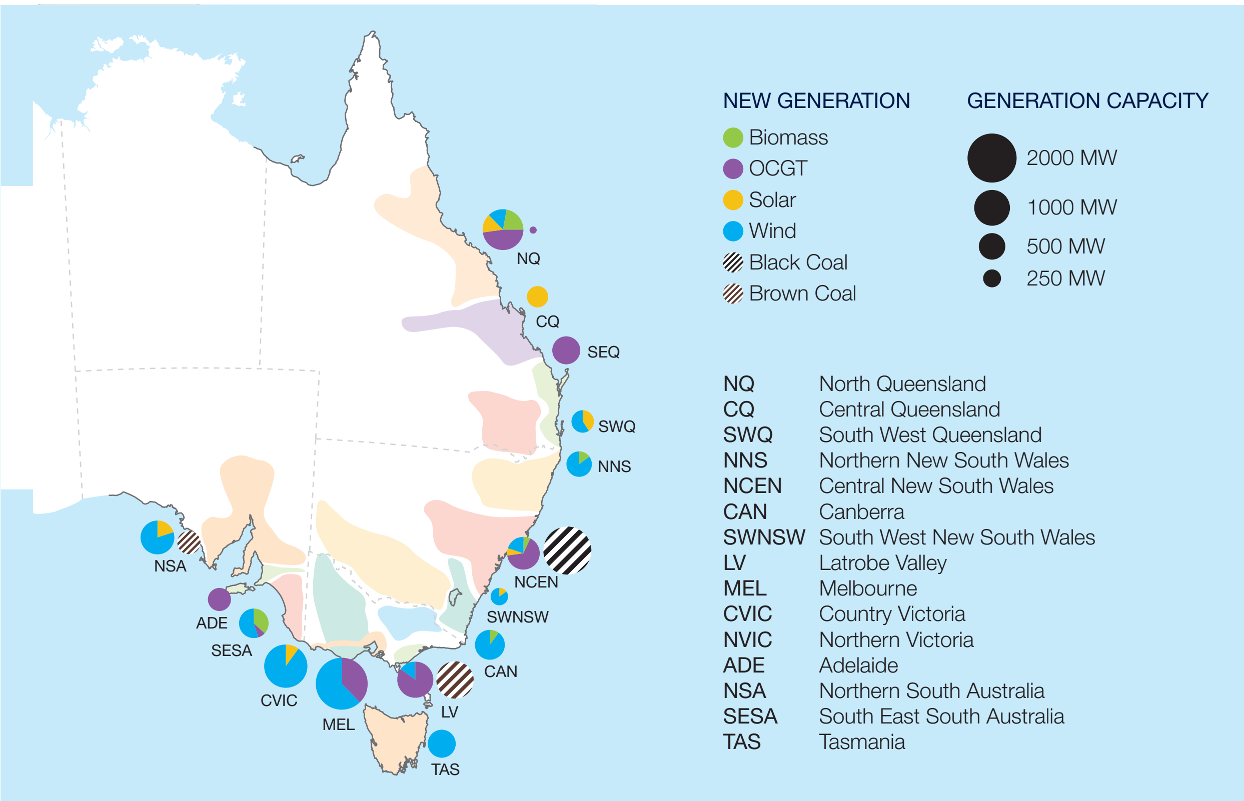
AEMO 2013 ESOO NSW SUMMER SUPPLY–DEMAND OUTLOOK



Source: AEMO 2013 ESoO

FIGURE 3.2

NEW GENERATION DEVELOPMENT IN THE NEM BY 2037/38 IN THE CARBON PRICE SCENARIO



Source: AEMO, 2013 NTNDP

The ESoO assessment modelling is dependent on a number of key criteria including:

- The NEM Reliability Panel's reliability target of 0.002% Unserved Energy (USE) and the associated minimum reserve plant margin for NSW;
- The retirement of Munmorah Power Station;
- Completion of the committed upgrade at Eraring Power Station;
- A reduction in summer capacity and an increase in winter capacity at Upper Tumut Power Station;
- A reduction in summer capacity at Guthega Power Station; and
- ESoO modelling assumes loads at 10% POE peak summer loads in all NEM regions.

RELATIONSHIP BETWEEN GENERATION REQUIREMENTS AND TRANSMISSION PLANNING

The ESoO establishes an acceptable level of generation reserve, taking into account the available supplies over the interconnectors. This reserve would cover the risk of some generating plant or interconnection capacity (surplus power available in adjoining states) not being available at times of peak load through such factors as plant maintenance, breakdown or fuel shortages.

The NTNDP has provided a range of scenarios which provide generation developments and the retirements of coal-fired generation, which in principle take into account the reserve requirements. The generation developments are broadly located within zones of the NSW system, without being specific as to actual power station locations.

TransGrid uses the outcomes of the NTNDP to derive future generation profiles. Knowledge of connection applications and site constraints enables scenarios of generation developments to be translated into models of the future power system which are suitable for long term strategic planning. Due to the diverse range of generation and interconnection supplies it is also necessary to analyse the NSW system across a range of feasible generation dispatch patterns. Over the next ten years it is expected that only a limited number of basic options exist for generation developments in NSW. Most peak demand needs are likely to be met by either Open Cycle Gas Turbine (OCGT) peaking plant and/or by commercially driven DM arrangements. There is also likely to be ongoing development of Combined Cycle Gas Turbine (CCGT) power stations.

3.1.1 POWER STATION DEVELOPMENT SCENARIOS

AEMO has summarised the forecast development of major generators in the NEM in the graphic reproduced in Figure 3.2[12].

12 AEMO, 2013 National Transmission Network Development Plan for the National Electricity Market, December 2013.

The main aspects of this generation forecast that would potentially affect the development of the NSW transmission system are set out below.

3.1.2 COAL-FIRED POWER STATION SITES

There is significant potential for expansion of existing power stations and the development of new power stations on the coal-fields of NSW, potentially using clean coal technologies to reduce CO_2 emissions. The following potential developments are possible:

- The Gunnedah basin area, north of the Hunter Valley;
- The Upper Hunter Valley in the vicinity of Bayswater and Liddell power stations;
- The Ulan area near Wollar; and
- The Mt Piper/Wallerawang area.

The prominent sites are located close to the NSW main transmission system, but reinforcement of the remainder of the main system is expected to be required for any significant development that is not otherwise offset by closure of existing generation in the same location.

3.1.3 GAS TURBINE POWER STATION SITES

There is a wide range of potential gas turbine power station sites across NSW. Favourable locations are near the intersection of gas pipelines with transmission lines. The following potential large scale developments are possible:

- The Richmond Valley area near the border with Queensland, possibly accessing coal seam methane;
- The Narrabri – Gunnedah area, again possibly using coal seam methane;
- Along the route of any future gas pipeline development from Queensland to the Newcastle or Hunter Valley area;
- In the Newcastle area;
- In the Wellington area;
- Through the greater Sydney area;
- In the Wollongong area;
- The Marulan area; and
- South west NSW.

Other smaller scale developments along existing gas pipelines and future pipelines are also possible in many areas.

Many of the more likely gas turbine power station sites are located in the proximity of the NSW 330 kV system. For the sites which are some distance from the major load areas network reinforcement may be required to cover increased network loading to the major load centres. Power station development within the major load areas would tend to reduce the need for future network development to those areas. Smaller scale power station developments may also support the local transmission network.

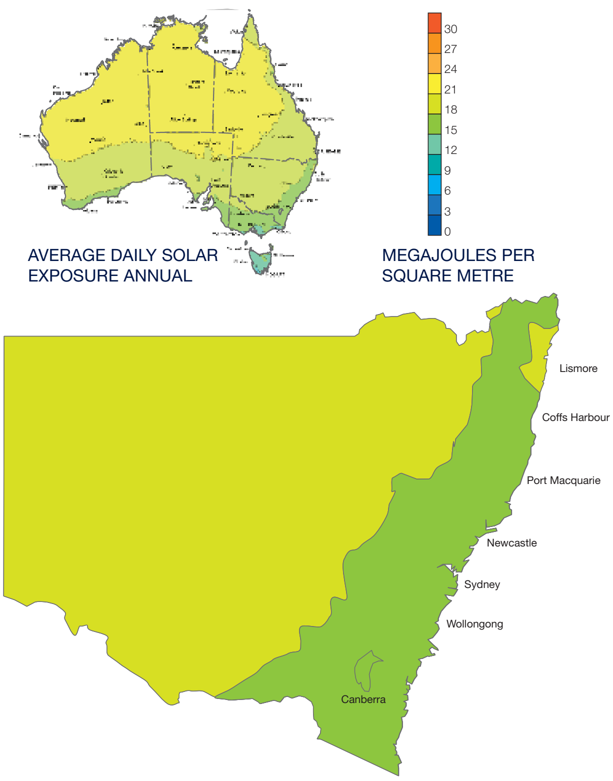
3.1.4 SOLAR GENERATION

Solar generation may be of small scale (kW) or of larger scale (MW). The technologies for these usually differ. Small scale installations are usually solar PV whereas larger installations concentrate the sun's rays and use a thermodynamic cycle to generate electricity from conventional rotating machines.

The commercial attractiveness of solar generation depends upon the level of solar energy. This is depicted in Figure 3.3. From this diagram, it can be observed that the majority of the eastern seaboard of NSW has a lower average level of solar energy exposure than inland areas.

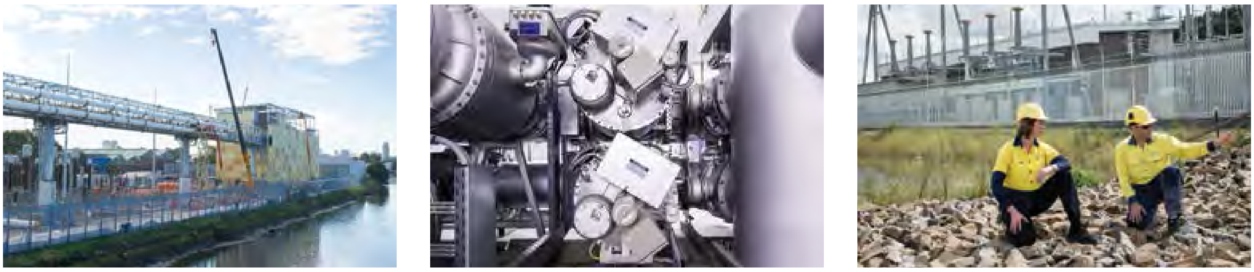
FIGURE 3.3

NSW AVERAGE DAILY SOLAR EXPOSURE, ANNUAL



Based on 22 years (1990 – 2011) of solar exposuredata derived from Japan Meteorological Agencyand NOAA satellite imagery

Source: Commonwealth Government Bureau of Meteorology, 2012



As a consequence of these moderate levels of solar energy exposure, it is reasonable to conclude that the development of solar electrical generation is likely to follow these paths:

- There will be a continuation of the trend of increasing penetration of small scale solar PV installations throughout NSW, until equipment prices reach minimum efficient levels; and
- Larger scale solar generators are unlikely to be developed on the eastern seaboard, near the major population centres. They would likely require the extension of distribution or transmission network in regional centres to remote areas. The cost of a lengthy electrical connection would be a significant economic disincentive to the installation of larger scale solar generators in remote areas, other than in conjunction with storage arrangements in areas not already connected to the grid or with inadequate supply.

The principal influence of solar PV generation within NSW on the transmission network is therefore expected to be to reduce the net energy delivered by the network and alter the profile of the demand, principally on summer days.

Being further north, parts of Queensland generally have better solar resources than NSW. Should those resources be developed to a significant extent increased interconnector capacity with Queensland may be required.

3.1.5 WIND FARM DEVELOPMENT

Large scale and remote wind farms are connected to the transmission network rather than to distribution networks. Figure 3.4 illustrates the average wind speeds for NSW. The most favourable locations are those with the highest average wind speed, preferably close to existing network infrastructure.

Wind farms may be developed in favourable wind locations throughout the northern tablelands, the southern tablelands, the Canberra – Snowy area, the NSW – Victoria border area and the far west of NSW.

In connecting wind farms and transmitting their energy output to the load centres there is a challenge in determining the economically optimum level of network capacity required. The relatively low capacity factor of the wind farms, the diversity of wind conditions across different sites and the intermittent nature of wind generation need to be considered.

Some of the known sites are close to the NSW 330 kV network or 132 kV network. Some potential sites are quite remote from the main network or have significant potential output which is not compatible with the power transfer capability of the existing network. In these cases, the network between the wind farm and the main system may need to be upgraded.

Large-scale wind farm development in the south of the state may require significant upgrading of the system between Snowy and the south coast and Sydney area. This is particularly the case if further gas-turbine power stations were also developed south of Sydney.

Large scale wind farm development in the far west of NSW and the NSW – Victoria border area may require additional interconnection development with Victoria/South Australia and network developments north of Snowy.

Large scale wind farm developments in the north of the state may require upgrading of the system north of the Hunter Valley. Further reinforcement of the system south of the Hunter Valley may be required. Wind farm connection along QNI may either improve or degrade the power transfer capability of the interconnection between NSW and Queensland, depending on the connection location and design of the wind farms.

The planning authorities of South Australia and Victoria have recently assessed the system impact of large scale wind generation in those states, taking into account the performance of wind farms under system disturbances and the impact on voltage regulation throughout the network. Due to the relatively large load in NSW there is a corresponding increased potential to accept wind farm generation. Increased local network capability constraints will however need to be managed.

Being closer to the “roaring forties”, Tasmania and the southern coastline of South Australia and Victoria have generally better wind resources than NSW. Should additional major wind generators be established within those states, it is probable that additional interconnector capacity, including between NSW and Victoria and between NSW and South Australia, would be required.

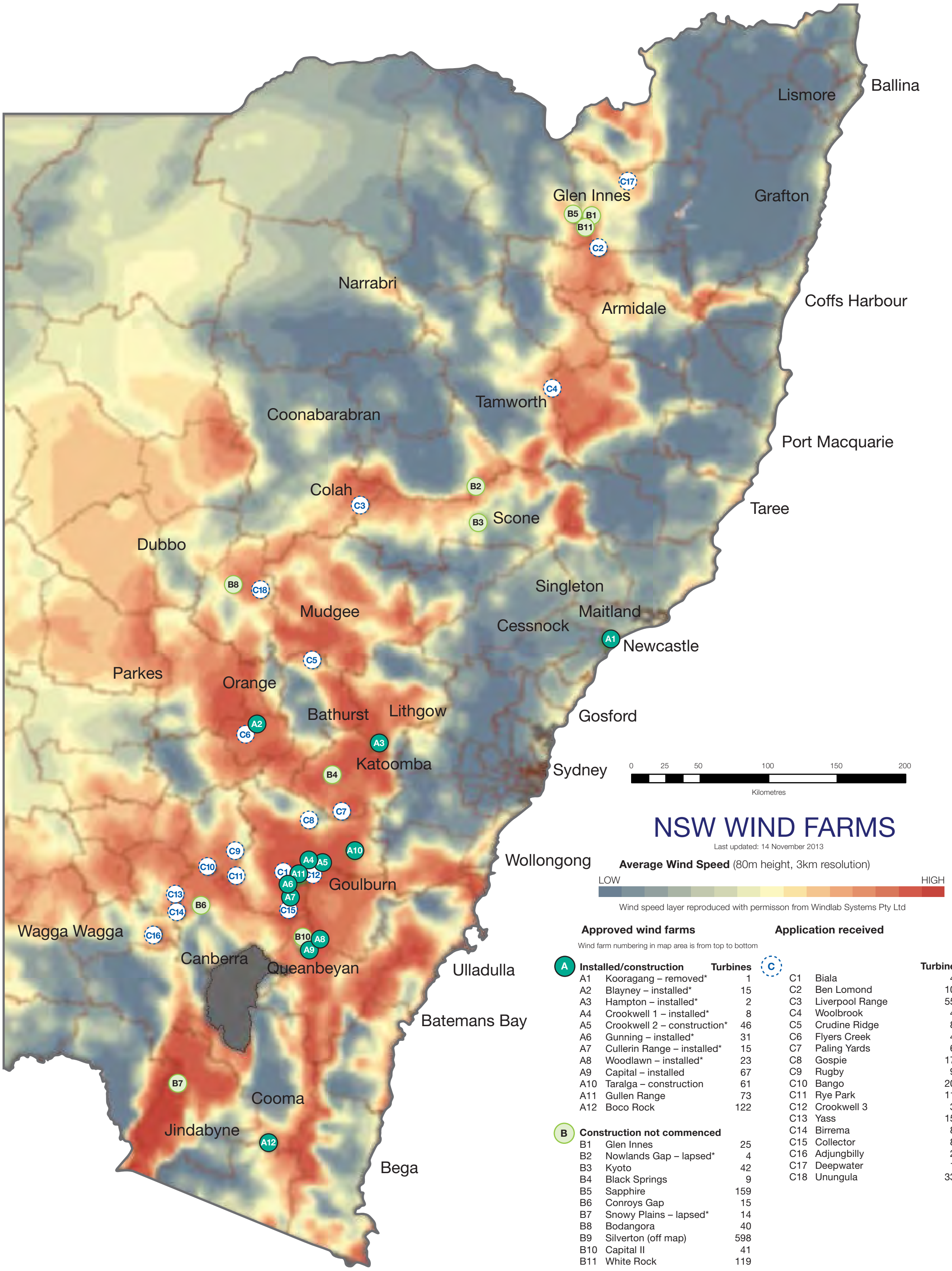
3.1.6 GEOTHERMAL ENERGY

Geothermal resources (“hot rocks”) may be used for electricity generation. There are four types of geothermal resources: hydrothermal, geopressured, hot dry rock and magma. Of the four types, only hydrothermal resources are currently commercially exploited. Hydrothermal generation has been used for decades in New Zealand, via steam generated by pumping water through hot rocks underground. Geothermal resources for power generation have not yet been developed in Australia.

Hydrothermal energy relies upon the presence of both an aquifer and a suitable underground rock formation with an impermeable cap. There is the potential for this form of generation in the great Artesian Basin, from central

FIGURE 3.4

NSW WIND FARMS



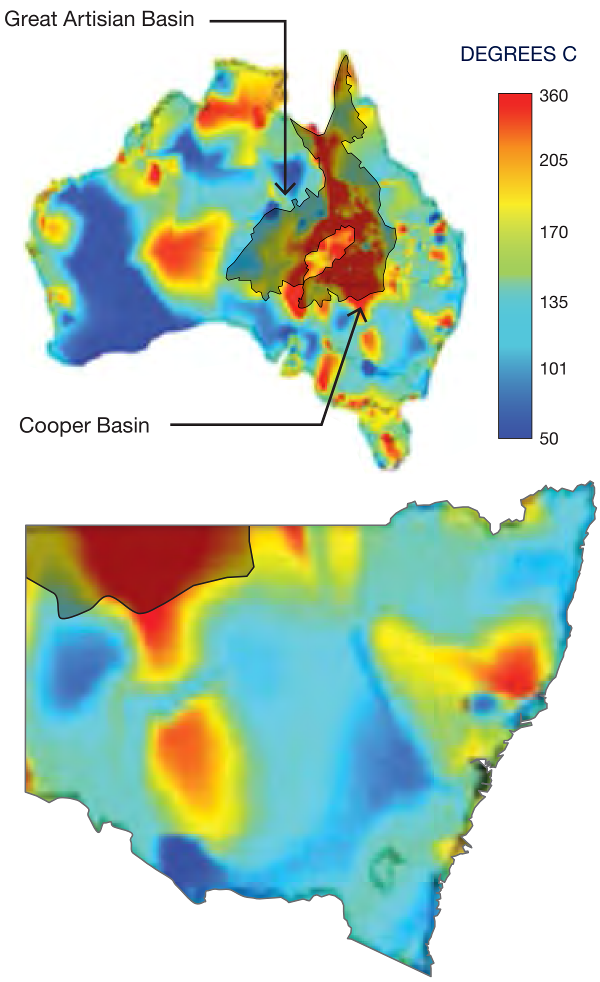
*Approved under Part of the Environment Planning and Assessment Act 1979 (NSW
Source: NSW Department of Planning

South Australia through most of western Queensland to the Gulf of Carpentaria. This resource is illustrated in Figure 3.5, as the grey overlay on the map.

The geological profile of Australia is such that there is greater potential for Hot Dry Rock (HDR) technologies to be used for energy production. The SA Department of Transport, Energy and Infrastructure map in Figure 3.5 shows the temperature of Earth's crust at a depth of 5 km.

FIGURE 3.5

GEOTHERMAL RESOURCES



Courtesy of the Hot Rock Energy program, Australian National University and SA Dept. of Transport, Energy and Infrastructure

The potential for HDR technologies is closely related to the temperature of underground rocks and the high temperature areas illustrated in Figure 3.5 are those most likely to be capable of supporting geothermal generation.

