NEW SOUTH WALES

Transmission Annual Planning Report 2014

TransGrid

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Version	Date Issued	Comment
0	30 June 2014	Original Issue

Foreword by the Managing Director

TransGrid is adapting and enhancing its business operations to become more responsive to the changing energy environment so that we can continue to provide safe, reliable and economically efficient transmission services to New South Wales, the Australian Capital Territory and the National Electricity Market.

The electricity industry is in a time of transformation. The last five years have seen a shift towards renewable sources of generation, adoption of energy efficiency initiatives, energy storage technologies becoming more affordable and smarter ways of managing peak demand for electricity. Consequently, the electricity supply chain of the future will look very different to that of the past.

TransGrid is shaping the transmission network of the future, and has committed to adapt to the changing environment by altering the way we plan, build, operate and maintain the network and aligning our business priorities with the changing needs of electricity consumers.

This Transmission Annual Planning Report 2014 (TAPR 2014) provides advance information to market participants, customers, consumers and other interested parties on the nature and location of emerging constraints in TransGrid's transmission network. It also includes information on the status of network augmentation and asset renewal projects as they evolve from need identification to completion. The TAPR 2014 places particular focus on TransGrid's commitment to more effective consumer engagement, non-network options and renewal of assets nearing the end of their serviceable lives.

In recognition of the impact our investment decisions have on transmission costs and ultimately on electricity end users, TransGrid has established a comprehensive consumer engagement program to give consumers a voice in the development of TransGrid's business plans. We have held a number of forums with residential and small business customers, talked with our directly connected customers, carried out consumer surveys and started conversations on our new engagement website – Have Your Say TransGrid. We have worked closely with consumer representatives and large businesses on specific aspects of our business plans and operations.

TransGrid is committed to using non-network options to address network constraints where feasible and cost-effective. This TAPR outlines TransGrid's future demand management initiatives with a key focus on collaboration to improve consumer understanding of demand management, capturing synergies across different industry participants' demand management activities and reducing regulatory barriers to demand management uptake.

To improve understanding of the demand management market, TransGrid proposes research to better understand today's drivers of peak demand, businesses' energy behaviours and demand response capacity. TransGrid also seeks to overcome practical barriers to the application of demand management tools and technologies. To develop the "market" for non-network options, TransGrid intends to procure pre-emptive demand management in the Sydney inner metropolitan area.

A key element of TransGrid's investment plans is judicious renewal of parts of the network that are nearing the end of their serviceable lives. The electricity transmission network in New South Wales was first developed in the 1950s and 1960s, to improve efficiency and reliability above that of individual local or distributed generation systems that existed at that time. To date, TransGrid has mainly undertaken replacement and refurbishment of individual items of equipment to keep existing substations and transmission lines operational at the lowest cost. Now, parts of the network are in need of more comprehensive renewal.

TransGrid's proposed asset renewal program comprises the most economic combination of replacement and refurbishment options for transmission equipment nearing the end of its serviceable life. The program is essential to ensure the safety of staff, contractors and the public and to maintain a reliable electricity supply.

In early 2014, the Australian Energy Regulator (AER) undertook a review of the TAPRs produced by all Transmission Network Services Providers (TNSPs) within the NEM. That review resulted in the AER asking TransGrid to provide additional information in its TAPR.

Some changes have been made to this TAPR to accommodate evolving circumstances and in response to some of the AER's requests. Prior to making further improvements, TransGrid intends to consult with other stakeholders having an interest in the TAPR.

I believe that consultation is key to TransGrid's future. As a TNSP, our continued role in the electricity supply chain depends on our capacity to be responsive to change. We must consider and take into account the opinions and preferences of our customers, and be ready and willing to adapt to new ways of doing business.

In delivering this TAPR, we invite you to share your views and take part in a robust discussion that will influence the shape of the transmission network of the future. We look forward to your valuable feedback on the TAPR 2014.

Peter McIntyre
Managing Director

June 2014

Executive Summary

CHAPTER ONE

Executive Summary

TransGrid is the owner, operator and manager of one of the largest electricity transmission networks in Australia. With 96 substations and over 12,900 kilometres of transmission lines, its network forms the backbone of the National Electricity Market (NEM) serving the people of New South Wales (NSW) and the Australian Capital Territory (ACT) and facilitating interstate energy trading.

This TAPR provides advance information to market participants, customers and other stakeholders on the nature and location of emerging constraints in TransGrid's transmission network. It also includes information on the status of network augmentation and asset renewal projects as they evolve from need identification to completion. The TAPR 2014 is focused on TransGrid's commitment to more effective consumer engagement, non-network options and judicious renewal of assets nearing the end of their serviceable lives. The information presented in the TAPR will allow interested parties to contribute to TransGrid's plans, and in particular, it aims to assist prospective proponents to develop proposals for non-network options such as embedded generation and demand management (DM).

Planning and development of the network is undertaken on a cyclical and a needs basis to ensure that transmission service delivery to our customers is cost-effective, environmentally responsible, responsive to changing requirements and meets the jurisdictional, contractual and National Electricity Rule (NER) obligations.

The TAPR 2014 represents a status report as at June 2014 to our customers and stakeholders on the needs, options, augmentation and asset renewal projects as they move through TransGrid's formal network investment process. That process progresses from need identification and consumer engagement, option formulation and evaluation through to implementation of the most efficient option. It is briefly described in Section 2.6.