With the exception of a relatively small area inland of Port Macquarie, the area of greatest potential for geothermal generation is in far north western NSW, This is over 1,000 km from the major load centres of Sydney, Newcastle and Wollongong and remote from both transmission and distribution networks. As a consequence, it is considered unlikely that geothermal energy will play a part in the energy supply to NSW, unless a sufficiently large scale plant was developed. This could involve a transmission connection (potentially direct current, because of the distance) to the 500 kV network in the central west of NSW.

3.2 IMPACT OF CLIMACTIC CONDITIONS ON GENERATION DEVELOPMENT

The pattern of generation in NSW and the NEM is dependent in the short term upon weather patterns. In particular, drought conditions directly affect the available output of hydro generation, principally the Snowy and Shoalhaven schemes. However, the inland coal fired power stations (Liddell/Bayswater and Wallerawang/Mt Piper) are also dependent upon water for cooling and drought conditions can lead to their output being curtailed.

Prolonged years of drought caused by climate change or climate cycles:

- Would adversely affect the financial viability of thermal power stations, potentially leading them to withdraw from the market; and
- Could similarly affect the long term viability of hydro stations, if reduced volumes of available water were diverted to alternative uses.

If this were to take place, generation from alternative sources would emerge to meet consumer demand.

The location and concentration of alternative sources of generation would affect the way in which their output was conveyed to consumers and, potentially, the way in which the transmission system was developed. TransGrid would respond as required, to facilitate the connection of new generators and ensure the transmission network is capable of making the associated energy transfers.

4.0

Developments to meet strategic challenges and future demand

Developments to meet strategic challenges and future demand

4.1 NETWORK DEVELOPMENT BACKGROUND

TransGrid's electricity transmission network is one of the largest in Australia. It extends from the Queensland border to the Victorian border and connects the major load supply points and the major power stations throughout NSW. TransGrid's electricity transmission network, which has a replacement value of almost $10 billion, operates primarily at voltage levels of 500, 330, 220 and 132kV.

TransGrid's electricity transmission network incorporates:

- Over 12,900 kilometres of high voltage overhead transmission line and underground cable operating at voltages of up to 500kV;
- 96 substations including switching stations;
- Over 40 connection points to generators, located in western NSW, the Central Coast, Hunter Valley and the Snowy Mountains;
- Over 300 electricity distributor and direct customer connection points; and
- Four of the five interconnectors to Victoria and Queensland.

In developing the electricity transmission network, substations are normally located on land owned by TransGrid, while the transmission lines are 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. Field staff are co-ordinated from major depots located in Western Sydney, Newcastle, Tamworth, Orange, Wagga Wagga and Yass. TransGrid's head office is located at Ultimo in Sydney. A detailed description of the network is contained in the Renewal and Maintenance Strategy.

4.2 HISTORICAL NSW TRANSMISSION NETWORK DEVELOPMENT

Consistent with the development of networks in each state of Australia the NSW transmission network was originally planned and designed by a vertically integrated organisation that had control of both generation and transmission capacity. The prime aim of transmission network development was to provide reliable and cost effective connections between the major power stations and load centres in NSW. This included the development of a 330 kV network to transfer the NSW and ACT allocation of Snowy power towards Sydney supplying the Yass/Canberra/Wagga area on the way. The network was also developed to provide reliable supplies to the more remote parts of the state.

Over the past three decades there has been only a limited number of major transmission links built in NSW. These have included:

- The Eraring – Kemps Creek 500 kV link (commissioned in the early 1980s to match the commissioning of Eraring Power Station);
- The Bayswater – Mt Piper – Marulan 500 kV link constructed in the late 1980s and early 1990s to match the commissioning of Bayswater and Mt Piper power stations. Originally operated at 330 kV and upgraded to 500 kV operation in 2010;
- The 330 kV and 220 kV network west of Wagga (developed to service western area loads in the late 1980s);
- The Armidale – Dumaresq 330 kV link (forming part of the QNI interconnector) (2000);
- The 330 kV cable network to Haymarket supplying the inner Sydney CBD (2004);
- The Wollar – Wellington 330 kV transmission line established in 2010 to provide support to the Wellington area; and
- The establishment of a second 330 kV supply to the Tuggerah 330/132 kV Substation in 2009 to provide increased supply reliability to that area.

These major links have been supported by 132 kV and other supply developments, including:

- The Coffs Harbour supply system and the 132 kV link between Coffs Harbour and Kempsey (2002) and a second Coffs Harbour – Kempsey 132 kV transmission circuit in 2010;
- The Ingleburn (1984), Vineyard (1994), Liverpool (1985) and Regentville (1997) substations in the Sydney area;
- The Darlington Point – Deniliquin 132 kV line (1989);
- The Narrabri – Moree 132 kV line (1983);
- The Inverell – Moree 132 kV line (1999);
- The 132 kV development to the Molong (2001) and Manildra (2003) areas.
- Wagga North 132 kV Substation in 2009;
- The establishment of the Macarthur 330/132/66 kV Substation in 2010 to provide increased supply capacity to that area south west of Sydney;
- Orange North 132 kV Switching Station in 2012;
- The Manildra – Parkes 132 kV transmission line in 2012;
- The Kempsey – Port Macquarie upgrade of single circuit to double circuit 132 kV transmission line in 2011; and
- The Glen Innes – Inverell 132 kV transmission line in 2012.

FIGURE 4.1

NSW TRANSMISSION NETWORK

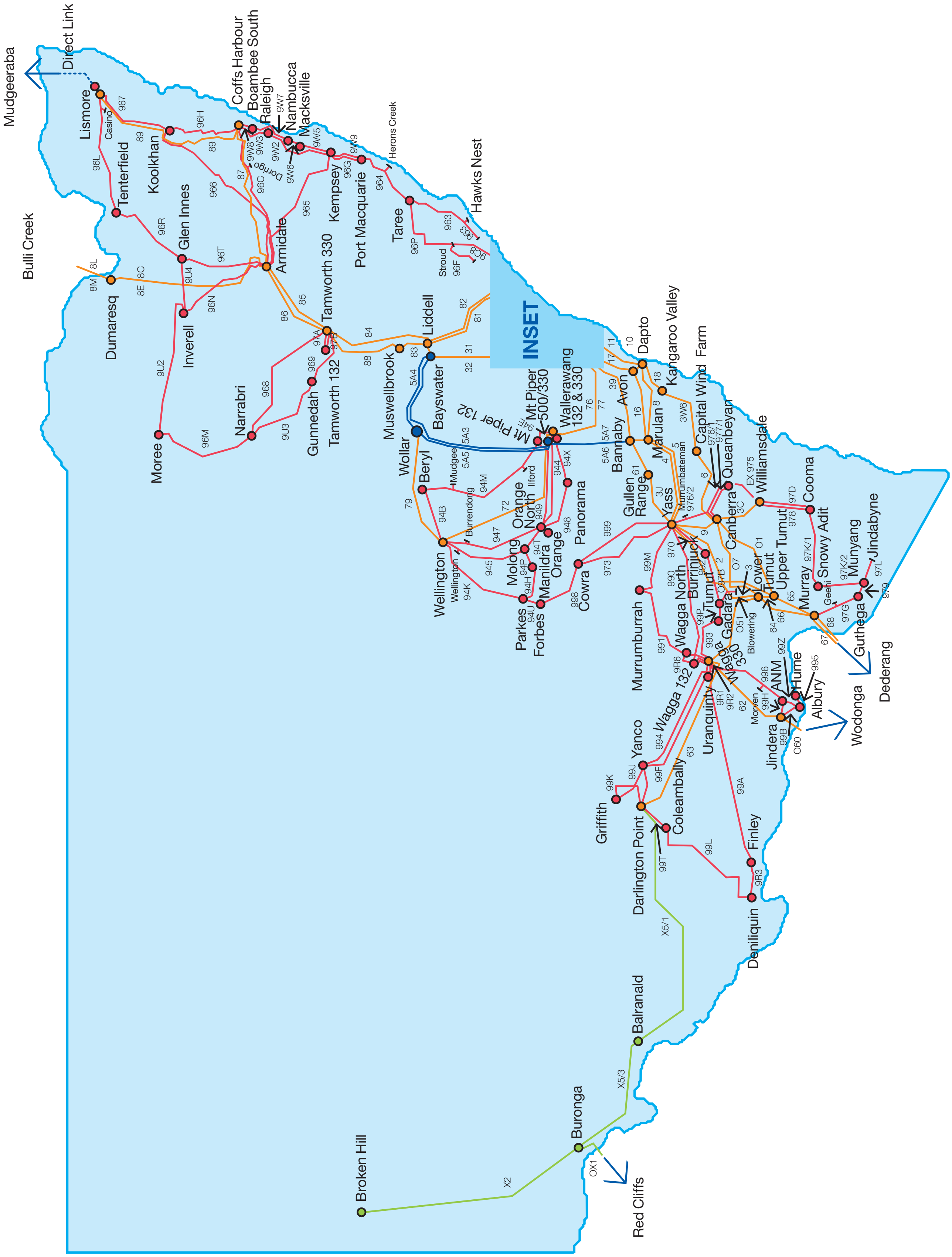
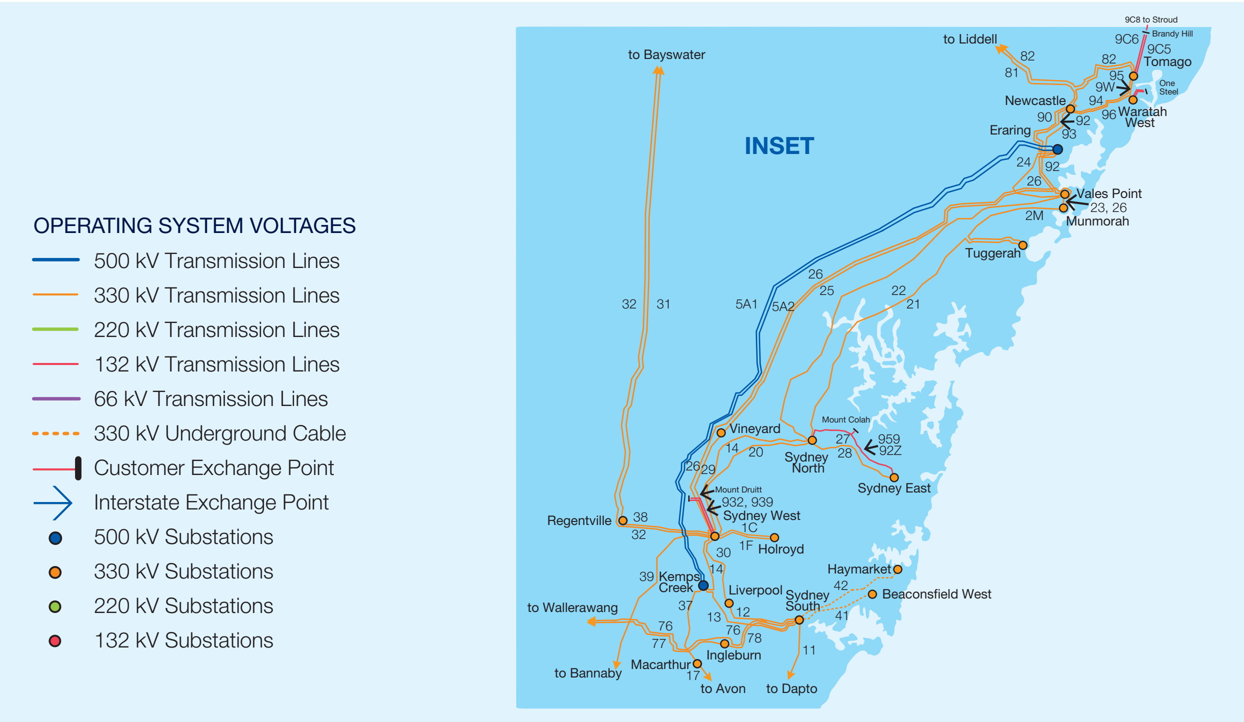


FIGURE 4.1

NSW TRANSMISSION NETWORK – INSET



The major network developments have been supported by extensive installations of reactive plant, an extensive communications system to ensure system security and sophisticated control systems.

The establishment and development of the south-east Australian transmission network, now referred to as the NEM, subsequently imposed a wider range of loading conditions on the network than was originally planned.

4.3 WHAT THE NETWORK CURRENTLY LOOKS LIKE

Today, TransGrid's network currently operates primarily at voltage levels of 500, 330, 220 and 132 kV. Within the TransGrid network there are 96 substations and over 12,900 kilometres of transmission lines, which forms the backbone of Australia's NEM, one of the most extensive electricity systems in the world.

The NSW main network is interconnected with the Victorian network via the Snowy area, Jindera (in the Albury area) and Buronga in the Red Cliffs area and is also interconnected with the Queensland network via the Dumaresq and Directlink interconnectors. The peak NSW load constitutes about half of the combined NEM peak demand and hence the NSW network is a significant part of the interconnected south eastern Australian system. Its adequacy and performance is heavily influenced by the power flows between the state systems.

Figure 4.1 shows the transmission system in NSW, the connections to NSW generation and interstate interconnections. The inset shows the transmission system that supports power transfer to the Newcastle and Sydney load areas. The combined Wollongong–Sydney–Newcastle area amounts to about one third of the load of the NEM.

The core transmission system extends from the Snowy through Wollongong, Sydney and Newcastle to Armidale and Queensland and operates at voltages of 500 and 330 kV. Supply to the regional areas is at 330 and 132 kV and in some cases the 132 kV networks are owned and operated by the distributors.

4.4 DEVELOPMENT INVESTMENT DRIVERS

The transmission network has been established as an open access regime. As a consequence, TransGrid must respond to connection inquiries for generators and customers and to their changing patterns of supply and demand. The transmission network is thus subject to a number of investment drivers. The principal drivers of network and non-network investments are set out in Table 4.1.

TABLE 4.1
NETWORK INVESTMENT DRIVERS

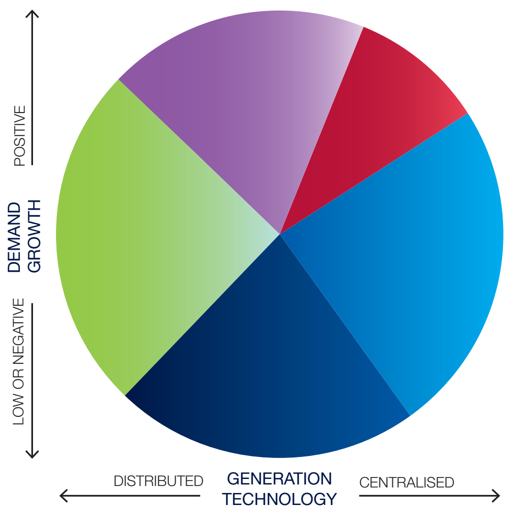
Driver	Impact on transmission network
Increase in renewable generation sources (eg wind, solar, geothermal)	→ Extension of the transmission network to the renewable generation source (typically these renewable generation sources are located in rural locations) → Connection of the renewable generation source to the transmission network → Enhance the system control and operating systems (to deal with the more variable power flows)
Increase in base load generation sources (eg. Gas combined cycle, clean coal, thermal, nuclear)	→ May involve extension of the transmission network to the generation source if it is not a redevelopment of an existing generation site → Connection of the generation source to the transmission network → If the generation source is in another state, then an enhancement and/or duplication of the interstate interconnectors may be required
Increase in small scale local generation sources (eg. solar PV)	→ Enhance the system control and operating systems (such as to deal with the more variable power flows)
Increase in use of local storage devices (eg. battery storage devices)	→ Enhance the system control and operating systems (such as to deal with the more variable power flows)
Increase in electric vehicle popularity	→ May increase peak demand and require network and/or non-network investment to maintain adequate reliability and security
Compliance with regulatory and security standards (such as n–1)	→ Enhance the security and reliability of the network → Ensure that the network meets safety and environmental standards
Growth in population	→ Secure supply to load centres by network or non-network investment
Deterioration in the condition of the existing assets (eg. assets exceeding their serviceable lives, or with deteriorating performance)	→ Replace and renew existing assets as required
Reduction in demand (due to consumer adoption of energy efficient technologies, increased local generation, fuel switching, etc.)	→ Fewer new transmission developments. Maintain, replace and renew existing assets as required.

4.5 NETWORK DEVELOPMENT SCENARIOS

The transmission network must provide the means of connecting relatively large scale sources of generation to major customers and the distribution networks. The way in which the network is developed depends to a great extent on how customer demand grows and whether that demand is met through centralised generation connected to the transmission network or through distributed generation resources largely connected within distribution networks. Figure 4.2 displays the manner in which these interdependencies are expected to influence the overall development of the transmission network.

FIGURE 4.2

NETWORK DEVELOPMENT SCENARIOS



- Connect new loads
- Augment existing substation and line capacity
- Provide additional substations and lines

- Augment generator connections
- Increase interstate interconnection capacity

- Extend network to connect remote renewables
- Protection and control systems development to integrate large scale renewables

- Few new developments
- Manage existing assets (without needing to increase the capability to supply demand)
- Rationalisation of assets (if demand reduces)

- Protection and control systems development to integrate distributed generation

It is important to note that the development scenarios in Figure 4.2 typify, in a general sense, how the transmission network may be developed. The development of the core transmission network and interconnections is expected to be largely driven by demand growth and the development of centralised generation. Where demand growth is static and distributed generation increases in penetration, little development of that network is expected to take place and maintaining the serviceability of existing assets will become the principal focus.

The range of possible developments within each regional area is more diverse and depends to a large extent upon local factors. Each regional area plan is individual and must recognise the local potential for generation developments and local development opportunities that could affect customer demand.

4.6 FORMULATING THE NETWORK DEVELOPMENT STRATEGY

Network planning process aims to develop least overall cost solutions to meet the needs of NSW electricity consumers. The transmission network provides for "common carriage" of energy between customers and generators and plans to augment or develop the network are developed in response to the following "trigger events":

- Connection applications by generators;
- Connection applications by major loads; and
- To maintain statutory requirements concerning network security, reliability and power quality. This occurs with demand growth and when assets reach the end of their economic life and need to be replaced to ensure the continued acceptable performance of the system, or in response to growth in demand.

These events are the trigger for a holistic review of the most appropriate way to develop the network, which takes into account the following factors:

- Expected demand and generation growth, to determine the appropriate scale of the development to cater for future needs, bearing in mind that major network assets have very long service lives;
- The condition of existing system assets and whether their refurbishment can form part of an integrated planning solution;
- The capability of the existing system and whether it can be economically increased using active or reactive support or "smart network" technology; and
- Stakeholder expectations in relation to the community and environmental impact of developments.

REGARDLESS OF THE EXTENT OF THE DEVELOPMENT OF THE NETWORK, THE MANAGEMENT AND, WHERE NECESSARY, RENEWAL OF EXISTING AND NEW NETWORK ASSETS REMAINS AN OVERRIDING PRIORITY.

DM and non-network options are also considered and generally factored in to the planning analysis as the time draws nearer to when works are required.

The NDS covers the potential development of the transmission network over about the next 40 years. The NDS also identifies those possible developments that may be required in the next ten years. It is divided into sub-sections covering the following topics:

- Condition based asset replacement;
- Strategic property acquisitions;
- Network developments:
  - The core 500/330 kV NSW network;
  - Interconnection possibilities; and
  - Subsystems that are supplied from the main network.

To determine possible transmission network developments a number of overall supply system scenarios are developed.

The two main supply system scenario variances are:

- Load growth variations; and
- New generation planting including by location, timing and type.

Over a ten year planning horizon a number of load growth and generation planting variances would be considered which would result in a significant number of transmission development scenarios. However in preparing this report which covers a more uncertain planning horizon greater than ten years a simplified approach has been used:

- Only a medium economic growth 50% POE load growth scenario has been adopted; and
- Only a small number of the most likely generation development outcomes are considered.

This approach is supported by the following considerations:

- Load growth variations average out over the longer term and in the shorter term usually only modify the timing of transmission development needs rather than their scope; and
- Transmission development needs resulting from unforseen generation development are not expected to impose significant or unmanageable changes to anticipated main network or sub system developments.

No attempt has been made to justify the need for each individual development or to consider alternative options. That is the role of the normal planning process and the environmental and regulatory consultation processes that would be undertaken when developments are initiated.

4.7 WHAT THE NETWORK MAY LOOK LIKE IN FORTY YEARS

TransGrid considers that in forty years the NSW transmission network will largely contain the same types of elements (lines and substations) as today, although the configuration may differ.