While TransGrid's key interface has historically been with generators, distribution network service providers and some large directly connected customers, TransGrid understands that energy consumers are interested in its operations in terms of the prices they pay for electricity, their access to electricity when and where they need it and the financial, environmental and community impacts of new infrastructure.

In recognition of the importance of community engagement, TransGrid is opening its planning processes and has redefined the way in which it engages with the community on capital works programs. Conversations with the community will now start in the early planning stages, when a need is identified to address an energy problem to give consumers a voice in the development of TransGrid's business plans.

TransGrid's new stakeholder engagement process is proactive and transparent. It is based on meaningful, open and honest engagement; focuses on listening to feedback; incorporating and addressing stakeholder views in our business plans; and responding to and acting upon stakeholder feedback.

The TAPR is one of a number of channels through which TransGrid communicates information pertinent to transmission and distribution planning in the NEM. Through these channels, TransGrid aims to raise levels of awareness and increase consumer understanding regarding the broad areas of load forecasts, supply demand balance, transmission networks planning and distribution networks planning.

TransGrid is the nominated Jurisdictional Planning Body (JPB) for NSW in the NEM and as such is responsible for the coordination of the planning and development of electricity transmission networks in NSW.

Load forecasts are a fundamental input to the network development and planning process. In 2012, TransGrid transferred the responsibility for load forecasts for the NSW region to Australian Energy Market Operator (AEMO). AEMO now produces load forecasts for each NEM region based on economic scenarios, historical data and expected patterns in demand side response such as solar photovoltaic (PV) generation. TransGrid works with AEMO in ensuring the integrity of the forecasting process, modelling and underlying assumptions.

AEMO has provided forecasts for the NSW region which are included in Chapter 3. The key economic, price and demographic projections underpinning these forecasts are available from AEMO.

The AEMO energy forecasts show an annual energy growth of 0.4% for the forecast period 2014/15 to 2023/24. AEMO has also forecast the 50% Probability of Exceedance (PoE) summer and winter peak demands to grow at an annual rate of 1.1% for the forecast period. The forecast energy growth rate is lower than the 2013 forecast. The forecast summer and winter demand growth rates are higher than the 2013 forecasts. Both summer and winter peak demand forecasts have a lower starting point than the 2013 forecasts.

TransGrid also receives bulk supply point forecasts from the connected distribution network owners for the purposes of network planning. The bulk supply point forecasts are included in Appendix 3. Those forecasts show lower starting points and marginally lower growth rates relative to the 2013 forecast.

Engagement with stakeholders is an important part of the overall investment planning process

Both AEMO's NSW region demand forecast and the bulk supply point forecasts are considered in network planning. This includes their impact on required commissioning dates and/or scope and nature of options to manage constraints.

In addition TransGrid considers a range of load growth scenarios when making investment decisions, to test whether those decisions are sensitive to this factor. For the largest potential investment within the planning horizon, "Powering Sydney's Future", the various options have been tested against a no net growth scenario.

TransGrid takes a holistic approach to planning and considers non-network options on an equal footing with network options when planning its network. TransGrid's approach to considering non-network options is described in Chapter 4.

TransGrid's joint planning with NSW and ACT distributors provides a mechanism to identify opportunities for non-network options. The distributors follow a similar process to TransGrid in preparing planning reports for their networks, thereby providing another useful source of information for proponents of non-network options.

To develop the market for non-network options TransGrid has proposed, as part of its recent revenue proposal, that it should procure pre-emptive demand management in the Sydney inner metropolitan area.

The roles of AEMO, TransGrid and other parties in the planning process are broadly set out in Chapter 2. AEMO is responsible for the preparation and publication of a National Transmission Network Development Plan (NTNDP) covering the interconnected system which forms the network parts of the NEM. TransGrid supports and assists AEMO in undertaking the analysis and planning which underpin the NTNDP. Chapter 5 provides an overview of the latest NTNDP and sets out the linkages between it and TransGrid's network development plans.

One of the key components of TransGrid's planning process is the Annual Planning Review carried out since the publication of the previous TAPR. This review includes:

- identification of emerging constraints taking account of latest available load forecasts;
- quantification and location of constraints; and
- discussion on the options that have been identified for relieving each constraint.

Timely identification of emerging constraints allows the market to identify potential non-network options and TransGrid to develop and implement appropriate measures. Chapters 6 and 7 of the TAPR 2014 cover this aspect of the planning process.

Chapter 6 sets out the works completed since the publication of the last TAPR, which are now delivering network services to our customers. This section also details those developments where contracts have been finalised and the works are now committed. In order to move to the committed stage, the required regulatory consultation process as set out in the National Electricity Rules (NER) must be completed. Section 6.3 lists the projects that have progressed to this stage.

Chapter 7 sets out constraints that are expected to emerge within a five year planning horizon, and have not advanced sufficiently to be included in Chapter 6. This chapter describes one or more options for the removal of other constraints expected to emerge within a five year planning horizon where there is currently no firm proposal.

In order to provide a complete picture over the planning horizon, Chapter 7 also summarises constraints that are expected to arise over a time frame longer than five years along with one or more indicative options to meet those constraints.

In accordance with the NER requirement, Section 7.5 provides constraint information and an indication as to whether TransGrid intends to issue a Request for Proposal (RfP) for non-network options with respect to the identified constraints.

Chapters 6 and 7 include needs arising from assets reaching the end of their serviceable lives. TransGrid's asset management system has been independently reviewed against the newly released international standard ISO55001. As a result of that review TransGrid is expecting to attain full certification later this year. TransGrid's asset management system is described in Chapter 2 and Appendix 2.

In early 2014, the Australian Energy Regulator (AER) reviewed the TAPRs produced by all Transmission Network Service Providers in the NEM. As part of the review process, the AER requested TransGrid to increase the information provided in its TAPR. Some of the requested changes have been made in this TAPR.

TransGrid intends to consult other stakeholders who use the TAPR to determine their views on more significant changes and whether the inclusion of additional information in the TAPR is the most effective method of providing that information. This will inform TransGrid's approach in preparing future TAPRs.

This TAPR aligns with TransGrid's recent revenue proposal. Comments on this TAPR 2014 are welcome. For contact details, please refer to the inside back cover of this report. Comments on TransGrid's investment proposals can also be made by taking part in the AER's consultation process on TransGrid's revenue proposal.

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CHAPTER TWO

Introduction

2.1 ABOUT TRANSGRID

TransGrid owns and manages one of the largest high voltage electricity transmission networks in Australia, connecting generators, distributors and major end users in New South Wales (NSW) and the Australian Capital Territory (ACT).

TransGrid's network, with 96 substations and over 12,900 kilometres of transmission lines, serves the largest state in Australia's NEM, facilitates interstate energy trading and forms the backbone of the NEM.

2.1.1 Our Objectives

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

- To be a successful business, and, to this end:
  - To operate as efficiently as any comparable businesses;
  - Maximise the net worth of the State's investment in it; and
  - Promote social responsibility by having regard to the interests of and engaging with the community in which it operates
- 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*
- Demonstrate responsibility towards regional development and decentralisation in the way in which it operates
- Operate efficient, safe and reliable facilities for the transmission of electricity and other forms of energy
- Promote effective access to these transmission facilities.

2.1.2 Our Network

Our network operates primarily at voltage levels of 500 kV, 330 kV, 220 kV and 132 kV. The substations are normally located on land owned by TransGrid, with the transmission lines and underground cables 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 services. The head office is located at 180 Thomas Street in Sydney. Field staff are co-ordinated from major depots located in Western Sydney, Newcastle, Tamworth, Orange, Wagga Wagga and Yass.

TransGrid's network is shown on the electricity network maps overleaf.

2.2 OUTCOMES OF THE ANNUAL PLANNING REVIEW FOR 2014

The TAPR 2014 documents the process and outcomes of the NSW Annual Planning Review carried out since the publication of the previous TAPR. The purpose of the Planning Review and this TAPR is to:

- Identify emerging constraints in New South Wales transmission networks over appropriate planning horizons;
- Provide advance information on the nature, quantification and location of the constraints. The level of information included in this document is intended to encourage market participants and interested parties to formulate and propose options to relieve the constraints, including those that may include components of DM and local generation or other options that may provide economically efficient outcomes;
- Discuss options that have been identified for relieving each constraint including network, local generation, DM and other options;
- Indicate, where possible, if and when TransGrid intends to issue a Request for Proposals (RfP) for non-network alternatives to relieve a constraint;
- Comply with National Electricity Rules (NER) requirements in respect of preparation of a Transmission Network Service Provider's (TNSP's) TAPR; and
- Provide a basis for annual reporting to the New South Wales Minister for Resources and Energy (the Minister) on the outcome of the Annual Planning Review.

The Annual Planning Review for 2014 included:

- A report of AEMO's NSW load forecast that took account of actual peak loads for the preceding summer and winter;
- Ongoing planning analysis and identification of network constraints and assessment of feasible options for relieving these constraints; and
- Publication of this TAPR 2014.

It is intended that the TAPR 2014 will provide electricity market participants and interested parties with information that will help them contribute to the optimum and economically efficient development of transmission networks in NSW and the ACT.

The timely identification of emerging constraints also allows the market to identify potential non-network alternatives and TransGrid to develop and implement appropriate and timely measures.

2.3 CONTEXT OF THE TRANSMISSION ANNUAL PLANNING REPORT

The NSW TAPR is one of a number of documents that disseminate information pertinent to transmission and distribution planning in the NEM. These documents cover the broad areas of supply demand balance, transmission networks planning and distribution networks planning.

TransGrid's network, with 96 substations and over 12,900 kilometres of transmission lines, serves the largest state in Australia's NEM, facilitates interstate energy trading and forms the backbone of the NEM

They are mandated through a variety of legislative and policy directives and therefore their scopes overlap to some extent. Nevertheless, they form an effective framework for the dissemination of network planning information throughout the NEM. They are summarised in Table 2.1.

Contact information relating to this TAPR 2014 is given on the inside back cover of this report.

2.4 SUPPLY RELIABILITY IN NEW SOUTH WALES

Within the NEM planning framework, the focus of the NSW TAPR is on supply reliability in NSW and the ACT. The following Sections detail TransGrid's approach to this responsibility.