The existing transmission network could be developed or reconfigured in the event of:

- Increased customer demand;
- New major loads (eg. mines and industries);
- The connection of new generators
- Interconnection with other states, such as to enable the sharing of generation resources; and
- Major network elements reaching the end of their serviceable lives.

Regardless of the extent of the development of the network, the management and, where necessary, renewal of existing and new network assets remains an overriding priority. This activity is integrated into the planning for augmentations and developments, where appropriate, in order to arrive at least cost outcomes.

In the event of declining demand, asset management strategies would be modified to relocate equipment (where practical) thereby avoiding the cost of procuring new assets. Any recovered equipment would be reused or recycled and property released for alternative use. It is expected that, in these circumstances, the cost of removal of assets and site restoration would be an important consideration. That cost would need to be balanced against the ongoing operation and maintenance costs of the assets and the benefits they provide in terms of network security and reductions in losses. Consequently, it is expected that, if it was to occur, removal of major network elements would be most likely to occur near the end of the serviceable life of the assets concerned (when retaining them in service may become more difficult).

The potential network developments are discussed from section 4.9.

4.8 NETWORK DEVELOPMENT STRATEGIES

4.8.1 DEMAND MANAGEMENT AND CONSIDERATION OF NON-NETWORK OPTIONS

As described in Section 2.4.2 TransGrid considers non-network on an equal footing with network options. The balance of this chapter describes possible network developments, under a number of scenarios. Prior to making an investment decision a detailed assessment of options, including non-network options, would be undertaken.

4.8.2 STRATEGIC PROPERTY AND EASEMENT ACQUISITIONS

TransGrid's strategic acquisition of property is intended to keep open a range of options for the development of the network. This, in turn, should provide greater flexibility in the response to load and generation developments. The AER has previously supported the concept of strategic property purchases for future projects where prudent.

All transmission network developments and facilities are subject to the *Environmental Planning and Assessment Act, 1979 (EP&A Act)* and a range of other environmental legislation. TransGrid complies with these requirements and undertakes consultation to minimise the community and environmental impact of future developments. The timing of route selection and property acquisition aligns with the development approval processes required under the *EP&A Act*.

TransGrid recognises that there are existing utility "corridors" in areas where there are existing transmission lines and other utility infrastructure. To the extent practicable, developments will be confined to those corridors by the refurbishment or reconstruction of transmission lines. However, situations will inevitably arise where new lines or substations are required and where this is the case, TransGrid will need to acquire additional property or easements.

TransGrid's property needs comprise the acquisition of:

- Land for substation development and communication facilities; and
- Easements for new transmission lines and underground cables.

The locations required for new substations and possible alternate route options for network development are strongly interdependent.

There are a number of current constraints in acquiring property for large scale infrastructure:

- A project need has to be identified in a foreseeable time span;
- Suitable land needs to be identified with regard to the impact on the community and the environment of that selection;
- Regard has to be had to the legislative frameworks operating at the time and expected to be in place prior to project construction; and
- The cost of strategic acquisition must be balanced against the probability and timing of the project proceeding.

TransGrid is able to acquire land by virtue of the *Electricity Supply Act, 1995* and is required to pay compensation for such purchases in accordance with the *Land Acquisition (Just Terms Compensation) Act, 1991*. However, property rights are normally acquired by negotiated agreement and only if that fails, by compulsory acquisition. In some cases, to overcome uncertainty in timing, option agreements to secure future rights have been utilised. Options, however, can be a non-recoverable cost if the project fails to proceed.

Population growth and development affect both TransGrid's property needs and the suitability of land to meet those needs. Moreover, Government policy is encouraging the higher density redevelopment of urban areas. This has resulted in a growing scarcity of both sites and potential transmission route corridors.

Unless TransGrid takes an active role in the strategic acquisition of land and rights for transmission lines and cables, the task of achieving balanced objectives will be compounded by the challenges of securing corridors at a reasonable economic cost to the community in acquisition and in impairing the amenity of individual properties and their surroundings. Regard must also be given to the wider environment and impact at social and community levels.

The ways in which TransGrid is seeking to ensure its property requirements will be met are as follows:

- Within the Sydney environs the changing land usage is placing constraints on TransGrid's ability to secure suitable sites for future development. Industrial land is usually more suitable, however the selection of a site for a future substation must provide for the ability to secure cable or line corridors for the transmission connections.
- Through its planning processes, TransGrid identifies localities that may be suitable for future substations. In areas where it is considered that development may likely occur, it is prudent for TransGrid to consider purchasing land to allow for long term project development. This is a minimal risk option for TransGrid as it is preferable to acquire

undeveloped land as early as possible to avoid the later need to purchase built-up properties or consolidate smaller land parcels with more significant community impact. In the event that the land ultimately proves unsuitable for some reason, the costs can generally be readily recovered.

TransGrid has adopted this approach of securing suitable land to a limited degree where advancing development could otherwise sterilise the ability of TransGrid to secure effective infrastructure development. There is, however, a risk of later difficulties in securing line or cable routes from the proposed substation sites.

- The early planning controls for Sydney once provided scope for green belt corridors for infrastructure of varying types. The population growth of Sydney and outlying areas has led to competing priorities for land use.

  TransGrid has commenced discussions with Government to include future infrastructure plans in its planning documentation, to better enable early identification of joint infrastructure corridors.

There would be a risk in TransGrid securing easements without having development approval, as required under the current EP&A Act. In commencing acquisition of an easement it is important that it can be obtained in its entirety and can be utilised. Another aspect is that the cost of acquisition of an easement is unlikely to be recoverable if the project is abandoned, as there is no recognised market for sale.

4.9 DEVELOPMENT OF THE "CORE" NSW TRANSMISSION NETWORK

4.9.1 BACKGROUND

Creation of the NEM has significantly changed the role of the NSW transmission network leading to generation scheduling and consequent power flows which can now be quite different from those for which the network was originally planned.

In response to these developments the network has been fine tuned, with the objective of maximising the utilisation of its capacity. Recent reduction in the NSW demand due, amongst other things, to suppressed business activity following the 2008 GFC and steady growth in the penetration of solar PV generation has reduced the loading on many assets that were previously heavily loaded. However, load in NSW is still expected to increase, albeit at lower rates than previously which will ultimately necessitate further network or non-network developments.

Accordingly, TransGrid develops the NSW transmission network to ensure there is sufficient capacity to transmit the output of generators to the major load centres in NSW at an acceptable standard of reliability.

TransGrid also has the role of recognising the importance of efficient operation of the NEM through providing the physical network connections between Queensland, the NSW load centres and the Victoria/South Australia/Tasmania NEM regions.

The NSW transmission network serves NSW with the largest load in the NEM and also connects to Victoria and Queensland which have the next largest loads. It is therefore central to the operation of the NEM.

4.9.2 RELIABILITY STANDARD

Broadly the power supply system is designed to be capable of withstanding the forced outage of a single transmission network element (N–1) at any load level up to peak load (using a 10% PoE medium economic growth forecast) allowing for a range of likely power flows across the system.

Power flows are governed by load levels and generation dispatch. Allowance is also made for the necessity to secure the system within 30 minutes of a credible contingency by redispatch of generation, without the need to shed load, in anticipation of subsequent outages.

4.9.3 DEVELOPMENT OF THE CORE NETWORK

Figure 4.3 depicts the majority of the main NSW transmission network and highlights the "core" (most heavily loaded) section of the network.

In the longer term, the core network may reach the limit of its existing capacity to reliably supply the Newcastle/Sydney/Wollongong load area without further augmentation.

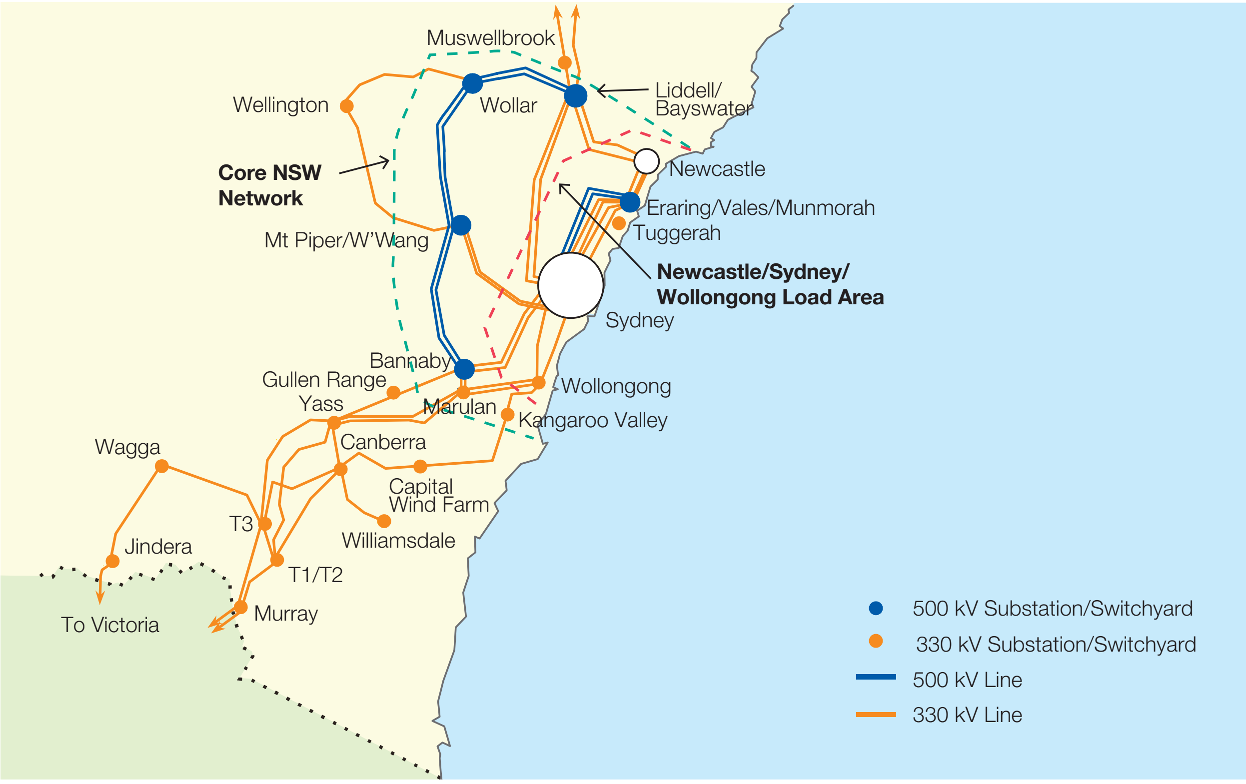
Due to the large distances involved and the distribution of generation sites in NSW it has been expected for a number of decades that eventually the existing 330 kV network, built predominantly during the 1960s and 1970s, would become inadequate to fully meet future NSW power system demands.

Extensive studies into this issue were undertaken in the late 1970s and early 1980s. A variety of options were developed and assessed at the time. The outcome of this work was the decision to commence the development of a 500 kV network in NSW. One of the major factors in this decision was the need to minimise the number of transmission line corridors into the Sydney area. The other major factor driving the need to develop a 500 kV network in NSW was the requirement to contain fault currents to within the capability of reasonably



FIGURE 4.3

THE "CORE" TRANSMISSION NETWORK IN NSW



available switchgear equipment. The establishment of a higher capacity 500 kV network has allowed the 330 kV network to be operated in a less meshed arrangement which reduces the 330 kV fault levels.

Development of a 500 kV network in NSW commenced in the early 1980s proceeding in stages as follows:

- The first stage was the construction of the Eraring to Kemps Creek 500 kV double circuit line. This provided for the reliable connection of Eraring Power Station.
- The second stage was the construction of the Bayswater to Mt Piper 500 kV line which was required to connect Bayswater Power Station in the mid to late 1980s.
- The third stage was construction of the Mt Piper to Marulan 500 kV line to match the commissioning of the Mt Piper Power Station in the early 1990s.

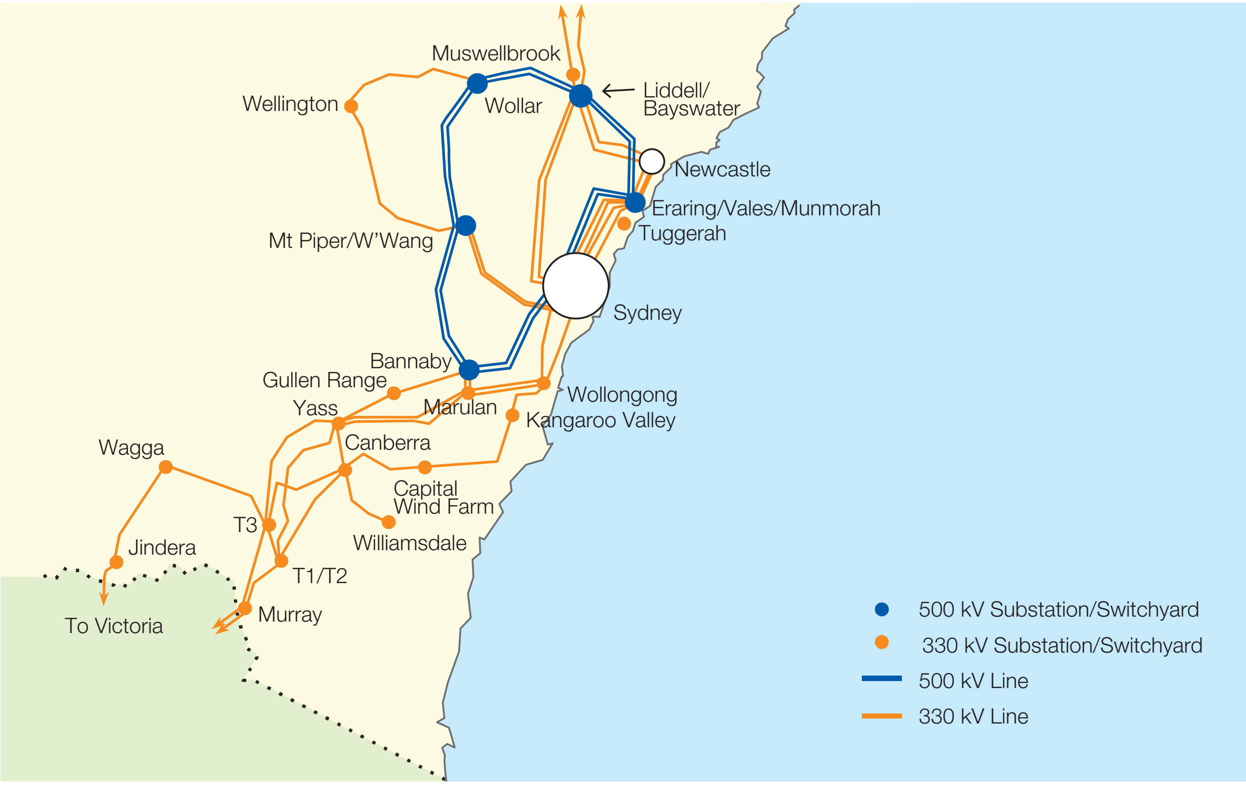
That line was recently converted to 500 kV operation, having operated initially at 330 kV to defer the high cost of 500 kV switchyard developments.

If the capacity of the existing network is reached there will be a need for further major transmission line developments into and within the Newcastle/Sydney/Wollongong/Central NSW "Core" area.

The number of locations where new generation could be connected to the existing NSW network without significantly increasing network constraints is limited. Connecting generators outside the Newcastle/Sydney/Wollongong load centre could be constrained by limited transmission line capacity to those major load centres. Connecting additional generators within the Newcastle/Sydney/Wollongong load area could be restricted by the fault interrupting capability of equipment within those areas.

FIGURE 4.4

FUTURE 500 kV RING DEVELOPMENT



The concept of developing a 500 kV ring around Newcastle/Sydney/Wollongong area to minimise transmission line routes into the Sydney basin and to effectively manage technical constraints (fault levels) on switchgear is an option in the long term to ensure a reasonable reliability of supply is maintained to these important commercial, industrial and domestic centres.

4.9.4 NEXT STEPS IN THE DEVELOPMENT OF THE 500 kV RING

There are two major links yet to be built to complete the 500 kV ring, one being a Bayswater – Eraring 500 kV line (the northern link) and the other a Bannaby – Western Sydney 500 kV line (the southern link). Which of these northern and southern links may be developed first is dependent upon load growth and the location and timing of future major generating sources.

ROAM consulting, an independent expert organisation on generation developments within Australia, was engaged to provide advice to TransGrid on likely generation developments for scenarios of future market development. Key outcomes of the ROAM report were:

- Coal and gas based generation developments and wind farm developments were considered to meet load growth with an emphasis on wind and gas if greenhouse initiatives were to be implemented;
- Any coal based generation development was considered most likely near Bayswater or at Ulan in the west of NSW, or at Mt Piper. Some upgrading of existing coal generators may also be possible;
- Major gas based generation developments would be generally sited at locations which may increase the power flow towards Sydney from the north and south of the state; and
- Significant wind farm developments were considered possible, mostly in the south of the state.

Based on scenario development and analysis arising from this work the southern link is more likely to be required first.

The only scenarios that are not adequately addressed by the above developments are where large scale base load power stations are developed in the upper Hunter Valley area or further north possibly in conjunction with an upgrade of the interconnection capacity with Queensland.

For this case the northern link would be more effective.

The northern and southern links in the 500 kV ring are depicted in Figure 4.4.

Possible 500 kV system developments and plans for reactive support have been addressed in TransGrid's TAPR and AEMO's NTNDP in recent years.

4.9.5 SUMMARY OF CURRENT AND INDICATIVE FUTURE DEVELOPMENTS

Indicative future developments of the core transmission network are described below. The order in which these developments take place could be expected to vary based on more detailed planning studies.

Within about ten years:

- Uprate where practicable a number of 330 kV lines for operation at higher conductor temperatures.
- Refurbish a number of key 40 to 50 year old 330 kV substations.

Beyond ten years:

- Rebuild the Bannaby to Western Sydney 330 kV line as a double circuit 500 kV line. This is likely to be the fifth stage of the development of the NSW 500 kV ring.
- Construct a 500 kV line from Bayswater to Eraring. Generation development outcomes could result in the Bayswater to Eraring line needing to be built before the Bannaby to Sydney line. TransGrid is keeping this program under close review.
- Establish a new 500 kV substation in the Kurri/Richmond Vale area to secure supply to the greater Newcastle area.
- Reconstruct short sections of 330 kV line to provide connections to Richmond Vale.
- Establish a new 500 kV substation in the western/north western area of Sydney probably near Vineyard.
- Continue to refurbish, rebuild and uprate existing 330 kV transmission lines and substations as required.

Continue installation of reactive power compensation equipment, capacitors, reactors and static VAr compensators (SVCs), as required.

4.10 INTERCONNECTION CAPACITY

The transmission networks in each jurisdiction were initially developed independently. Interconnections between the transmission networks have permitted the sharing of low cost generation in adjacent regions and have provided an overall economic benefit to customers through reduced energy prices.

Reinforcement of the interconnections between regions will take place when the benefits of the reinforcements outweigh the costs.

Increased interconnection capability with Victoria, South Australia and Queensland may be developed in the future. This would increase the ability for the other states to access any surplus power from NSW and alternatively would permit NSW access to generation in the other states. In particular enhanced interconnection may provide access to significant renewable generation developments in Victoria and South Australia and significant base load generation potential in Queensland. These developments are illustrated in Figure 4.5.

There is potential to increase the capability of the existing networks though the installation of specialised control plant (such as power flow controllers and series compensation) within substations. Any substantial increase in interconnection capacity will require the construction of new transmission lines. As far as the NSW network is concerned there are a number of "natural" augmentations which could be developed. These would "harmonise" increased interconnection capacity with likely transmission network augmentations expected to be needed to satisfy network reliability requirements in northern and southern NSW.

One of those options is depicted in the Figure 4.5. This development together with compatible connections in Queensland and Victoria could significantly increase the interconnection capability. Interconnection between NSW and Queensland or between NSW and Victoria could take the form of new 330 or 500 kV lines.

Over the next 40 years it would be expected that increasing the interconnection capacity to South Australia and possibly Tasmania would also be investigated.

It has been recognised that significant benefits have come from the development of the NEM and interconnection between the various NEM regions (states).

A number of studies have been undertaken to test the economic benefit of interconnection upgrades:

- TransGrid and VENCorp (now AEMO) jointly examined an upgrade of the NSW – Snowy – Victoria interconnection;
- TransGrid and Powerlink have jointly examined the technical requirements and benefits associated with an upgrade of QNI; and
- AEMO and ElectraNet have initiated a project to upgrade the Victorian – South Australian interconnector.

Indicative developments in NSW associated with increased interconnection capacity over the period of this plan are described below.

Within about ten years:

- Where practicable, uprate 330 kV lines for operation at higher conductor temperatures.
- Provide "series compensation" and/or voltage control facilities on some critical interconnection transmission lines.

FIGURE 4.5

POSSIBLE INCREASED INTERCONNECTION WITH QUEENSLAND AND VICTORIA

Beyond ten years:

NSW – QUEENSLAND

- Construct a new 330 kV line from Dumaresq to Lismore in Northern NSW to provide adequate reliability to the NSW far north coast.
- Construct a 500 kV or 330 kV double circuit line from the Bayswater/Liddell area to Armidale or to the Queensland network.
- Develop compatible works in Queensland to fully utilise the increased NSW network capacity.

NSW – VICTORIA/SOUTH AUSTRALIA

- Reconstruct 330 kV and 132 kV lines from Bannaby to Yass and on to Wagga as 500 kV or 330 kV lines to increase network capacity in Southern NSW.
- Construct a new 500 kV or 330 kV line from Wagga to the Finley/Moama area (or elsewhere) to provide increased reliability of supply in south western NSW and possible increased interconnection capacity with Victoria. (Neither the reconstruction of existing lines for significantly higher capacity nor the construction of additional lines through the Snowy area is considered to be feasible).
- Establish new 500 kV and 330 kV substations in the Yass and Finley/Moama areas.
- Construct a new 330 kV line from Darlington Point to the Finley area.
- Develop compatible works in Victoria to fully utilise the increased NSW network capacity.

It is also possible that high level interconnection to South Australia will be required to take advantage of wind farm and geothermal energy developments in South Australia.

FIGURE 4.6

GREATER SYDNEY AREA NETWORK – PRESENT

4.10.1 EMERGING CONSTRAINTS AND LIMITATIONS

Power transfer on QNI is presently constrained by voltage control limitations, transient stability issues and ultimately the ratings of NSW 330 kV lines. In the absence of major power station developments seeking access to the loads in the adjoining states, the need to upgrade the capability will be driven by the economic benefits to the market.

NSW import from Victoria is limited by stability constraints. NSW import tends to be at off-peak times, taking advantage of lower cost generation in the southern states. Augmentation of the interconnection may provide access to significant renewable generation developments in Victoria and South Australia.

NSW export to Victoria is limited by voltage control and line rating limitations. Significant gas fired and renewable power station developments in NSW may lead to economic benefits in upgrading the interconnection.

4.11 SECURITY AND COMPLIANCE DEVELOPMENTS – INDICATIVE DEVELOPMENTS IN AREAS OF NSW

4.11.1 GREATER SYDNEY

Approximately half of the NSW power demand occurs within the greater Sydney metropolitan area, which has a population in excess of four million and a maximum demand of about 6,500 MW. About 60% of the Greater Sydney area demand occurs within the eastern metropolitan area with about 40% in the western metropolitan area.

As depicted in Figure 4.6 supply to the greater Sydney area is provided via a 500/330 kV substation at Kemps Creek and another twelve (soon thirteen) 330 kV supply points. These substations are interconnected with the state's power stations to the north and west of Sydney and the main transmission network to the south.

THOUGHTFUL APPLICATION OF DEMAND MANAGEMENT CAN RESHAPE THE DEMAND PROFILE AND ALLOW COST EFFECTIVE DEFERRAL OR AVOIDANCE OF INVESTMENT IN NETWORK CAPACITY.

TABLE 4.2

MAJOR 330 kV AND 500 kV LINE AND SUBSTATION DEVELOPMENTS

Period	Substations	Lines and cables
Early/mid 1960s	→ Sydney South, Sydney West, Sydney North	→ Dapto – Sydney South, Dapto – Sydney West, Sydney West – Sydney South, Sydney West – Sydney North, Sydney North – Sydney South, Vales Point – Sydney North, Munmorah – Sydney North, Vales Point – Sydney West.
Late 1960s		→ Sydney West – Yass
Early 1970s		→ Liddell – Sydney West, Sydney North – Sydney East (2)
Late 1970s	→ Ingleburn, Beaconsfield West, Sydney East	→ Wallerawang – Sydney South, Sydney South – Beaconsfield West (cable)
Mid 1980s	→ Liverpool, Kemps Creek	→ Eraring – Kemps Creek (500 kV), Sydney North – Sydney East (132 kV operation)
Mid 1990s	→ Vineyard	
Late 1990s	→ Regentville	
Mid 2000s	→ Haymarket	→ Sydney South – Haymarket (cable)
Late 2000s	→ Macarthur	
2013/14	→ Rookwood Rd, Holroyd	→ Sydney West–Holroyd, Holroyd–Rookwood Rd (cable), Beaconsfield West–Rookwood Rd (cable)

Throughout the 1960s and 1970s a series of major substations were developed on the 330 kV "ring" that circles the greater Sydney area. These substations are located at Sydney East, Sydney North, Sydney South and Sydney West. Other smaller substations have subsequently been developed along the route of some of the 330 kV ring lines at Ingleburn, Liverpool, Macarthur, Vineyard and Regentville. The Macarthur 330/132/66 kV Substation was established in 2010 to provide increased supply to the south west area of Sydney. A major cable supplied 330 kV substation was built in the late 1970s at Beaconsfield West. A second 330 kV cable from Sydney South to Haymarket was completed in 2004.

Emanating from the thirteen Sydney area 330 kV substations are the Ausgrid and Endeavour Energy networks of 132 kV overhead lines and underground cables and some lower voltage connections which supply distribution zone substations.

The major developments in establishing this 330 kV network are shown in Table 4.2.

ASSET CONDITION AND RENEWAL

Many of the assets that formed the original development of the 330 kV ring will reach the end of their serviceable lives during the period spanned by the NDS. This is likely to include those substations and lines constructed through to about the 1980s. These assets will be progressively refurbished or replaced as part of TransGrid's asset management strategies and depending upon the expected demand and development needs at the time may also be reconfigured or modified in capacity.

DEMAND GROWTH IN THE GREATER SYDNEY AREA

The summer and winter maximum demands for the Greater Sydney area are shown in the Figure 4.7. As with other areas of the state, growth in the Sydney area has moderated over the past several years. In particular, the reduction in winter maximum demand over the past few years reflects the trends seen in the state as a whole.

FIGURE 4.7

HISTORICAL GREATER SYDNEY AREA MAXIMUM DEMANDS

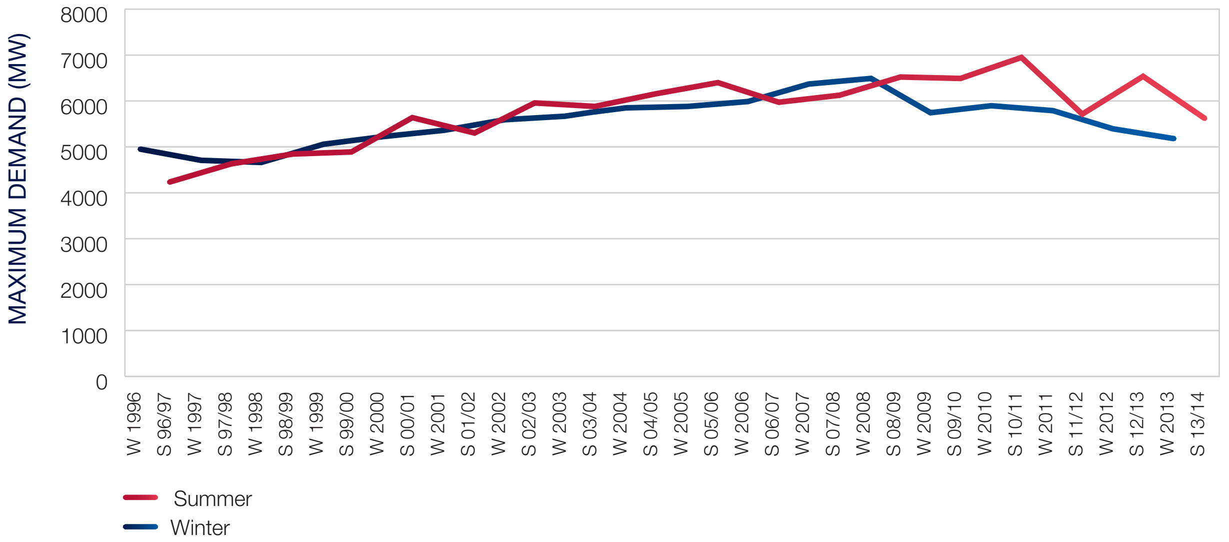


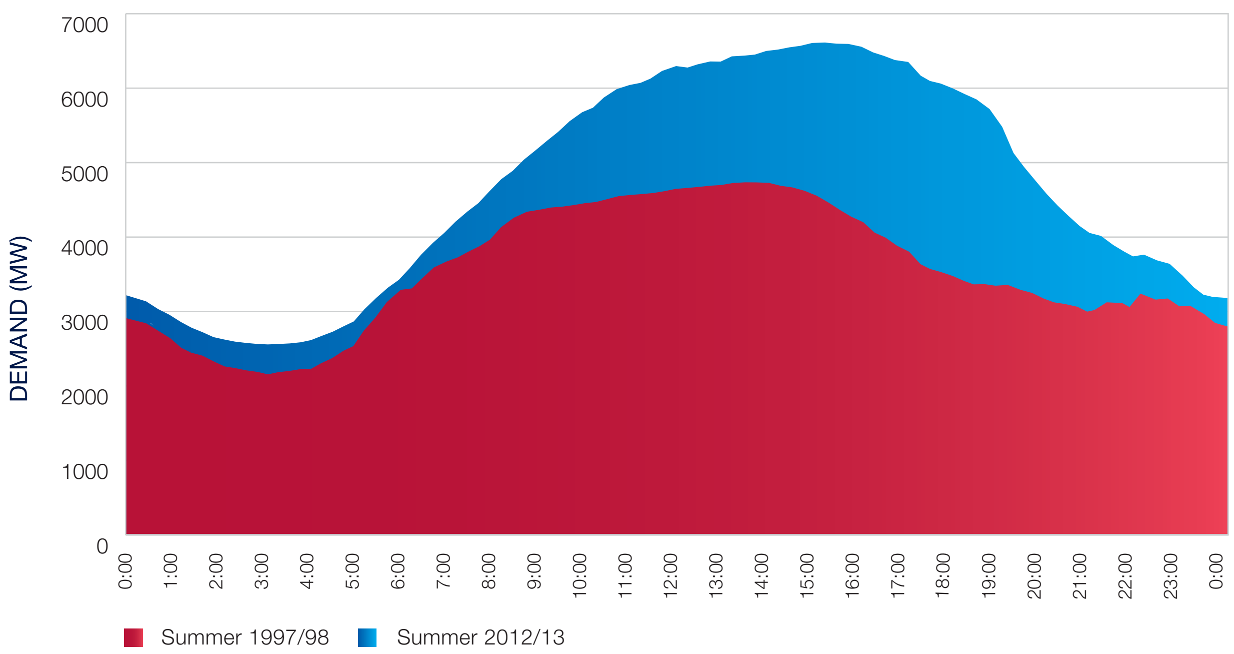
Figure 4.8 shows the changing load profiles in the Greater Sydney area on peak summer days. The large increase in afternoon and evening load is largely attributable to the increased penetration of residential air conditioning.

Future peak demand in the Sydney area is expected to be driven by housing developments in Sydney's north west and south west together with an increase in housing density around major transport corridors. However, it is likely to be moderated by DM and possibly by the development of local generation.

To date there has been limited development of local generation, co-generation and tri-generation in the Sydney area, although work in this area is on-going.

FIGURE 4.8

GREATER SYDNEY AREA SUMMER LOAD PROFILES



Source TransGrid

FIGURE 4.9

GREATER SYDNEY AREA NETWORK – INDICATIVE FUTURE

MAIN NETWORK CAPACITY TO THE GREATER SYDNEY AREA

The Sydney area network lies on the path of the main transmission network from the Hunter Valley and Central Coast to the south of the state. The development of the western 500 kV ring via the western coalfields has provided a significant power flow path from the north to south of NSW that bypasses Sydney. Nevertheless the capability of the power system to supply the Sydney area is influenced by the overall power flow patterns through NSW.

In the longer term, depending on load growth, it is possible that the main transmission network may need to be extended at 500 kV into the Sydney area to meet load requirements. Construction of a 500 kV line to Western Sydney from Bannaby would be an integral part of the formation of the NSW "500 kV Ring" and would also meet any need to increase transmission line capacity to the greater Sydney area.

It is expected that a new 500/330 kV substation will be required near Sydney West or Sydney North, possibly in the Vineyard area. Increased 500/330 kV transformer capacity may also be required at Kemps Creek.

INDICATIVE FUTURE DEVELOPMENTS IN GREATER SYDNEY AREA

Over the next 40 years there is the potential for five or more new 330 kV supply points to be required in the greater Sydney area, depending on load growth. The possible locations for these are determined by area supply limitations and the proximity to existing infrastructure (both TransGrid's and the distributors'). These developments are described in the following and illustrated in Figure 4.9. The development of the inner metropolitan area is discussed in greater detail in section 4.11.2.



TransGrid will develop the network to ensure secure and reliable supply whilst catering for four main eventualities:

- Providing sufficient supply capacity to existing substations, whether load grows or declines;
- Supporting Ausgrid's and Endeavour Energy's 132 and 66 kV networks at strategic locations;
- Accommodating possible generation developments; and
- Allowing the retirement of existing assets at the end of their lives.

DM and local generation initiatives will be vigorously pursued to delay or modify the extent of the works. These will be examined during detailed joint planning with Ausgrid and Endeavour Energy.

Accommodating generation developments on the network would depend on the magnitude and location of the generation. Relatively small developments should be able to be connected to Ausgrid's or Endeavour Energy's existing 132 kV or lower voltage networks. Larger developments would require more substantial connections at 330 kV. It is anticipated that access to transmission infrastructure would be a consideration in siting any new generation in the area and that major augmentations to accommodate generation are unlikely to be required.

The indicative major developments of the transmission network in the greater Sydney area are described below.

Within about ten years:

- Support Ausgrid's and Endeavour Energy's 132 and 66 kV networks at strategic locations.
- Uprate existing 330 kV substations where required.
- Install additional 330 kV cables from Rookwood Road to the Sydney inner metropolitan area.

In the period beyond ten years:

- Establish a new 330/132 kV supply point at Kemps Creek.
- Construct new and rebuilt 330 kV line connections from Kemps Creek to the Liverpool area and to Sydney West.
- Construct a new 500 kV line from Bannaby to South Creek.
- Establish new 330 kV supply points at Kemps Creek, in the Sydney inner metropolitan area and the Mt Druitt and/or Annangrove areas.
- Further uprate existing 330 kV substations including transformer capacity at some existing supply points.
- Uprate or reconstruct other 330 kV lines in the Sydney area.
- Establish a new 500 kV substation in the western/north western area of Sydney, probably near Vineyard.

4.11.2 CENTRAL SYDNEY

The capability of the inner metropolitan supply network is defined by the combined capacity of the parallel 330 and 132 kV networks. These networks have been planned to operate in unison, designed to share the network load in proportion to their respective ratings. There are a total of 16 such underground circuits that supply the inner metropolitan area, to the right of the dotted grey line A in Figure 4.10. The capacities into that area and also into the CBD (above line B) constitute the main limitations on the inner metropolitan network.

ASSET CONDITION AND RENEWAL

The SF6 gas insulated switchgear at Beaconsfield West was recently replaced and the substation expanded. Cable 41 (330 kV) was installed in the late 1970s on a route mainly direct buried in roadways. Following ongoing investigations, it has been determined that poor thermal properties of the backfill limit its capacity and the cable was recently derated to avoid deterioration through thermal damage. A project to replace the backfill will be implemented in the next few years, following which the rating of the cable may be improved. This cable condition will be closely monitored and it is likely that it will reach end of life and be retired during the course of this NDS.

The remaining TransGrid assets in this area will be carefully monitored as part of TransGrid's asset management strategies and refurbished as required.

The condition and rating of approximately thirteen Ausgrid 132 kV cables and 330 kV cable 41, however, are likely to be factors in the augmentation of supplies to the inner metropolitan network. These cables were installed during the 1960s and 1970s, use oil filled technology, and in some cases are approaching the end of their serviceable lives.

Ausgrid is reviewing the ratings of its 132 kV underground cable circuits. Its investigations have discovered a number of locations along cable routes with high natural soil thermal resistivity, resulting in a reduction of the rating of several critical circuits amongst those supplying Sydney inner metropolitan area and CBD.

Ausgrid plans to progressively remediate, replace or retire some of these cables over the next five to ten years. This may result in a reduction in the capacity of supply into the Sydney inner metropolitan area and CBD.

FIGURE 4.10

INNER METROPOLITAN AREA NETWORK – PRESENT

FIGURE 4.11

INNER METROPOLITAN AREA NETWORK – INDICATIVE FUTURE

RELIABILITY STANDARD FOR THE SYDNEY CBD AND INNER METROPOLITAN AREA

Under a range of reasonably forecast demands it is expected that the existing interconnected 330/132 kV network supplying the Sydney CBD and inner metropolitan area should be able to withstand an outage of any single transmission element.

TransGrid and Ausgrid have adopted a reliability standard for planning the combined networks in the Sydney CBD and inner suburbs.

The standard allows peak load to be supplied with:

- The simultaneous outage of a 330 kV cable and any 132 kV feeder or 330/132 kV transformer; or
- An outage of any section of 132 kV busbar.

This combined transmission and distribution reliability standard reflects the long times needed (several weeks to months) to rectify major cable or transformer failures and the potentially high cost of disruption to industrial and commercial activities in the Sydney area. It is comparable to reliability standards in the metropolitan areas of major cities throughout the world.

THE LOAD

A modest rate of demand growth is forecast for the inner Sydney metropolitan area. This growth has moderated over the last few years due in part to increased electricity prices, the use of energy efficient devices (eg. high efficiency lighting) and the gradual penetration of embedded renewable sources of power, including tri-generation installations in CBD buildings. The forecast demand growth is not expected to have a major impact on the scope and timing of future network needs in the short to medium term, as these are expected to be driven by the derating and retirement of existing cables.

INDICATIVE FUTURE DEVELOPMENTS IN INNER METROPOLITAN AREA

TransGrid is investigating the use of non-network options to address the forecast shortfall in supply capacity into the inner metropolitan area. DM initiatives including both load reduction and embedded generation schemes are being considered.

As TransGrid was able to procure 40 MW of DM in this area for Summer 2012/13, it is expected that at least this amount would be available in the future.

The effectiveness of DM in addressing the need is dependent on the geographic location of the solution. Within certain parts of the CBD and inner metropolitan area, that effectiveness can be close to 100%.

Accommodating generation developments on the network would depend on the magnitude and location of the generation. The relatively high capacity of Ausgrid's existing 132 kV network lends itself to the connection of generators of 100 MW or more. Smaller units would be connected at 33 or 11 kV. In all cases, the management of fault levels in this portion of the network will be necessary and factored into the connection arrangements.

The indicative major developments of TransGrid's transmission network in the greater Sydney area are described below and illustrated in Figure 4.11. It should be noted that in this illustration, some of the existing Ausgrid 132 kV cables are likely to be taken out of service and may not be replaced.

Within about ten years:

- Install phase shifting transformers at Beaconsfield to improve sharing of the 330 kV cable 41; and
- Install additional 330 kV cables from Rookwood Road to the Sydney inner metropolitan area.

In the period beyond ten years:

- Establish an additional inner CBD 330/132 kV substation at Riley Street, supplied from 330 kV cables terminated at Beaconsfield and Haymarket.