2.4.1 TransGrid's Obligations and Responsibilities

TransGrid is responsible for the planning and development of transmission networks in NSW in two interrelated roles.

First, it has been nominated by the Minister to be the Jurisdictional Planning Body (JPB) for NSW in the NEM. In this role it:

- Provides jurisdictional information for input to the ESOO and NTNDP;
- Carries out an Annual Planning Review during which it:
  - Prepares a TAPR for NSW;
  - Holds a public forum which considers the TAPR and related transmission planning matters;
  - Reports to the Minister on matters arising from the Annual Planning Review; and
  - Reports to the Minister on matters arising from the ESOO and NTNDP.

Second, it is registered as a TNSP in the NSW region of the NEM. In relation to a TNSP's obligations for planning and development of networks, the NER require a TNSP to:

- Analyse the future operation of its transmission network to determine the extent of any future network constraints;
- Conduct annual planning reviews with distributors to determine the extent of any emerging constraints at points of connection between the TNSP's network and the distributors' networks;
- Carry out joint planning with distributors to determine options for the relief of constraints that can be considered by Registered Participants and Interested Parties;
- Coordinate a consultative process for consideration and economic analysis of the options in accordance with the AER's regulatory consultation process if required;
- On the basis of the consultative process and economic analysis determine the recommended option;
- After resolution of any disputes concerning the recommended option, arrange for its implementation in a timely manner; and
- Prepare and publish a TAPR by 30 June of each year.

The NER require that the TAPR must include:

- Results of annual planning reviews with distributors during the present year;
- Load forecasts submitted by distributors;
- Planning proposals for future connection points;
- Forecast and quantification of constraints over one, three and five years;
- Plans and dates to issue an RfP for non-network alternatives for certain constraints;
- Summary information for proposed augmentations; and
- Summary information for proposed replacement transmission network assets.

These obligations are described more fully in Clause 5.16 of the NER and the AER's RIT-T guidelines.

Figure 2.1 illustrates the main tasks and interrelationship of TransGrid's dual roles.

For regulatory consultations initiated from 1 August 2010, the RIT-T applies for transmission network augmentation proposals where the cost of the most expensive credible option exceeds $5 million. The RIT-T process is described in Figure 2.2 and is also addressed in Section 2.7.

A rule change introducing the Regulatory Investment Test for Distribution (RIT-D) came into force from 1st January 2013.

The NER describe the regulatory consultation process to be followed for a funded augmentation and this is illustrated in Figure 2.3.