TABLE 4.3

DEVELOPMENT OF THE TRANSMISSION NETWORK IN THE NORTH COAST AREA

Period	Substations	Lines
Mid/late 1950s	→ Taree substation	→ First Newcastle – Taree 132 kV line
Early 1960s	→ Koolkhan substation	→ Armidale – Koolkhan 132 kV line
Mid 1960s	→ Kempsey substation	→ Armidale – Kempsey 132 kV line
Late 1960s	→ Lismore 132 kV substation → Glen Innes and Tenterfield substations	→ Koolkhan – Lismore 132 kV line → Armidale – Glen Innes – Tenterfield 132 kV line
Early 1970s		→ Tenterfield – Lismore 132 kV line
Mid 1970s		→ Second Newcastle – Taree 132 kV line
Late 1970s	→ Coffs Harbour 132 kV substation → Port Macquarie substation	→ Armidale – Coffs Harbour 132 kV line → Coffs Harbour – Koolkhan 132 kV line → Taree – Port Macquarie 132 kV line
Early 1980s		→ Armidale – Coffs Harbour Line (330 kV construction) → Koolkhan – Lismore Line (330 kV construction)
Mid 1980s		→ Port Macquarie – Kempsey 132 kV line
Early 1990s	→ Lismore 330/132 kV substation	→ Coffs Harbour – Koolkhan line (330 kV construction) → Operation of 330 kV construction lines at 330 kV
2001		→ “DirectLink” 180 MVA d.c. “MNSP Link” – Mullumbimby to Terranora
2002	→ Nambucca substation	→ Coffs Harbour – Kempsey 132 kV line
2003		→ Uprating Armidale – Kempsey 132 kV line 965 for higher conductor temperature operation
2005		→ “DirectLink” – Mullumbimby to Terranora converted to “Regulated Status”
2006		→ Coffs Harbour 330 kV substation
2006		→ Uprating Armidale – Koolkhan 132 kV line 966 for higher conductor temperature operation
2010		→ Coffs Harbour – Kempsey 132 kV transmission line, establishment of second circuit
2010		→ Uprating Armidale – Coffs Harbour 132 kV line 95C for higher conductor temperature operation
2012		→ Kempsey – Port Macquarie 132 kV transmission line converted from single circuit to double circuit

4.11.3 NORTH COAST

The North Coast is supplied from a 330 kV and 132 kV network emanating from 330/132 kV substations at Lismore, Coffs Harbour, Armidale and Newcastle.

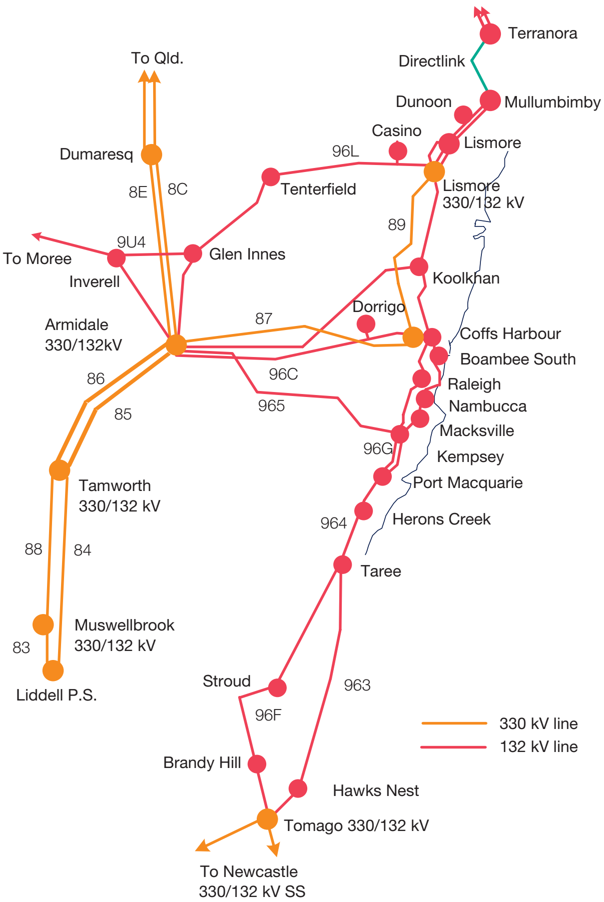
Prior to the mid 1950s, the area was supplied by a 66 kV network together with some local generation. That network has been progressively reinforced by the establishment of a 132 kV network and in more recent times by the first elements of a 330 kV network. Major developments to date are shown in Table 4.3.

The 132 kV TransGrid network supplies a number of Essential Energy 132 kV zone substations at: Dorrigo; Casino; Boambee South, Raleigh, Macksville, Hawks Nest and Herons Creek.

The existing North Coast transmission network is shown Figure 4.12.

FIGURE 4.12

TRANSMISSION NETWORK IN THE NORTH COAST – PRESENT



ASSET CONDITION AND RENEWAL

During the currency of this NDS many of the assets currently in service will reach the end of their serviceable lives. This is likely to include those substations and lines constructed through to about the 1980s. These assets will be refurbished or replaced as part of TransGrid's asset management strategies and depending upon expected demand at the time may also be reconfigured or modified in capacity. In some cases replacement of all (or a major part) of an asset will be necessary.

THE LOAD

The NSW north coast has for many years experienced population and demand growth amongst the highest of any region in NSW. Demand growth from population migration to the area is expected to continue.

GENERATION OPPORTUNITIES

Wind: Wind resources have been identified in the Armidale area. The most prospective area is bounded approximately by Armidale, Glen Innes and Inverell. Within this area, several hundred MW of potential generation has been identified. It is expected that it could be accommodated by connections to existing 132 kV or 330 kV lines in the area. This may entail establishment of new 132 kV lines and possibly a new 330/132 kV substation.

Hydro: There are small hydro generators at Oakey (east of Armidale) and Nymboida (south of Grafton). No significant additional hydro generation is anticipated.

Renewables: Increased generation at sugar mills in the Grafton area has been proposed. There is a generator of around 30 MW capacity in the Lismore areas which has experienced materials handling difficulties that have limited its output.

Gas: Natural gas from coal seams or conventional sources is available in the Lismore area and could be utilised for generation.

Geothermal: There may be potential for geothermal generation in the area west of Port Macquarie. A large scale generator in that area would require connection at 330 kV.

NETWORK LIMITATIONS AND INDICATIVE DEVELOPMENTS

The 132 kV network supplying the Coffs Harbour to Kempsey, Port Macquarie and Stroud areas has recently been reinforced. If demand continues to increase, in the longer term developments at 330 kV will be needed to support the existing 132 kV system.

Directlink is a direct current (dc) link capable of delivering approximately 160 MW in either direction between NSW and Queensland, provided that the networks to which it is connected are capable of transmitting that load. Power transfer from NSW to Queensland loads the NSW system in the far north to well beyond its thermal rating capability and voltage control capability should an outage of a 330 kV line occur. To manage this, a scheme has been installed to trip Directlink for an outage of either 87 or 89 lines when it is transferring power towards Queensland.

Directlink may be able to be used to supply some of the Lismore load during critical contingencies. Powerlink's 275 kV system supplying Mudgeeraba and the Mudgeeraba – Terranora 110 kV double circuit line are now capable of supplying Directlink from the north. The primary limitation on the ability of Directlink to support the Lismore area is its availability.

DM and local generation initiatives would be vigorously pursued to delay or modify the extent of the works. These would be examined during detailed joint planning with Essential Energy. These options are not considered in detail here, however:

- Readily accessible local energy sources in the area are limited; and
- The area does not have significant amounts of industrial and large commercial loads, which generally offer the greatest opportunity for DM.

Indicative developments of the transmission network in this area are described below and indicated in Figure 4.13.

Within about ten years:

- Essential Energy may require injections from new 132 kV substations to support its lower voltage networks. These are expected to be required at Gloucester and in the Hallidays Point (Nabiac) area.
- Install reactive power compensation equipment as required.

In the period beyond ten years:

- Construct a new 330 kV line from Dumaresq to Lismore to reinforce supply to the Lismore area.
- Increase the 330/132 kV transformer capacity at Coffs Harbour.
- Increase the transformer capacity at existing 132 kV substations as capacity limits are reached.
- The capacity limitations of the 132 kV network between Tomago and Coffs Harbour may eventually require the staged reinforcement at 330 kV in the area. Eventually two additional 330/132 kV substations may be required, in the Taree area and in the Port Macquarie/Kempsey area.
- Detailed planning and line route feasibility investigations will establish the preferred reinforcement between these 330 kV substations. Two alternative developments are shown in Figure 4.13, involving either 330 kV interconnection, or duplication and reinforcement of the 132 kV system.
- Further uprate key 132 kV lines in the area.
- Further uprate existing 132 kV and 330 kV substations in the area.
- Continue installation of reactive power compensation equipment as required.

FIGURE 4.13

TRANSMISSION NETWORK IN THE NORTH COAST – INDICATIVE FUTURE

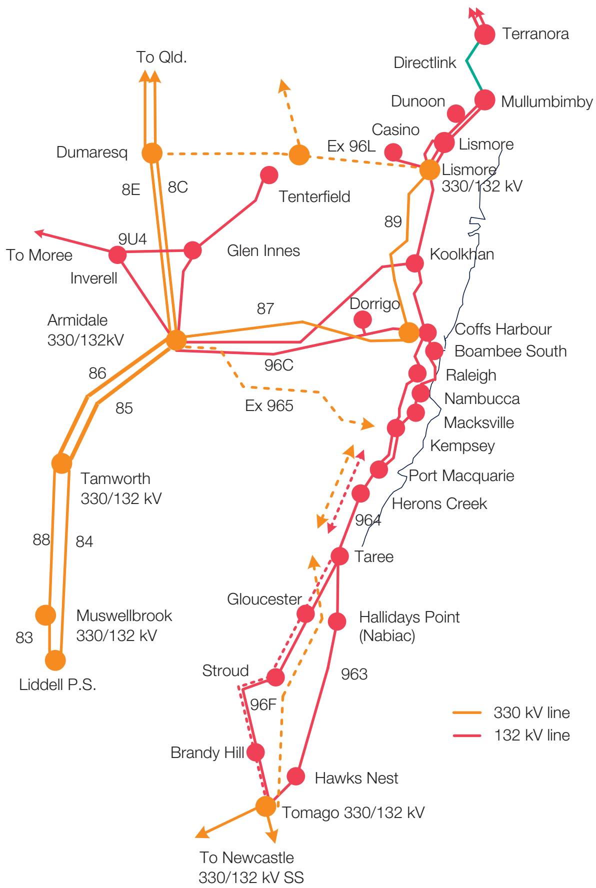


TABLE 4.4

NORTH WEST AREA TRANSMISSION DEVELOPMENTS

Period	Substations	Lines
Early 1960s	→ Tamworth 132/66	
Mid 1960s	→ Narrabri 132/66 kV	→ Tamworth – Narrabri (via Gunnedah)
Late 1960s	→ Tenterfield, Glen Innes (temporary)	→ Armidale – Glen Innes – Tenterfield
Early 1970s		→ Narrabri – Moree (which operated at 66 kV for a number of years)
Mid 1970s		→ Tamworth – Narrabri
Early 1980s	→ Inverell	→ Armidale – Inverell
Mid 1980s	→ Gunnedah, Moree	
Late 1990s		→ Inverell – Moree
2007	→ Glen Innes	
2010	→ Tamworth 330, Tamworth 132	→ Short section of double circuit 132 kV transmission line
2011	→ Tamworth 330, Armidale 330	→ 330 kV line uprating
2012	→ Glen Innes, Inverell	→ Glen Innes – Inverell 132 kV transmission line
2007	→ Glen Innes 132/66 kV Substation (replacement for temporary substation) → Armidale 132/66 kV Substation replacement of transformers with 2 x 60 MVA units	
2010		→ Tamworth – Gunnedah short section of double circuit 132 kV transmission line
2012		→ Glen Innes – Inverell 132 kV transmission line

4.11.4 NORTH WEST

The north western area of NSW is supplied via a network of 132 kV lines emanating from 330/132 kV substations at Tamworth and Armidale as shown in Figure 4.14. There are three 132 kV "rings":

- → the first is around 230 km long and connects Tamworth, Gunnedah and Narrabri
- → the second connects Armidale, Glen Innes and Inverell and is around 280 km in length; and
- → the third and main one is around 500 km in length and connects Tamworth to Narrabri, Moree, Inverell and Armidale.

A 132 kV line between Glen Innes and Inverell largely on the route of an Essential Energy 66 kV line was completed in 2012.

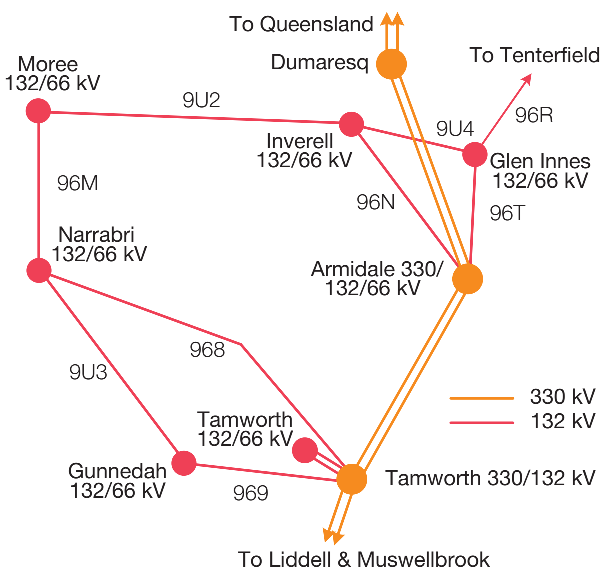
Major developments in establishing the 132 kV network are shown in Table 4.4.

A section of 132 kV line to connect a new mine in the Boggabri area is expected to be completed in the near future.

The development of Essential Energy's network is not specifically addressed in this document, other than briefly considering possible developments which may emanate from TransGrid's existing network.

FIGURE 4.14

TRANSMISSION NETWORK IN THE NORTH WEST AREA – PRESENT



ASSET CONDITION AND RENEWAL

During the period spanned by this NDS many of the assets currently in service will reach the end of their serviceable lives. In the short to medium term this will include Tamworth and Narrabri 132/66 kV substations, and is likely to include those substations and lines constructed through to about the 1980s. These assets will be refurbished or replaced as part of TransGrid's asset management strategies and depending upon expected demand at the time may also be modified in capacity. In some cases replacement of all (or a major part) of an asset will be necessary.

THE LOAD

The load is primarily rural, with associated commercial and light industrial loads in population centres. A large proportion of the state's cotton is grown in the area and a major component of the load results from the associated irrigation and ginning. In addition, there is some coal mining the Gunnedah/ Narrabri area.

In addition to weather conditions on particular days, the load in the area is influenced by longer term effects such as rainfall which affects the need or opportunity for irrigation. During drier times, the opportunity to irrigate can be limited by water storage levels (mostly Keepit and Copeton dams). During wetter times there can be less need to irrigate. Also, the availability of water at the required times can affect the cotton crop and hence the ginning load.

GENERATION OPPORTUNITIES

Some natural gas has been identified in the Narrabri area and is being used to supply a small power station near Narrabri. That station utilises multiple small reciprocating engines. It is capable of being expanded if additional gas is available.

Coal deposits and associated coal seam methane in the Gunnedah/ Narrabri area provide an opportunity for larger scale generation to be developed. Coal is also available in the Ashford area, although it is less commercially attractive than that in the Gunnedah/Narrabri area. The connection of a larger scale generator would involve the extension of 330 kV into the area and could also influence the development of the core 500 and 330 kV networks.

A natural gas pipeline from the Surat basin (in Queensland) to Newcastle has been proposed. It would pass through the area and, should it proceed, could fuel generation in the area or provide an outlet for coal seam methane developments.

Wind resources have been identified in the Armidale area. The most prospective area is bounded approximately by Armidale, Glen Innes and Inverell. Within this area, several hundred MW of potential generation has been identified.

Depending on the scale and proximity of such a development to existing lines, connection at 132 kV or 330 kV is envisaged.

There are small hydro generators at Keepit and Pindari dams and a larger unit at Copeton dam. Their operation is linked to water releases; consequently their output is seasonal and dependent on dam levels. No additional hydro generation of any significance is anticipated in the area.

NETWORK LIMITATIONS

The network includes a number of long 132 kV lines. Consequently, its capability is mostly limited by unacceptably low voltages on outage of critical lines. At present the most critical lines are:

- Tamworth – Gunnedah; and
- Tamworth – Narrabri.

Over the years, a number of capacitor banks have been installed to manage these limitations. There is some scope to install additional capacitors, however the majority of the most effective locations have already been utilised.

In addition to the voltage limitation, the original Tamworth – Narrabri line (now the 969 Tamworth – Gunnedah and the 9U3 Gunnedah – Narrabri lines) has a smaller conductor than other lines in the area. In the near term the thermal rating of the 969 Tamworth – Gunnedah line is expected to impose limitations on outage of the 968 Tamworth – Narrabri line.

INDICATIVE DEVELOPMENTS

Development of the network entails the following main components:

- reinforcing supply to the Gunnedah/Narrabri/Moree area; and
- accommodating possible generation developments.

Indicative developments of the transmission network in this area are described in the following and indicated in Figure 4.15. DM and local generation initiatives would be vigorously pursued to delay or modify the extent of the works.

Within about ten years:

- Rebuild further sections of the presently decommissioned 66 kV 875 line from Tamworth to Gunnedah to operate at 132 kV to form a new Tamworth – Gunnedah 132 kV circuit.
- Additional lines would be required to connect new or significantly expanded mines in the Gunnedah area.
- Rebuild of Tamworth 132/66 kV Substation.
- Respond to any non-forecast industrial/mining load or generation developments in the area.
- Respond to wind generation developments in the Armidale – Glen Innes – Inverell area.
- Install reactive power compensation equipment as required.

In the period beyond ten years:

- Increase 132/66 kV transformer capacity at Tamworth.
- Uprate some existing 132 kV and 330 kV substations in the area.
- Further uprate key 132 kV lines in the area.
- Reinforce the network supplying both Narrabri and Moree, such as by constructing a new 330 kV line from Tamworth to the Narrabri area or from Dumaresq to the Moree area and reinforcing the connection between the two areas, such as by forming a second 132 kV line from Narrabri to Moree.
- Continue the installation of reactive power compensation equipment as required.

4.11.5 GREATER NEWCASTLE

The greater Newcastle area is supplied via Ausgrid's 132 kV network from Newcastle, Waratah West and Tomago 330/132 kV substations. The transmission network in the Newcastle area is illustrated in Figure 4.16.

Part of the load on the Mid North Coast is supplied from the Newcastle area. The southern section of 963 line is owned by Ausgrid and the northern section by TransGrid.

FIGURE 4.15

TRANSMISSION NETWORK IN THE NORTH WEST AREA – INDICATIVE FUTURE

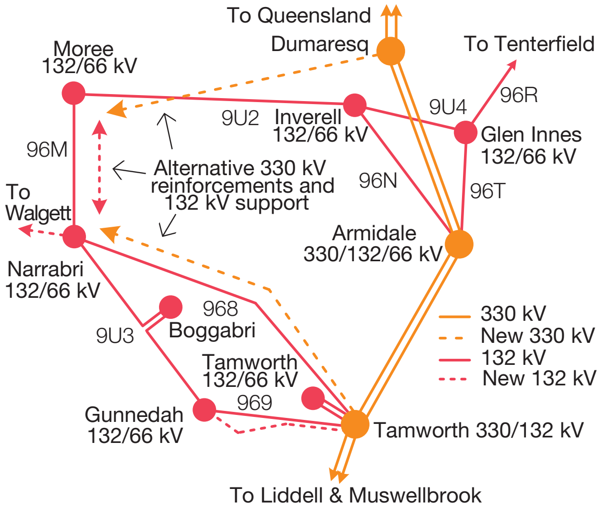
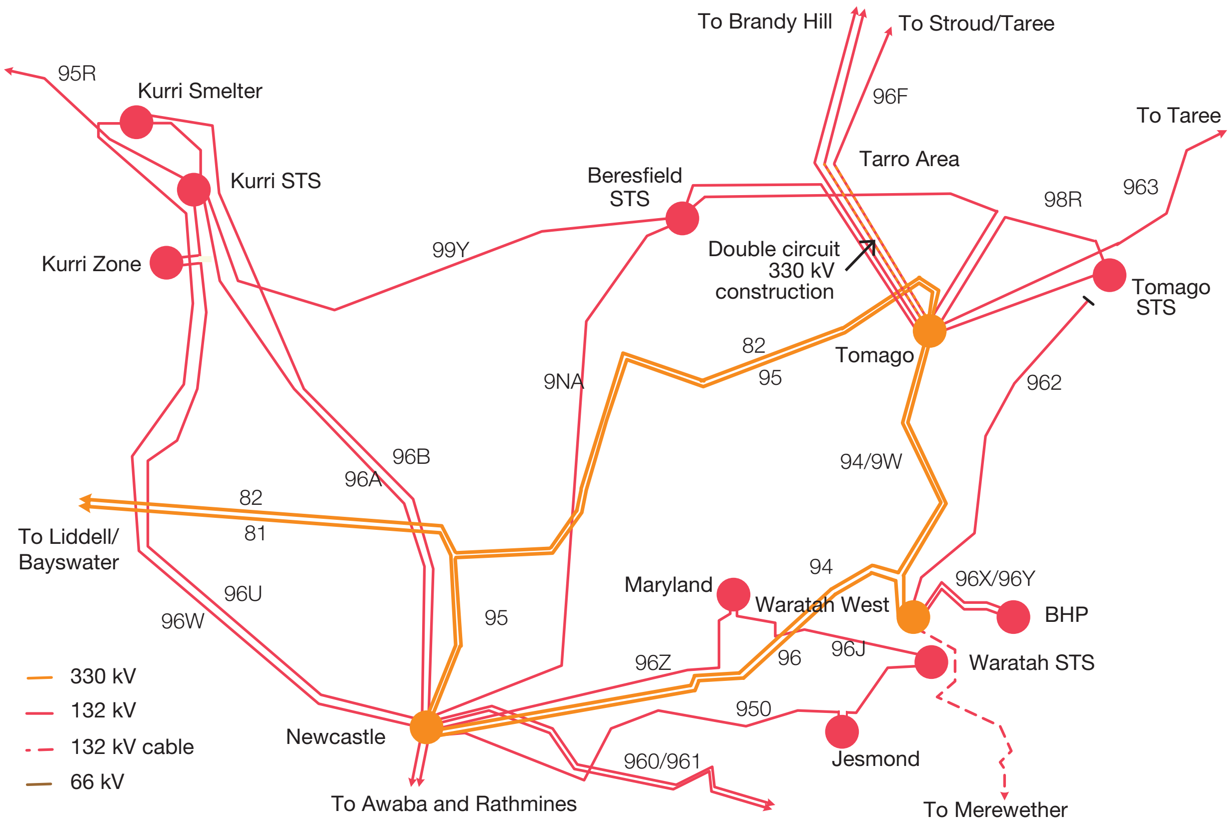


FIGURE 4.16

TRANSMISSION NETWORK IN THE GREATER NEWCASTLE AREA – PRESENT



Major developments in establishing the 330 kV network supplying the area are shown in Table 4.5.