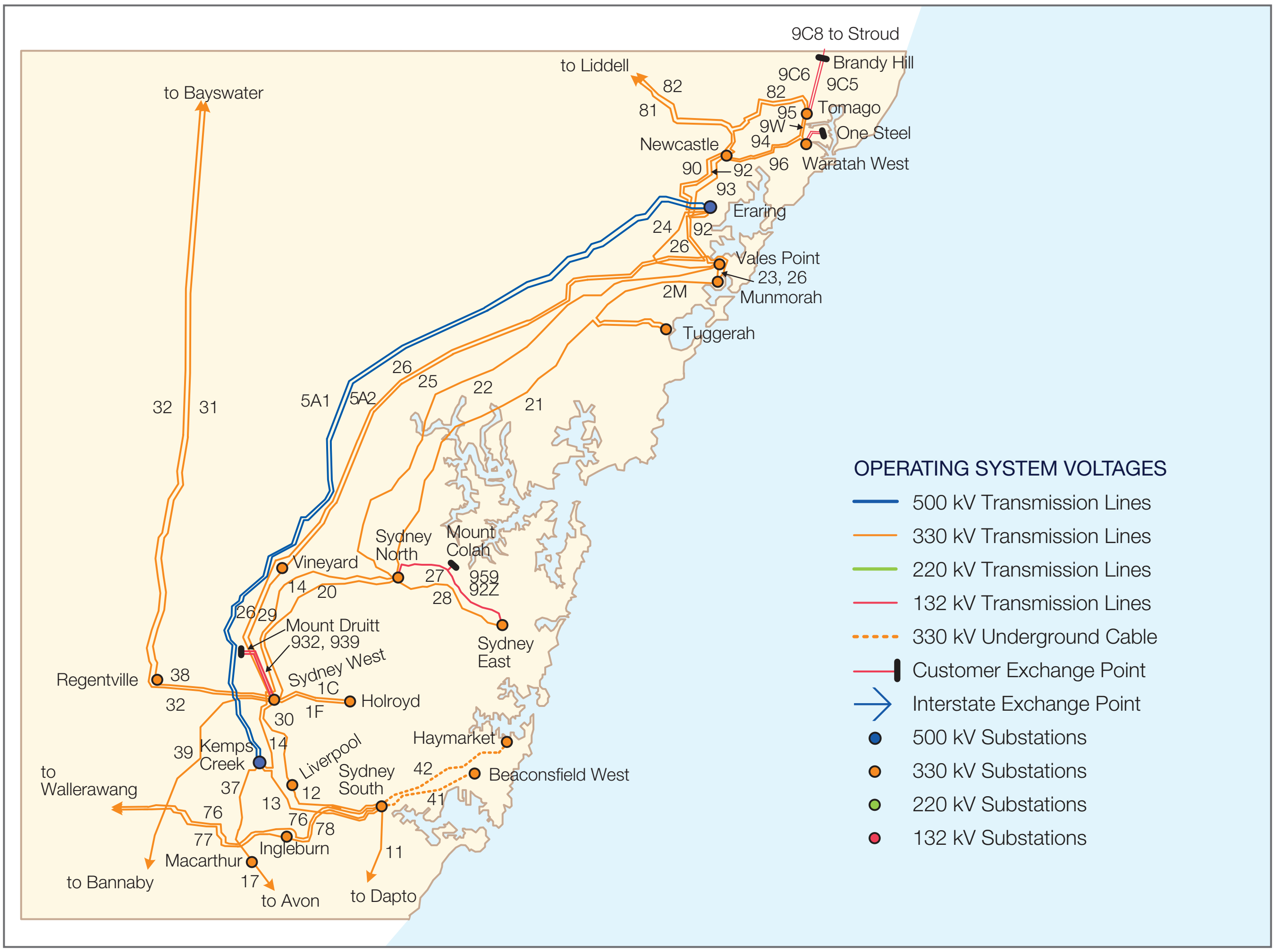
TABLE 2.1 – SUMMARY INFORMATION FOR ANNUAL PLANNING DOCUMENTS

Document	Published by	Covers
Electricity Statement of Opportunities for the National Electricity Market (ESOO)	AEMO	Supply demand balance and outlooks in the NEM
National Transmission Network Development Plan (NTNDP)	AEMO	National transmission planning
Transmission Annual Planning Reports	TNSPs	Regional transmission planning
Distribution Annual Planning Reports	DNSPs	Distribution planning

2.4.2 Network Planning Approach

TransGrid's approach to planning of the NSW transmission network is derived from its planning obligations under the NER and NSW legislation. This is detailed in Appendix 1. TransGrid's asset management system is derived from its Network Management Plan and explicitly links the consideration of asset condition to planning of the network along with the consideration of non-network options. Further information on TransGrid's asset management system is included in Section 2.5 and Appendix 2. TransGrid's consideration of non-network options is detailed in Chapter 4 on demand management.