TABLE 4.5

GREATER NEWCASTLE AREA TRANSMISSION DEVELOPMENTS

Period	Substations	Lines
Late 1960s	→ Newcastle 330/132 kV substation	→ Vales Point – Newcastle, Newcastle – Liddell 330 kV lines
Early 1970s		→ Second Newcastle – Liddell 330 kV line
Early 1980s	→ Tomago 330 kV substation	→ Two double circuit 330 kV lines to Tomago
Early/mid 1980s		→ Eraring – Newcastle
Early 1990s	→ Waratah West 132 kV switching station	
2004	→ Waratah West 330/132 kV substation	
2011	→ Tomago 330/132 kV transformation and additional transformer at Waratah West	→ Conversion of a Newcastle – Waratah West circuit which initially operated at 132 kV to operate at 330 kV
2014		→ Tomago – Stroud double circuit 132 kV line

ASSET CONDITION AND RENEWAL

During the period covered by this NDS many of the assets currently in service will reach the end of their serviceable lives. In the short to medium term this will include the remaining single phase 330/132 kV transformers at Newcastle. Assets will be refurbished or replaced as part of TransGrid's asset management strategies and depending upon expected demand at the time may also be modified in capacity. In some cases replacement of all (or a major part) of an asset will be necessary.

THE LOAD

The Newcastle area is the second largest load area in NSW.

The load has historically had a significant industrial component and consequently has a high load factor. Over the years, there have been a number of changes, including rationalisation of the former BHP activities and the recent closure of the Kurri aluminium smelter.

The load has remained largely static in winter and exhibited modest growth in summer until 2010/11, suggesting growth in other sectors sufficient to compensate for the reduced industrial component. Summer maximum demands are now greater than winter maximum demands. In common with many other areas, energy consumption and demand growth has declined in recent years.

GENERATION OPPORTUNITIES

Natural gas and coal are available in the Newcastle area. Gas fuelled generation in the Tomago area has been considered.

There is a small wind generator on Kooragang Island; however, the development of larger scale wind generation is not expected as this is not a recognised high wind resource area.

NETWORK LIMITATIONS AND INDICATIVE DEVELOPMENTS

The recent installation of 330/132 kV transformation at Tomago has relieved limitations in Ausgrid's network supplying Beresfield and Tomago 132/33 kV substations. A double circuit 132 kV line between Tomago and Stroud has recently been completed to relieve limitations in the network north of Tomago. Replacement of the banks of single phase transformers at Newcastle 330/132 kV substation is currently under way. Following the closure of the aluminium smelter at Kurri, it was decided to retire (and not replace) one bank of transformers.

If there is a rationalisation of generators in the Upper Hunter Valley area, there may be a need to provide additional transformer capacity at Muswellbrook to replace the 33 kV supplies presently drawn from Liddell. Joint planning between Ausgrid and TransGrid will identify the preferred development.

Although there have been no recent inquiries, should significant mine developments take place in this area reinforcement of the 330 kV supply to Muswellbrook could also be necessary.

The connection of new generation developments would depend on the magnitude and location of the generation. Relatively small developments should be able to be accommodated by connections to Ausgrid's existing 132 kV network. Larger developments would require more substantial connections at 330 kV. It is anticipated that access to transmission infrastructure would be a consideration in siting any new generation in the area and that major augmentations to accommodate generation are unlikely to be required.

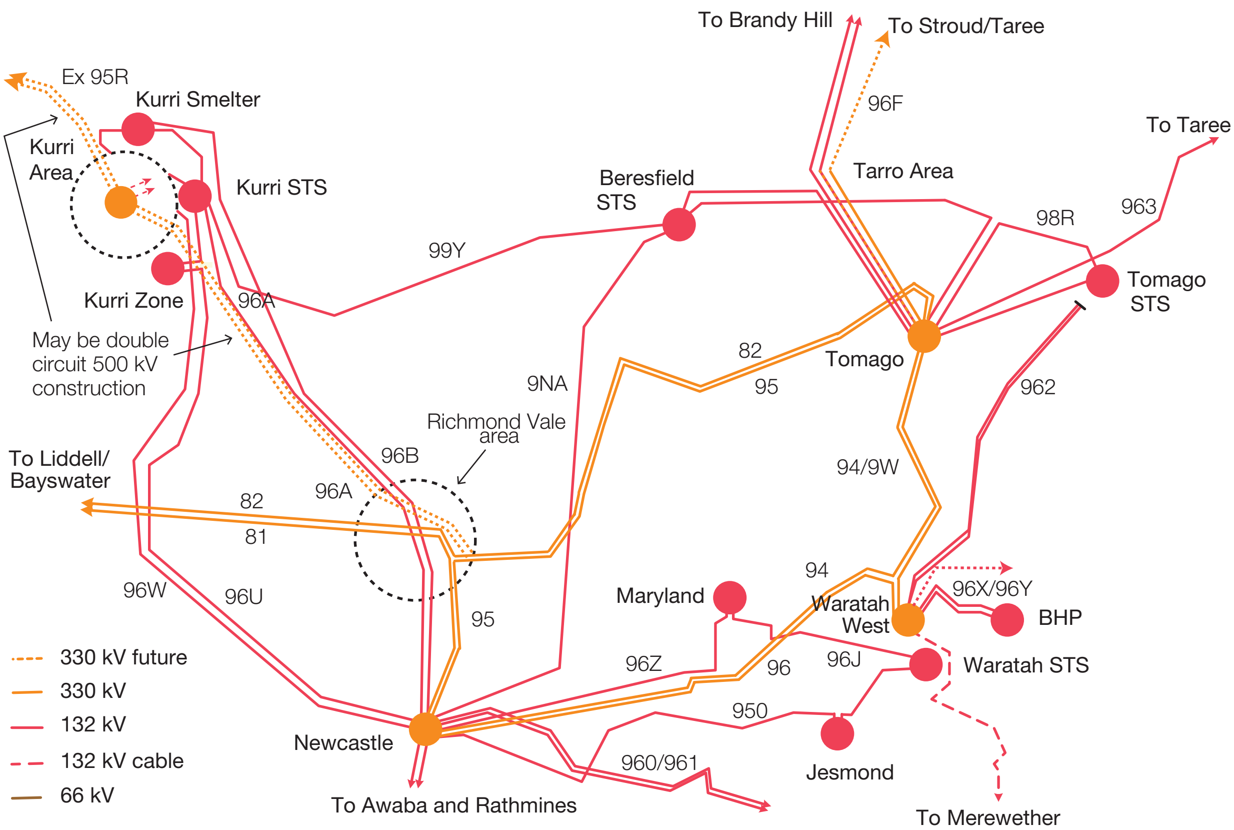
The potential network limitations include:

- A need to augment the supply capacity to Muswellbrook if there is a rationalisation of generators in the Upper Hunter Valley;
- The system supplying the mid north coast from the Tomago area will reach the limit of its supply capacity in the longer term; and
- The 330 and 500 kV systems supplying the larger Sydney, Newcastle and Wollongong load area reaches its limitations in the longer term.

Indicative developments of the transmission network in this area are described below and illustrated in Figure 4.17.

FIGURE 4.17

TRANSMISSION NETWORK IN THE GREATER NEWCASTLE AREA – INDICATIVE FUTURE



DEMAND MANAGEMENT IS LIKELY TO PLAY AN IMPORTANT ROLE IN MITIGATING DEMAND GROWTH IN SOME SITUATIONS, ENABLING THE DEFERRAL OR AVOIDANCE OF AUGMENTATION OF THE TRANSMISSION NETWORK.

They are influenced by a number of considerations:

- Relocation of the New England Highway is planned in the Maitland area. This may require the rearrangement of parts of Ausgrid's four 132 kV single circuit lines between Newcastle and Kurri and the formation of a double circuit 330 or 500 kV line as part of a new line between Bayswater and Richmond Vale, the site identified for a future 330 kV switching station or 500/330 kV substation. If the line is 500 kV, it may eventually be extended to Eraring;
- The need to accommodate possible future major industrial developments within the area, should they occur; and
- The need to accommodate possible generation developments, should they occur.

Within about ten years:

- Construct a short section of 330 kV double circuit line from Tomago to the Tarro area and connect at 132 kV initially (in progress).
- Respond to any non-forecast industrial load or generation developments in the area.
- Install reactive power compensation equipment as required.

In the period beyond ten years:

- Establish a new 500/330 kV substation in the Kurri/Richmond Vale area (supplied by a 500 kV line that would be constructed from Bayswater) and establish 330 kV connections to nearby 330 kV lines.
- Further uprate existing 330 kV substations including some transformer capacity at existing supply points.
- The need to cater for increasing load on the mid north coast including the need for a 330 kV supply to that area from Newcastle in the long term.
- Continue to respond to any non-forecast industrial load or generation developments in the area.
- Continue the installation of reactive power compensation equipment as required.

4.11.6 CENTRAL COAST

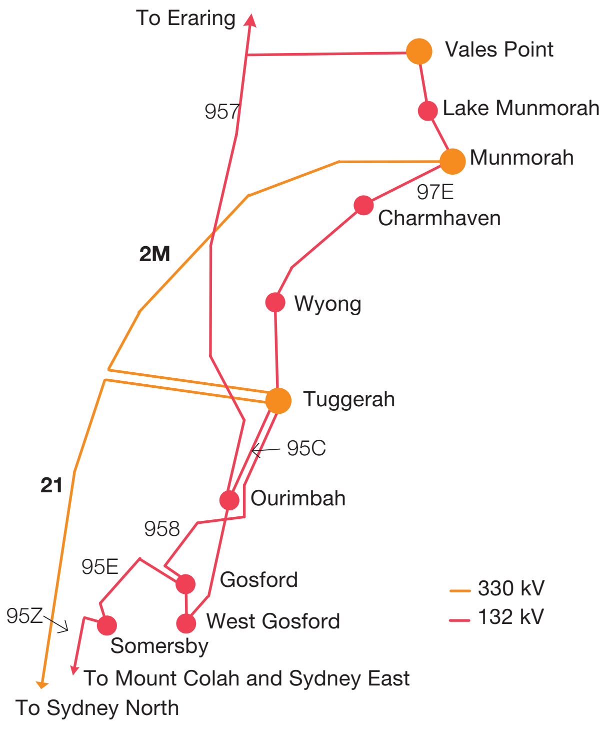
The NSW Central Coast extends from the Hawkesbury River and Broken Bay in the south to the Lake Macquarie area in the north. It presently has a population of around 300,000 and includes the major centres of Gosford, the Tuggerah/Entrance area and the Wyong/Munmorah area.

The majority of the Central Coast area is supplied via a network of 132 kV feeders emanating from TransGrid's 330/132 kV substations located at Tuggerah, Munmorah, Vales Point and Sydney East, as shown in Figure 4.18. This network of 132 kV feeders supplies a number of zone substations as well as major subtransmission substations at Ourimbah and Gosford.

The 132 kV network, other than the section of line from Mount Colah to Sydney East, is owned by Ausgrid and is being progressively developed to supply the area demands.

FIGURE 4.18

TRANSMISSION NETWORK IN THE CENTRAL COAST AREA – PRESENT



Two 375 MVA 330/132 kV transformers are installed at Tuggerah Substation, two 200 MVA 330/132 kV transformers are installed at Vales Point Substation, and Munmorah Substation has a single 375 MVA 330/132 kV transformer. Colongra Gas Turbine power station is connected at 330 kV to Munmorah.

The major developments in establishing the 330 kV and 132 kV network are shown in Table 4.6.

TABLE 4.6

DEVELOPMENT OF THE SUPPLY SYSTEM IN THE CENTRAL COAST AREA

Period	Substations	Lines
Early 1960s	→ Vales Point	→ Vales Point – Sydney North (now Vales Point – Munmorah and Munmorah – Sydney North)
Mid 1980s	→ Tuggerah	→ Tuggerah – Sterland
Late 1990s	→ Munmorah	
Early 2000s		→ Reconstruction of Tuggerah – Sterland
2007	→ Vales Point	→ Replacement of 330/132 kV transformers
2008	→ Tuggerah	→ Installation of second 330/132 kV transformer and “looping” the 330 kV supply
2009	→ Munmorah	→ Colongra Gas Turbine connection
2017	→ Munmorah	→ Retirement of Munmorah Power Station

ASSET CONDITION AND RENEWAL

In the short to medium term, the assets that are expected to require refurbishment or replacement are Munmorah (established 1967) and Vales Point (1964–70).

TransGrid’s asset management strategy is to monitor the condition of all assets and the substations and lines constructed through to about the 1980s are likely to need refurbishment or replacement during the period covered by this NDS. At the time, consideration will be given to their upgrade or rationalisation.

THE LOAD

The area’s electrical load is characterised primarily by urban residential loads, commercial/light industrial loads in the main population centres and semi-rural loads in surrounding areas. Demand growth in this area has consistently been above the NSW average, due primarily to population growth.

GENERATION OPPORTUNITIES

The limited natural resources in this area will not support significant renewable (wind, solar, geothermal, hydro) generation.

Munmorah Power Station was closed in 2012 and it is expected that Vales Point Power Station will similarly be retired in the longer term as it reaches the end of its serviceable life. Natural gas and coal are both available in the area for generation. Any new moderate scale generation developments are expected to utilise existing substation infrastructure to connect to the 330 kV network.

NETWORK LIMITATIONS AND INDICATIVE DEVELOPMENTS

There are presently no immediate constraints affecting TransGrid's network in the area. However, in the longer term, developments to meet demand growth may be required.

Indicative future developments of the transmission network in this area are described below and illustrated in Figure 4.19.

Within about ten years:

- Respond to any non-forecast industrial load or generation developments in the area.
- Develop 132 kV busbars at Vales Point 330 kV substation to accommodate additional connections to Ausgrid's 132 kV network.
- Install reactive power compensation equipment as required.

In the period beyond ten years:

- Further uprating of existing 330 kV substations including some additional transformer capacity at existing supply points.
- Continue to respond to any non-forecast industrial load or generation developments in the area.
- Continue the installation of reactive power compensation equipment as required.

FIGURE 4.19

TRANSMISSION NETWORK IN THE CENTRAL COAST AREA – INDICATIVE FUTURE

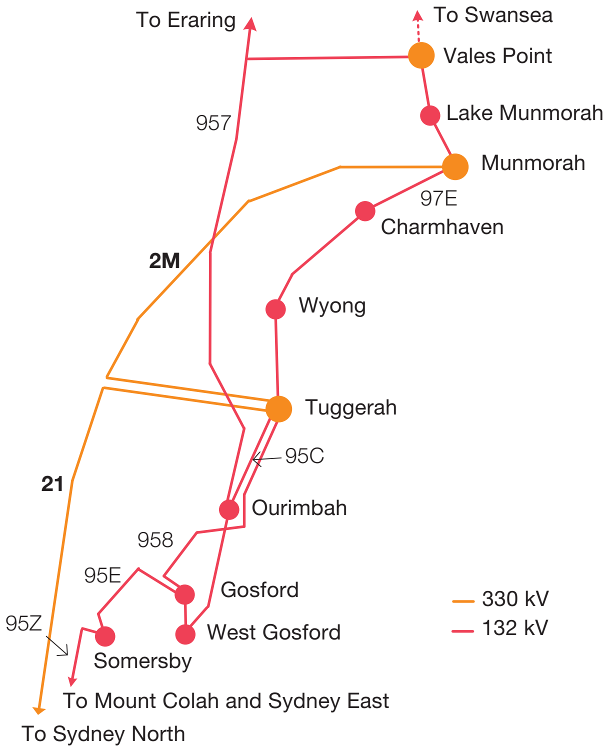
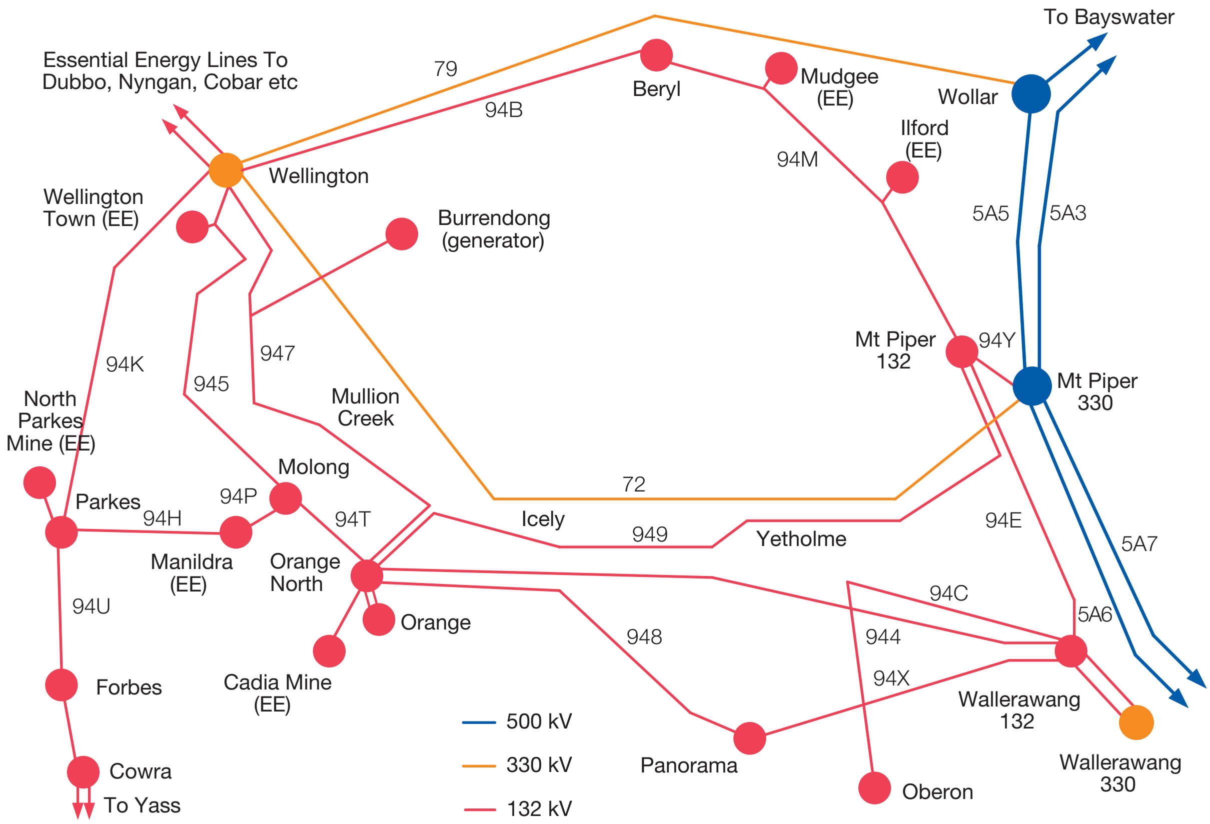


FIGURE 4.20

SUPPLY SYSTEM IN THE WEST AND CENTRAL WEST AREAS – PRESENT





4.11.7 WEST AND CENTRAL WEST

The west and central west areas of NSW are supplied via a network of 132 kV lines emanating from 330/132 kV substations at Mount Piper, Wallerawang, Wellington and Yass. Wellington 330/132 kV Substation is supplied from Mount Piper and from Wollar by the two 330 kV lines in the area. This network is shown in Figure 4.20.