TRANSGRID'S ELECTRICITY NETWORK MAP – INSET



TRANSGRID'S ELECTRICITY NETWORK MAP

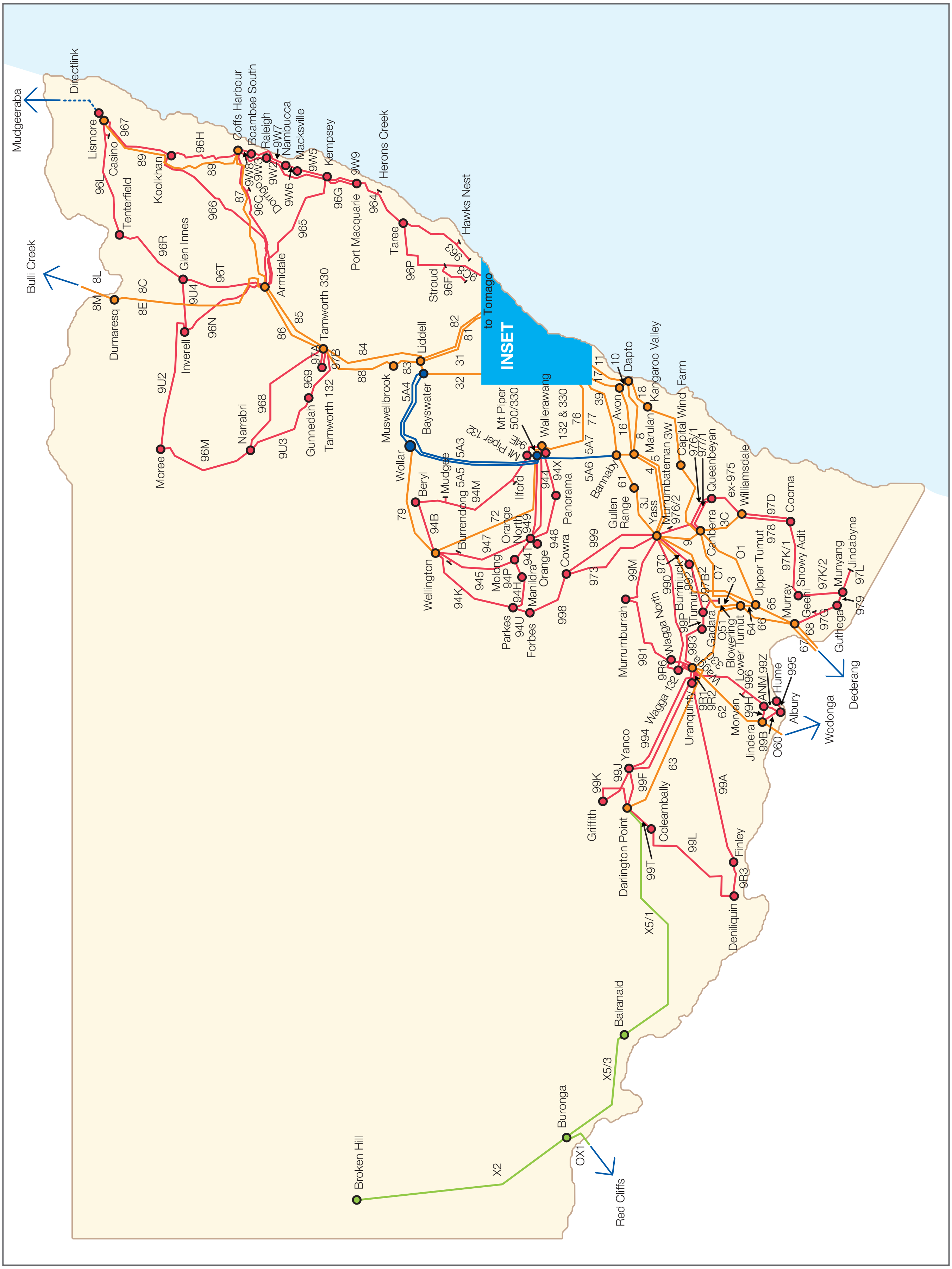


FIGURE 2.1 – TRANSGRID'S PLANNING ROLES

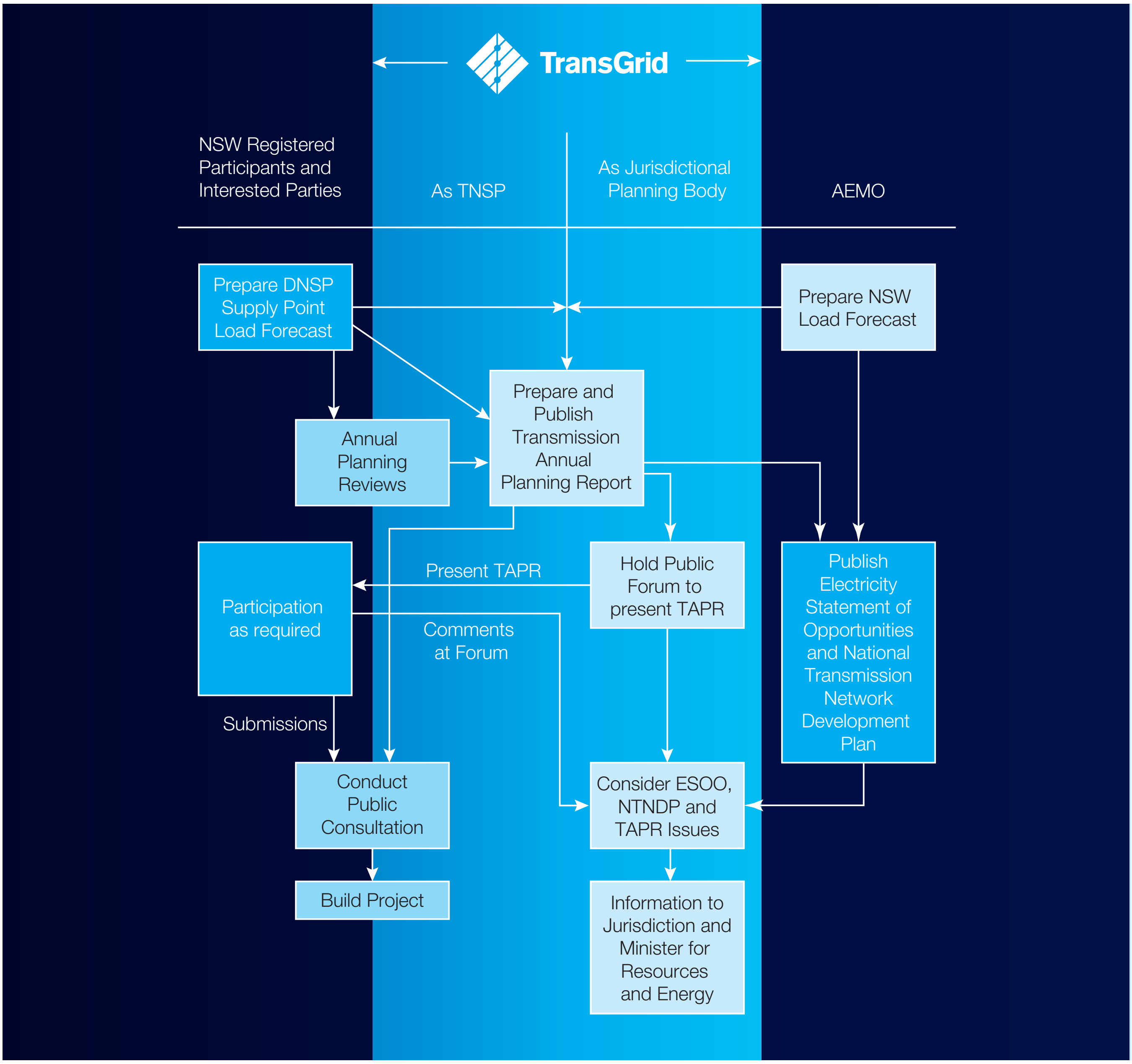
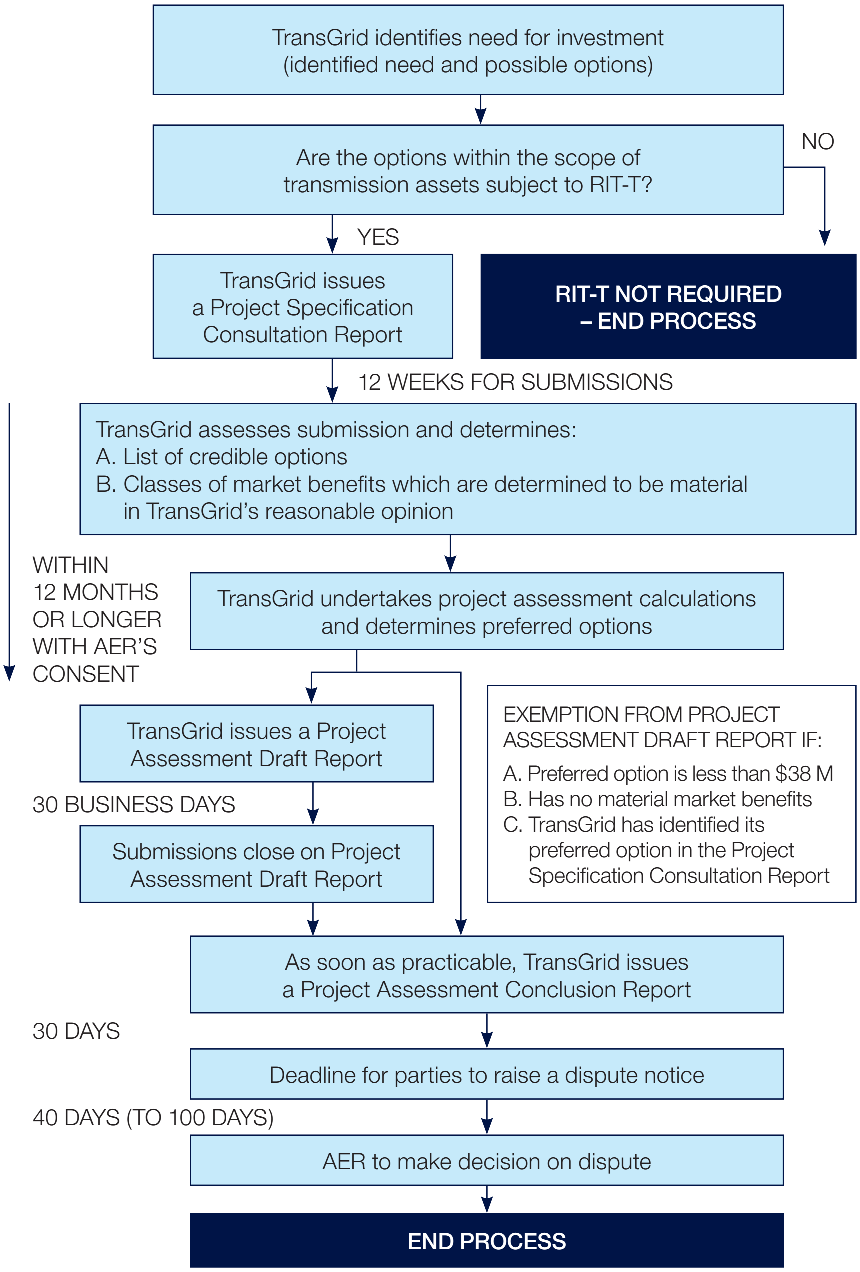
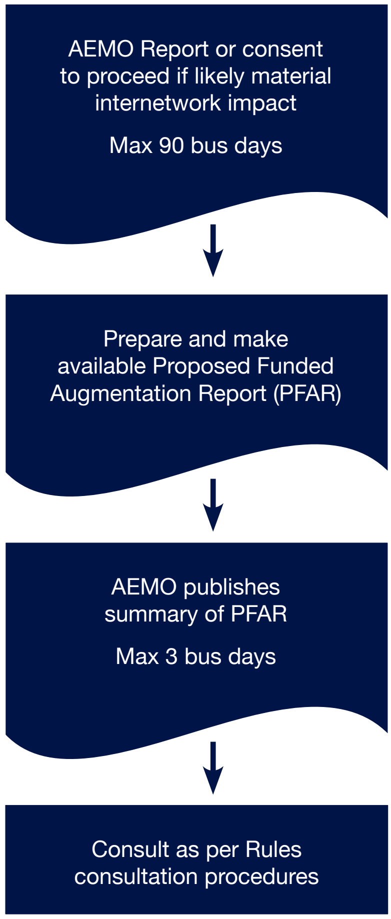


FIGURE 2.2 – NER REGULATORY CONSULTATION PROCESSES, RIT-T



Source: Adapted from AEMC Final Rule Determination National Electricity Amendment (RIT-T) Rule 2009

FIGURE 2.3 – NER PROPOSED FUNDED AUGMENTATION PROCESS



2.4.3 Annual Planning Review with Distributors

In accordance with NER requirements, TransGrid conducts an annual planning review with each distributor connected to its network. The purpose of these reviews is to:

- Identify emerging network constraints at points of connection between TransGrid's and the distributors' networks and elsewhere in TransGrid's network or the distributor's network;
- Carry out joint planning to determine options for the relief of network constraints; and
- Review the load forecast provided by the distributor.

TransGrid also conducts planning meetings and reviews with major customers.