The 132 kV network from Wellington to Dubbo, Nyngan and Cobar (not shown) is owned by Essential Energy as are 132 kV lines supplying the Cadia and North Parkes mines.

The major developments in establishing the 330 kV and 132 kV network other than those to connect new industries are shown in Table 4.7.

ASSET CONDITION AND RENEWAL

During the period spanned by this NDS many of the assets currently in service will reach the end of their serviceable lives. In the short to medium term this will include:

- Orange 132/66 kV substation; and
- 944 Wallerawang – Orange 132 kV transmission line.

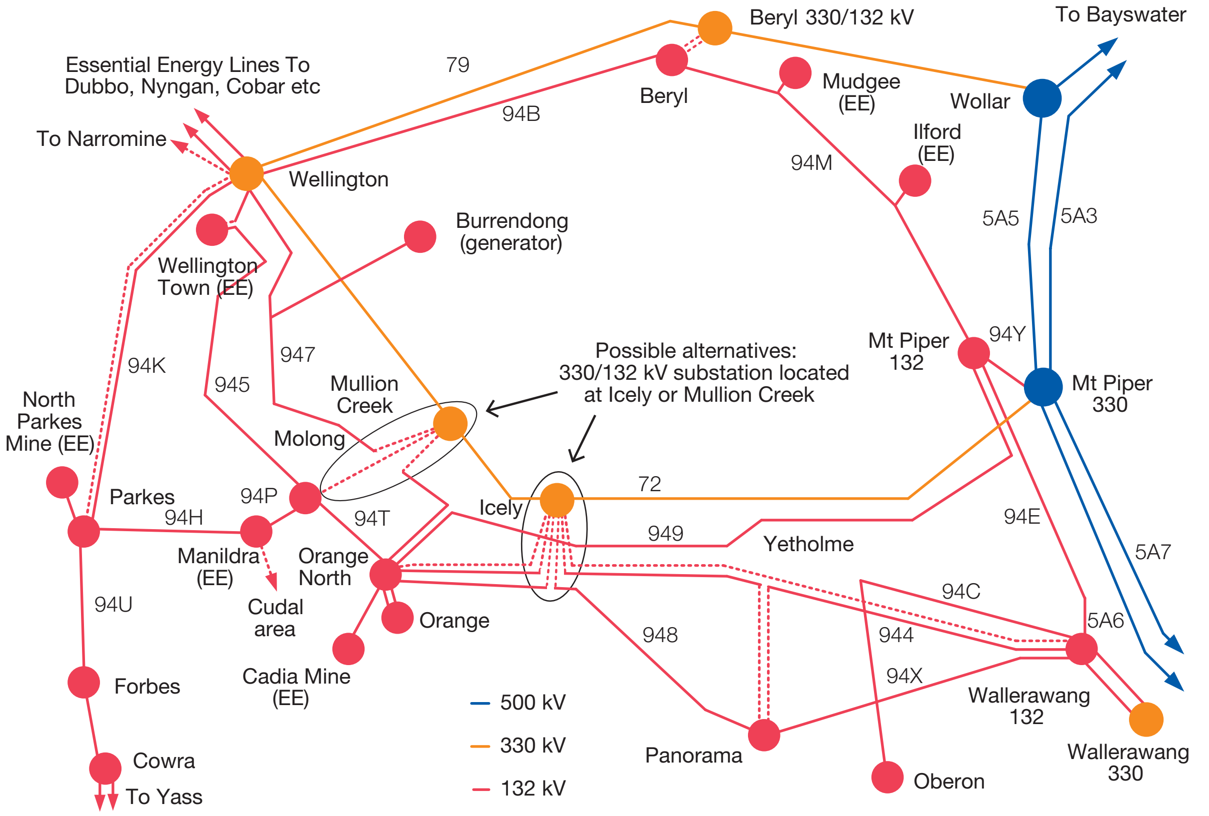
In the longer term it must be expected that those substations and lines constructed through to about the 1980s will need refurbishment or replacement. These assets will be closely monitored as part of TransGrid's asset management strategies and depending upon expected demand at the time may also be modified in capacity.

TABLE 4.7
DEVELOPMENT OF THE SUPPLY SYSTEM IN THE WEST AND CENTRAL WEST AREAS

Period	Substations	Lines
Mid 1950s	→ Orange	→ Wallerawang – Orange (944)
Late 1950s/ early 1960s	→ Cowra	→ Orange – Dubbo (via Wellington),
Mid 1960s	→ Dubbo	→ Yass – Cowra (999), Cowra – Forbes, Wallerawang – Orange (via Bathurst)
Late 1960s	→ Forbes, Nyngan	→ Dubbo – Cobar
Mid 1970s	→ Beryl	→ Wallerawang – Dubbo (via Orange and Wellington), Yass – Cowra
Late 1970s	→ Panorama, Wellington (132 kV switching station)	→ Wallerawang – Beryl
Early 1980s	→ Wellington 330/132 kV	→ Wellington – Beryl
Mid 1980s		→ Mount Piper – Wellington 330 kV
Late 1980s	→ Mount Piper 132/66 kV	→ Wellington – Forbes (via Parkes)
Early 1990s	→ Parkes	
Early 2000s	→ Molong, Manildra	
2010	→ Wollar 330/132 kV Substation	→ Wollar – Wellington 330 kV transmission line
2012	→ Orange North 132 kV Switching Station	→ Manildra – Parkes 132 kV transmission line
2013/14	→ Wallerawang 132/66 kV (replacement)	

FIGURE 4.21

SUPPLY SYSTEM IN THE WEST AND CENTRAL WEST AREAS – INDICATIVE FUTURE



THE LOAD

The load in the area has exhibited modest growth, punctuated with "step" increases due to the establishment of various industries, primarily mines.

Overall, summer maximum demands are slightly below those in winter. Winter maxima still predominate in higher areas such as Orange and Bathurst. Summer maxima predominate in the Cowra/Forbes/Parkes area.

GENERATION OPPORTUNITIES

Hydro: Hydro generators have been installed at Burrendong and Wyangala dams. The output of both depends on water releases and dam levels. No significant additional hydro generation development proposals in the area are expected.

Wind: Wind generation is presently installed at Hampton (south of Lithgow) and Blayney. There is potential for additional wind generation in the Lithgow to Orange area, with a prospective area being in the Oberon/Blayney region.

The associated network development would depend on the magnitude and location of the generation. Relatively small developments should be able to be accommodated by connections to the existing 132 kV network (or possibly to Essential Energy's 66 kV network). Larger developments, either single projects or an aggregation of smaller projects, would require more substantial connections at 330 kV.

Gas: There are no known gas reserves in the area. Natural gas is available in most major centres in the area. Consequently there is potential for gas fuelled generation, although the capacity of the laterals from the Moomba – Sydney pipeline may limit the amount. Small scale gas fuelled generation is likely to be connected to Essential Energy's network. Whereas larger scale developments would need to be connected to the 132 kV or 330 kV network.

Coal: The coal deposits in the Ulan area may be utilised to fuel a power station in the area. Should this be developed, it would almost certainly require a connection to the Bayswater – Mount Piper 500 kV line.

Solar: There is the potential of solar generation to the west of Dubbo. Should any proceed, it would be connected to Essential Energy's network in that area.

NETWORK LIMITATIONS AND INDICATIVE DEVELOPMENTS

This system is approaching a number of load related constraints. Indicative developments of the network in this area are described in the following and shown in Figure 4.21.

Within about ten years:

- Uprate and/or refurbish existing substations, including some transformers, at Orange, Parkes and Wallerawang (some done or in progress).
- Respond to any non-forecast industrial load or generation developments in the area.
- Install reactive power compensation equipment as required.



In the period beyond ten years:

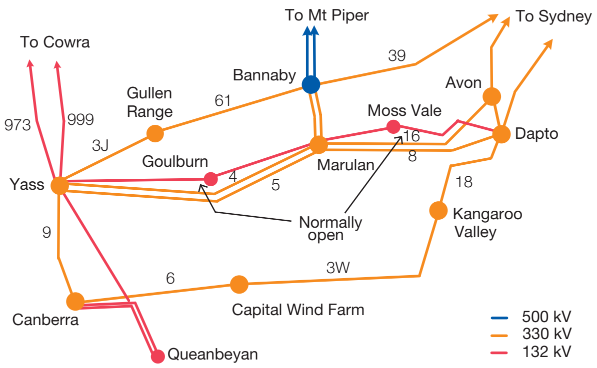
- Establish a possible new 330/132 kV substation in the Beryl area, including 132 kV line connections.
- Rebuild 944 Wallerawang – Orange 132 kV line as double circuit.
- Further uprate existing 330 kV substations including some transformer capacity at existing supply points.
- Establish a possible new 330/132 kV substation in the Mullion Creek or Icely area, including 132 kV line connections.
- Reinforce supply to Panorama by connecting in the reconstructed 944 line.
- Continue to respond to any non-forecast industrial load or generation developments in the area.
- Continue installation of reactive power compensation equipment as required.

4.11.8 WOLLONGONG AND THE SOUTH COAST

Wollongong, the NSW south coast and parts of the southern highlands are supplied from 330/132 kV substations at Dapto and Marulan. The 330 kV network and the 132 kV network which parallels parts of it are shown in Figure 4.22. Dapto has four 375 MVA 330/132 kV transformers, one of which is an in-service spare, and Marulan one 160 MVA transformer. Marulan has spare 330 and 132 kV bays partly fitted out for the installation of a second transformer should the need arise.

FIGURE 4.22

TRANSMISSION NETWORK IN THE WOLLONGONG AND SOUTH COAST AREA – PRESENT



The 132 kV system supplying Goulburn is owned by Essential Energy and that supplying Moss Vale owned by Endeavour Energy. Endeavour Energy also owns the 132 kV network around and south of Wollongong (not shown). This network also provides a 132 kV supply to Essential Energy loads south of Ulladulla at Batemans Bay and Moruya via two 132 kV lines that run south from Endeavour Energy's Evans Lane Switching Station (located west of Ulladulla).

The bulk of the load is supplied via Dapto, with the Moss Vale and Goulburn areas being supplied from Marulan. Alternate supplies to Moss Vale and Goulburn are provided from Dapto and Yass respectively. There is substantial gas fired generation at Tallawarra, which is connected via Endeavour Energy's 132 kV network to Dapto.

The 330 kV network between Yass/Canberra and Sydney is part of the main system, the development of which is discussed in section 4.9.

ASSET CONDITION AND RENEWAL

During the period covered by this NDS, many of the assets currently in service will reach the end of their serviceable lives. In the short to medium term this will include several of the 330 kV lines in this area:

- Dapto – Sydney South 11;
- Canberra – Upper Tumut and Upper Tumut – Yass; and
- Yass – Marulan lines 4 and 5.

In the longer term, substations and lines constructed prior to about the 1980s are likely to need refurbishment or replacement. TransGrid's asset management strategies will seek to maintain the assets in service for as long as it is economically and technically justified.

THE LOAD

The demand in the area has historically exhibited sustained modest growth, which is expected to continue into the medium term. Historically, peak network demands have occurred in winter, but in more recent years the load area has shifted to exhibit regular summer peaks.

The greatest load is that of the Wollongong area, which has a large industrial component as well as commercial and residential components. In particular, BlueScope Steel's Port Kembla mill is supplied at 132 kV from Dapto via Endeavour Energy's 132 kV Springhill substation. In recent years, this facility has seen an approximate 30% reduction in demand, due to production output reduction in line with steel market conditions.

The south coast and southern highlands loads are primarily rural with residential, commercial and some light industrial loads in larger centres. The coastal areas are particularly susceptible to sudden increases in load due to an influx of tourists and holiday makers during holiday seasons and on some public holidays.

GENERATION OPPORTUNITIES

Several different generation opportunities are a feature of the area. These have been outlined below in accordance with their energy source.

Gas: The Eastern Gas Pipeline terminates in the Wollongong area, passing close to Nowra and other centres in between. Also, the Sydney – Moomba pipeline passes close to Goulburn and Moss Vale. The availability of gas supplies in close proximity to the transmission network creates favourable conditions for local gas fired generation development.

A 440 MW gas fired combined cycle generation facility was established at Tallawarra in 2009, the output of which feeds into Dapto at 132 kV via Endeavour Energy's network. There is the potential to substantially expand this generation, which could require the reconnection of the generator(s) to Dapto at 330 kV.

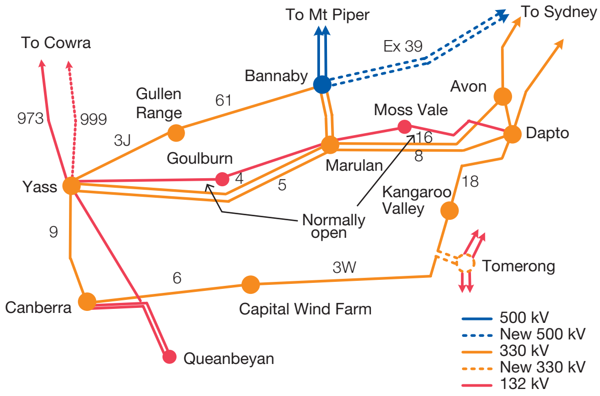
A gas-fired generator has been mooted for Bamarang (west of Nowra), on a site already approved for such a development. Depending on the scale of the development, its connection could be via high capacity 132 kV lines to Endeavour Energy's network and/or 330 kV to TransGrid's network, south west of Nowra. If this generator proceeds, it could significantly affect the long term development of both Endeavour Energy's and TransGrid's networks in this area and in particular the possible future establishment of a new bulk supply point south of Nowra, near Tomerong.

Wind: Significant wind resources have been identified in this area, particularly to the west of the Great Dividing Range. The most prospective sites lie along the Great Dividing Range in the Crookwell/Yass/Canberra area. In recent years the Capital, Cullerin, Gullen Range and Gunning wind farms have been established. The Capital wind farm is connected to TransGrid's 330 kV network near Canberra, Gullen Range to the 330 kV network near Yass and the others are connected to Essential Energy's 132 kV network between Yass and Goulburn. In the near term a wind farm near Taralga is expected to be developed. It would be connected to TransGrid's Marulan 330/132 kV substation.

Hydro: There is pumped storage hydro-generation/water supply pumping facility at Kangaroo Valley, which has a generating capacity of around 240 MW. Energy production is limited by the upper storage capacity and pumping is limited by the Shoalhaven River storage. No additional hydro generation of any significance is anticipated in the area.

FIGURE 4.23

TRANSMISSION NETWORK IN THE WOLLONGONG AND SOUTH COAST AREA – INDICATIVE FUTURE



NETWORK LIMITATIONS AND INDICATIVE DEVELOPMENTS

The majority of TransGrid's 330 kV network in the area is considered adequate in terms of configuration and capacity for the foreseeable future. This situation has been aided to some extent by the presence of generation at Tallawarra. Future investment in the 330 kV network is expected to be confined to the asset renewals described above and increasing the capacity of the supply points to Endeavour Energy and Essential Energy.

If additional Tallawarra generation triggers the reconnection of this facility to Dapto at 330 kV instead of 132 kV, the rearrangement would result in increased loading on the Dapto transformers, requiring either their augmentation or the possible establishment of another 330/132 kV substation at Tomerong. The need to undertake this development would also be influenced by whether the Bamarang generation proposal is developed.

Endeavour Energy's 132 kV network south of Wollongong can be subject to extreme peak loads during holiday seasons due to the influx of tourist and holiday makers into the coastal areas at those times. Accordingly, Endeavour Energy is currently implementing plans to reinforce its 132 kV network. The development of Tomerong would relieve this 132 kV system in the longer term.

Indicative developments of the transmission network in this area are described in the following and indicated in Figure 4.23.

Within about ten years:

- Refurbish and upgrade 330 kV lines as outlined above.
- Augment the capacity of the ageing 160 MVA 330/132 kV transformer at Marulan by installing a second transformer.
- Respond to any non-forecast industrial load or generation developments in the area.
- Install reactive power compensation equipment as required.

In the period beyond ten years:

- Establish a new 330/132 kV substation near Nowra, possibly in the Tomerong area, to "off-load" Endeavour Energy's 132 kV network south from Dapto.
- Continue to respond to any non-forecast industrial load or generation developments in the area.
- Continue installation of reactive power compensation equipment as required.
- As part of the development of the main grid supplying Newcastle, Sydney and Wollongong load areas rebuild the 330 kV line to 39 to form a new 500 kV double circuit line from Bannaby to South Creek.

4.11.9 CANBERRA AND THE FAR SOUTH COAST

Canberra and the far south coast of NSW is supplied primarily via a network of 132 kV lines emanating from Canberra and Williamsdale 330/132 kV substations. The Cooma/Bega area is supplied by two 132 kV lines from Williamsdale to Cooma. Essential Energy owns the 132 kV lines from Cooma to Bega and Snowy Adit substation. This system is illustrated in Figure 4.24.

Cooma 132/66/11 kV substation has an unconventional arrangement whereby an 11 kV supply is taken from the tertiary windings of the 132/66 kV transformers.

There are some very limited capacity (normally open) backup supplies to the Bega area at 33 kV from Moruya, to Munyang/Cooma at 132 kV from Murray via Guthega power station and to Canberra/Queanbeyan from Yass at 132 kV.

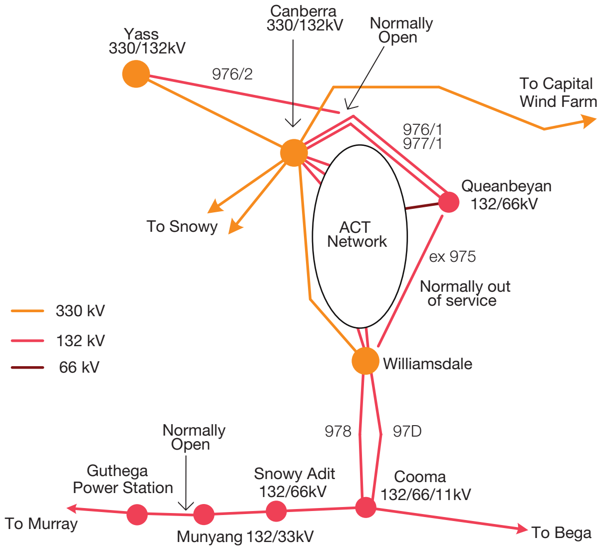
The bulk of the ACT is supplied via ActewAGL's 132 kV network from Canberra and Williamsdale with a small part being supplied from Queanbeyan at 66 kV. The Cooma/Bega area is supplied by two 132 kV lines from Canberra to Cooma. Essential Energy owns the 132 kV line from Cooma to Bega.

The Cooma/Bega area is supplied by two 132 kV lines from Williamsdale to Cooma. Essential Energy owns the 132 kV lines from Cooma to Bega and Snowy Adit substation.

The major developments in establishing the transmission network in the area are shown in Table 4.8.

FIGURE 4.24

TRANSMISSION NETWORK IN THE CANBERRA AND FAR SOUTH COAST AREA - PRESENT



ASSET CONDITION AND RENEWAL

During the period spanned by this NDS many of the assets currently in service will reach the end of their serviceable lives. In the short to medium term this will include:

- Cooma 132/66/11 kV substation. A new Cooma 132/66 kV substation will be constructed on a nearby site and Essential Energy will develop a 66/11 kV zone substation;
- The 132 kV line between Cooma and Guthega power station, which was established in the 1950s; and
- A range of assets at Canberra substation are in need of replacement.

In the longer term, those substations and lines constructed through to about the 1980s will progressively need refurbishment or replacement, as part of TransGrid's asset management strategy.

THE LOAD

The demand in the area has historically exhibited modest growth, which has moderated in recent years. Maximum demands occur in winter, with summer maximum demands being around 75% of those in winter.



The largest load is in the ACT and Queanbeyan. This is primarily commercial and residential, with some light industrial. The Cooma/snowfields load is highest in winter during the ski season, with a large component of snow making. This demand has also moderated in recent years.

GENERATION OPPORTUNITIES

Hydro: There are small hydro generators at Brown Mountain and Jindabyne. No additional hydro generation of any significance is anticipated in the area.

Natural Gas: There is potential for gas fuelled generation in the area as the Eastern Gas Pipeline passes close to Canberra, Cooma and Bombala.

Cogeneration: Waste from forestry activities in the Bombala area also provides a potential fuel source.

Wind: Wind resources have been identified in the area. The most prospective area is along and east of the Great Dividing Range between Bungendore/Lake George (to the east of Canberra) and Bombala. Within this area, several hundred MW of potential generation has been identified.

The network developments to accommodate generators would depend on the magnitude and location of the generation. Relatively small developments should be able to be accommodated by connections to the existing 132 kV network (or possibly to Essential Energy's lower voltage networks). Larger developments, either single projects or an aggregation of smaller projects, may require a more substantial 330 kV development.

A wind farm near Nimmitabel (Boco Rock) is being developed. It will be connected to Essential Energy's 132 kV network between Cooma and Bega.

NETWORK LIMITATIONS AND INDICATIVE DEVELOPMENTS

The co-development of Essential Energy's network is not specifically addressed in this document, other than briefly considering possible developments which may emanate from TransGrid's network.

Indicative developments of the transmission network in this area are described below and indicated in Figure 4.25.

Within about ten years:

- Transfer 975 line to Essential Energy to enable the supply of a zone substation at Googong.
- Rebuild and/or refurbish existing 132 kV substations, including Cooma.

TABLE 4.8

DEVELOPMENT OF THE TRANSMISSION NETWORK IN THE CANBERRA AND FAR SOUTH COAST AREA

Period	Substations	Lines
Mid 1950s	→ Queanbeyan → Cooma	→ Yass – Queanbeyan, Queanbeyan – Cooma, Cooma – Guthega
Early 1960s		→ (Second) Yass – Queanbeyan
Mid 1960s	→ Canberra 330/132 kV	
Late 1960s		→ Murray – Guthega
Late 1970s		→ Canberra – Royalla (330 kV structures)
Early 1980s		→ Cooma – Bega
Mid/late 1980s		→ Second Royalla – Cooma and reconstruction of the first
Late 1980s	→ Munyang 132/33 kV	
2010	→ Replacement of Queanbeyan 132/66 kV	
2012	→ Williamsdale 330/132 kV Substation	→ Upgrade Canberra – Williamsdale 132 kV lines to operate to 330 kV

- Connect Essential Energy's second Bega 132 kV line at Cooma.
- Construct a 330 kV supply to Williamsdale from the Yass/Canberra area, possibly at the Wallaroo area.
- Install reactive power compensation equipment as required.

In the period greater than ten years:

- Provide a second 330 kV supply to Williamsdale, most probably by rebuilding the existing Canberra – Williamsdale line as a double circuit.
- Construct a third line to Cooma from Williamsdale – probably of 330 kV construction, initially operating at 132 kV.
- Further uprate and refurbish existing 330 kV substations including some additional transformer capacity at existing supply points.
- Continue to respond to any non-forecast industrial load or generation developments in the area.
- Continue installation of reactive power compensation equipment as required.

4.11.10 SOUTH WEST AND FAR WEST

The south western and far western areas of NSW are supplied via a network of 132 kV lines emanating from 330/132 kV substations at Yass, Wagga and Jindera and a 330/220/132 kV substation at Darlington Point, as shown in Figure 4.26. Darlington Point also supplies a 220 kV network which extends west to Balranald, Buronga and Broken Hill.

FIGURE 4.25

TRANSMISSION NETWORK IN THE CANBERRA AND FAR SOUTH COAST AREA – INDICATIVE FUTURE

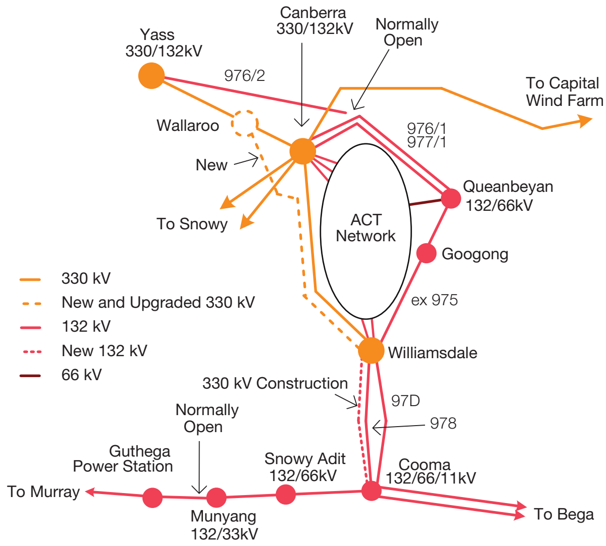
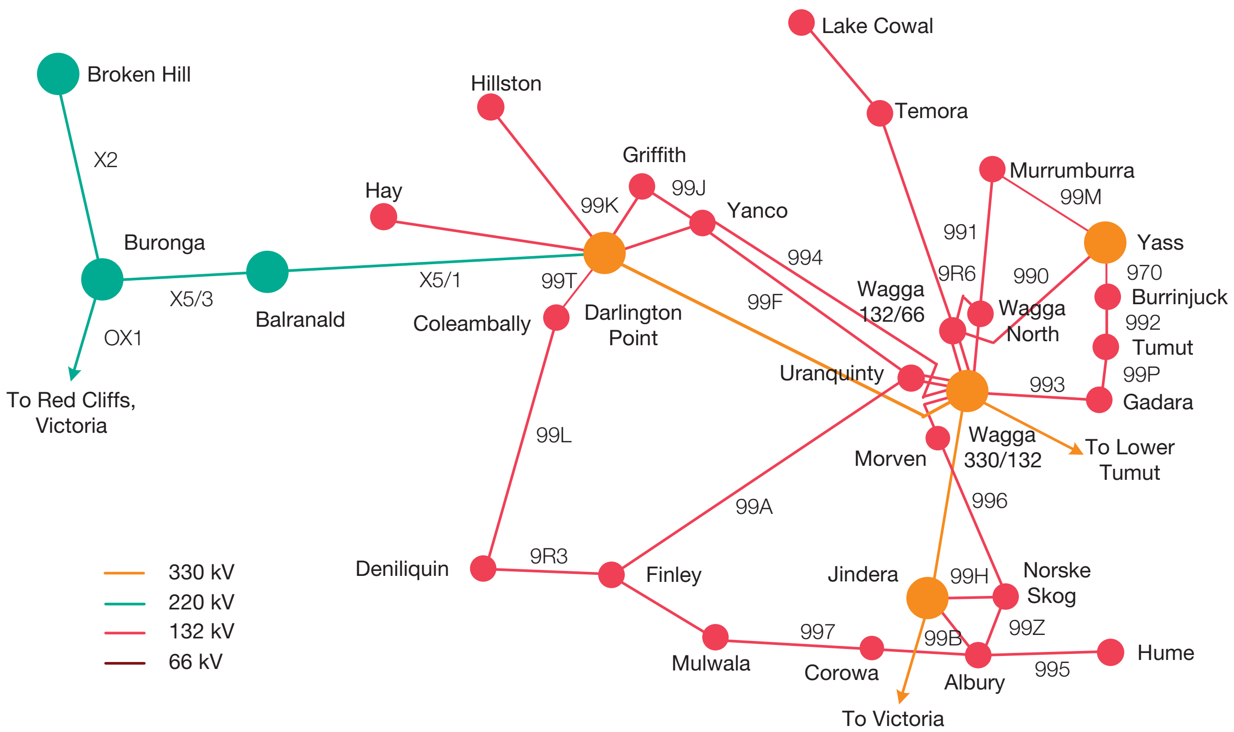


FIGURE 4.26

TRANSMISSION NETWORK IN THE SOUTH WEST AND FAR WEST AREA – PRESENT



The South West network is interconnected with Victoria at Buronga at 220 kV via Red Cliffs and at Jindera at 330 kV via Wodonga.

Essential Energy owns the Albury – Mulwala, Mulwala – Finley, Wagga – Temora, Darlington Point – Hay, Darlington Point – Hillston and Temora – Lake Cowal 132 kV lines. A new 132/66 kV substation has been established at Wagga North in recent years. Essential Energy has recently established a 132/66 kV substation at Morven (between Wagga and Albury).

The major network developments are listed in Table 4.9. It should be noted that a number of lines were operated for a number of years at voltages lower than their design voltage.

ASSET REPLACEMENTS

The major asset condition based replacements expect to be required in the short to medium term are described below:

- **Wagga 132/66 kV Substation:** An asset condition assessment found that the majority of the substation and its assets are in need of replacement. An evaluation of the feasible options identified the rebuild of the substation on the existing site as the preferred option.
- **Yanco 132/33 kV Substation:** Again, the majority of the substation and its assets are in need of replacement. Here, the piecemeal replacement of the substation is the preferred option.
- **Burrinjuck 132/66 kV Substation:** The majority of the substation and its assets were assessed as needing replacement. Replacement of the substation on the existing site using compact Gas Insulated Switchgear (GIS) is presently the preferred option.

In the longer term the substations and lines constructed prior to about the 1980s will need refurbishment or replacement. These asset renewals will take place as part of TransGrid's asset management strategies and depending upon expected demand at the time may also be modified in capacity.

THE LOAD

The load in the area has exhibited modest growth over recent years. This is due in part to relatively invariant industrial loads at Broken Hill and near Albury. Demand is highest in summer with winter maximum demands being around 90% of those in summer.

The load is geographically and sectorally diverse. The major components of the load are:

- Industrial loads, primarily mining at Broken Hill and Lake Cowal (north of Temora) and paper manufacturing near Albury;
- Irrigation along the Murray and Murrumbidgee rivers; and
- Rural loads with associated residential, commercial and light industrial loads in population centres.

GENERATION OPPORTUNITIES

Hydro: There are small hydro generators at Hume and Wyangala dams and at Mulwala Canal. No additional hydro generation of any significance is anticipated in the area, although "mini hydro" units may be installed at irrigation weirs.

Gas: There are no known gas basins in the area. Natural gas is available from the pipeline which connects the Moomba – Sydney pipeline at Young to the Victorian network at Wodonga and from laterals which run from north of Wagga east to Tumut and west to Griffith.

A gas turbine power station has been developed at Uranquinty (around 20 km to the west of Wagga).

Cogeneration: The Visy plant near Tumut includes cogeneration.

Coal: There are coal deposits in the Oaklands area (between Wagga and Finley) although these are less commercially attractive than deposits elsewhere in the state. A large scale generator development in the area would be connected to the 330 kV transmission system.

Wind: Wind generation potential in the Broken Hill area has been identified. A number of wind projects are in the process of gaining or have been granted development approval, totalling approximately 1400 MW.

TABLE 4.9

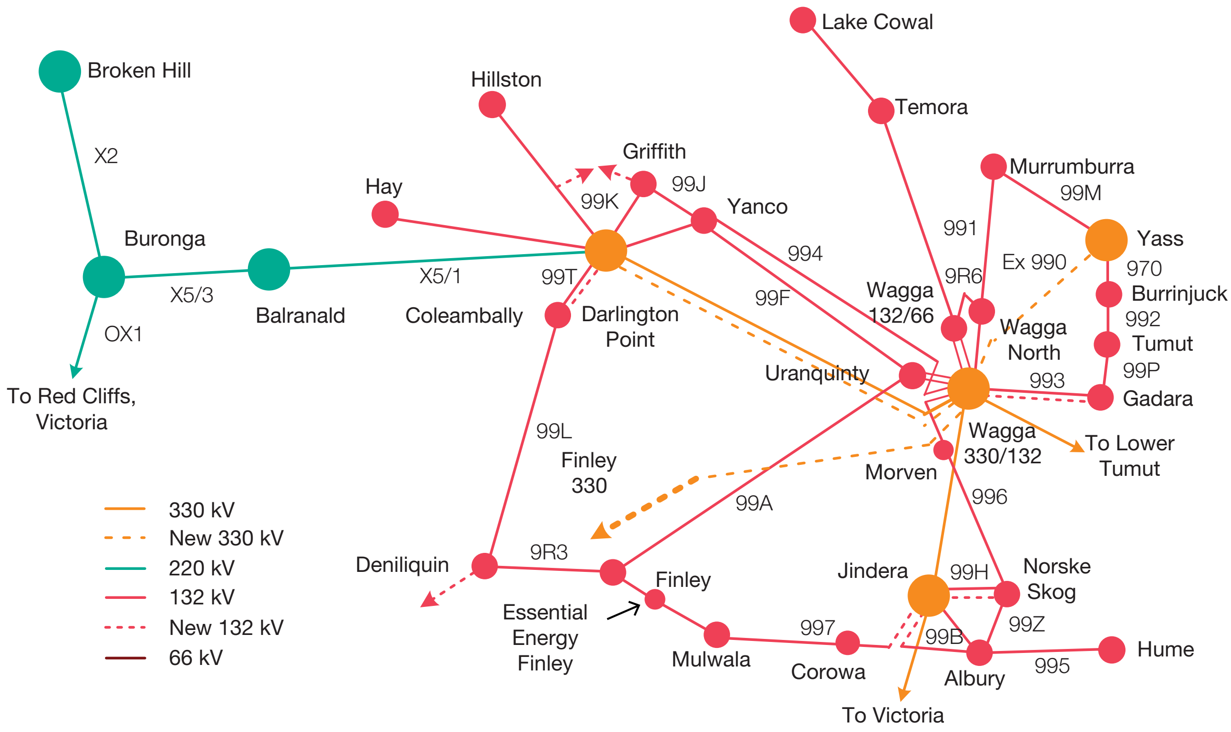
DEVELOPMENT OF THE TRANSMISSION NETWORK IN THE SOUTH WEST AREA

Period	Substations	Lines
Late 1930s	→ Burrinjuck P.S.	
1940s		→ Burrinjuck – Port Kembla (first 132 kV line in Australia)
Early to Mid 1950s	→ Wagga 132/66 kV	→ Yass – Wagga (No990) 132 kV → Wagga – Yanco and Wagga – Hume 132 kV
Late 1950s	→ Albury	→ 132 kV Yanco – Griffith and Albury – Mulwala
Mid 1960s	→ Griffith, Tumut	→ 132 kV Burrinjuck – Wagga (via present Tumut)
Late 1960s	→ Yanco	→ 132 kV Yass – Wagga (via present Murrumburrah)
Early 1970s	→ Wagga 330 kV → Deniliquin	→ 330 kV Lower Tumut – Wagga → 132 kV Wagga – Temora, Wagga – Deniliquin and second Wagga – Yanco
Late 1970s	→ Jindera 330 kV, Broken Hill 220 kV	→ 330 kV Wagga – Jindera – Victoria → 220 kV Red Cliffs – Broken Hill → 132 kV Jindera – Albury
Early 1980s	→ ANM (now Norske Skog)	→ 132 kV Darlington Point – Hay, Darlington Point – Hillston and Jindera – ANM
Mid 1980s	→ Murrumburrah	
Late 1980s	→ Darlington Pt 330 kV → Buronga 220 kV → Hay, Temora 132 kV	→ 330 kV Wagga – Darlington Point → 220 kV Darlington Point – Buronga → 132 kV Darlington Point – Deniliquin, Darlington Point – Yanco and Darlington Point – Griffith
Early 1990s	→ Finley (temporary) → Coleambally	
Early 2000s	→ Gadara, Balranald	
2009	→ Uranquinty connection → 132 kV substation	→ 132 kV transmission line connections to the substation
2010	→ Wagga North 132/66 kV Substation → Finley (permanent)	→ 132 kV line connections

EFFECTIVE MANAGEMENT OF ASSETS THROUGHOUT THEIR LIFE CYCLE IS CRITICAL TO ACHIEVING THE REQUIRED LEVELS OF SECURITY AND RELIABILITY FOR THE TRANSMISSION SYSTEM AND TO MINIMISING ASSET LIFE CYCLE COSTS.

FIGURE 4.27

TRANSMISSION NETWORK IN THE SOUTH WEST AND FAR WEST AREA – INDICATIVE FUTURE



Small to moderate sized generation developments could be accommodated by connections to the existing 220 kV network. However larger developments would involve significant augmentation of the transmission network. Possible developments include additional lines to (one or more) more strongly connected locations such as the 275 kV network in South Australia, the 220 kV network in the Buronga area or the 330 kV network at Wellington.

Solar: This form of generation has been proposed in the Broken Hill area. A 53 MW plant is under development.

NETWORK LIMITATIONS AND INDICATIVE DEVELOPMENTS

Indicative developments of the transmission network in this area are described in the following and illustrated in Figure 4.27. In the case of load related limitations, DM and local generation initiatives would be vigorously pursued to delay or modify the extent of any network developments, including during joint planning with Essential Energy. These options are not specifically considered in the following discussion, other than to note that:

- Natural gas is available in the area; and
- In an environment of modest load growth, the impact of demand side initiatives can be significant.

Within about ten years:

- Uprate and/or refurbish existing substations including additional transformer capacity at Finley, Yanco and Wagga (some in progress).
- Respond to any non-forecast industrial load increases or generation developments in the area especially associated with existing industries at Norske Skog and Gadara. Line 993 may be rebuilt to double circuit to increase capacity especially if the demand increases at the Visy (Gadara) plant.
- Install reactive power compensation equipment as required.

In the period beyond ten years:

- Loop in the existing Albury – Mulwala line into Jindera and potentially build an additional 132 kV circuit from Jindera to Norse Skog.
- Establish a new 132/33 kV substation to the west of Griffith to relieve the existing Griffith substation and Essential Energy's 33 kV system. That substation could initially be looped into the Darlington Point – Hillston line. Later, a new 132 kV line from the existing Griffith substation to West Griffith would establish a 132 kV ring supplying both substations.
- Coleambally 132/33 kV substation is connected to the 132 kV line to Deniliquin. In the longer term a second Darlington Point – Coleambally 132 kV line may be necessary.
- Line 990 from Yass to Wagga was recently rebuilt. This line may later be converted to 330 kV to reinforce capacity between Yass and Wagga should limitations appear on the existing 132 kV network between Yass and Wagga. This development would be postponed using a control system to limit the loading on critical 132 kV lines.
- Further uprate and refurbish existing 330 kV, 220 kV and 132 kV substations including some transformer capacity at existing supply points.
- Further uprate key 132 kV lines in the area.
- Continue to respond to any non-forecast industrial load or generation developments in the area.
- Continue the installation of reactive power compensation equipment as required.

Appendix

Glossary of Terms.

Appendix – Glossary of Terms

Term/Acronym	Explanation/Comments
ABS	Australian Bureau of Statistics
ACT	The Australian Capital Territory
AEMC	Australian Energy Market Commission. The organisation that makes the rules and develops the Australian energy markets.
AEMO	Australian Energy Market Operator. The company that administers and operates the National Electricity Market.
AER	The Australian Energy Regulator.
CBD	Central Business District.
Constraint (limitation)	An inability of a transmission network or distribution network to supply a required amount of electricity to a required standard.
DNSP	Distribution Network Service Provider (Distributor). A body that owns controls or operates a distribution network in the NEM.
DM	Demand management. A set of initiatives that is put in place at the point of end-use to reduce the total and/or peak consumption of electricity.
ESoO	The Electricity Statement of Opportunities is a document produced annually by AEMO that focuses on supply demand balance in the NEM.
EV	Electric Vehicle
GFC	The Global Financial Crisis
GHG	Greenhouse Gas
GWh	A unit of energy consumption equal to 1,000 MWh or 1,000,000 kWh.
kV	Operating voltage of transmission equipment. One kilovolt is equal to one thousand volts.
Local Generation	A generation or cogeneration facility that is located on the load side of a transmission constraint.
LRC	Low Reserve Condition
MW	A unit of active power (rate of energy consumption). One Megawatt is equal to 1,000 kilowatts or about 1,340 horsepower.
NDS	This Network Development Strategy
NER or "the Rules"	National Electricity Rules: The rules of the National Electricity Market that have been approved by participating state governments under the National Electricity Law. The NER supersedes the National Electricity Code (NEC or "the Code") and is administered by the AEMC.
NEM	The National Electricity Market.
NIEIR	National Institute of Economic and Industry Research
NTNDP	The National Transmission Network Development Plan is a document produced annually by AEMO that focuses on interconnection options in the NEM. The NTNDP is published concurrently with the ESoO.
POE	Probability of Exceedence
PV	Photovoltaic
RIT–T	The Regulatory Investment Test for Transmission is promulgated by the AER pursuant to the Rules. This test is required to be applied when determining the relative economic merits of options for the relief of transmission constraints.
SVC	Static VAr Compensator. A device that provides for control of reactive power.
TAPR	The Transmission Annual Planning Report is a document published annually, that sets out issues and provides information to the market that is relevant to transmission planning in NSW. The most recent Transmission Annual Planning Report was published in June 2013.
TNSP	Transmission Network Service Provider. A body that owns controls and operates a transmission network in the NEM.
USE	Unserved Energy
VAr	A unit of reactive power

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