2.4.4 Annual Planning Review for NSW

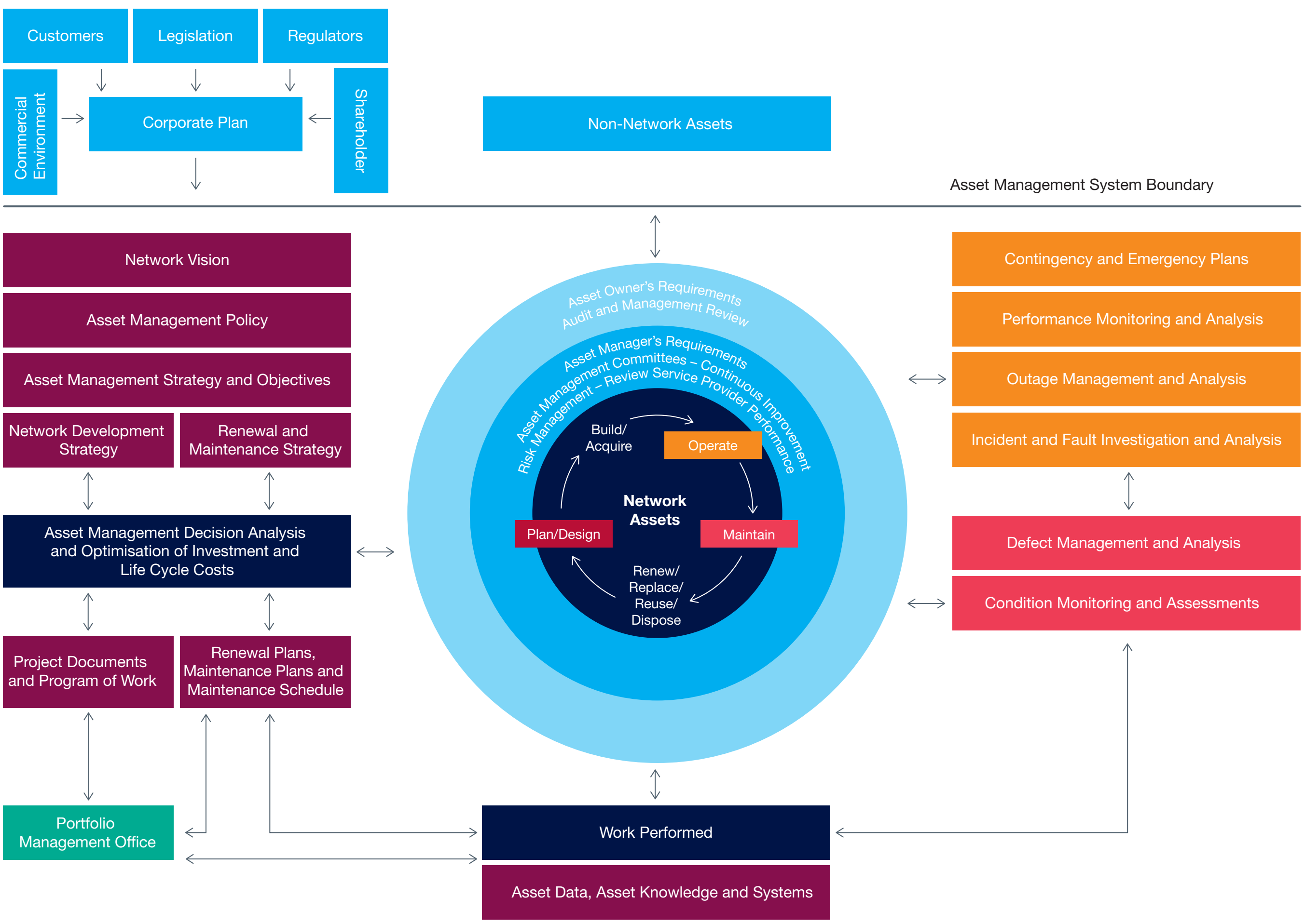
As the JPB for NSW, TransGrid carries out an Annual Planning Review of transmission networks across the State. The purpose of the review is to focus on an optimum level of transmission investment, which includes encouraging interested parties to propose options for the relief of transmission constraints which may involve components of DM and local generation. The NER underpins this by requiring all TNSPs to carry out annual planning reviews with distributors and publish the results in a TAPR.

The Annual Planning Review for 2014 commenced in October 2013 with a request by TransGrid for the distributors to provide their updated connection point load forecasts. These forecasts take into account electrical loads experienced during the preceding summer and winter. Based on these revised load forecasts and AEMO's demand forecast for the NSW region of the NEM, TransGrid has updated its short term (one, three and five years) and longer term (five to 20 years) analyses of present and emerging network constraints and has summarised the results in this TAPR.

2.4.5 NSW Government Directive on Reliability Standards

The NSW Government, through the former division of Industry and Investment (now the Department of Trade and Investment, Regional Infrastructure and Services), has put in place the *Transmission Network Design* and *Reliability Standard for NSW, December 2010* and has directed TransGrid to implement this standard in developing its plans.

FIGURE 2.4 – TRANSGRID'S ASSET MANAGEMENT SYSTEM



TransGrid's network investment process is designed to enhance its ability to deliver its capital program effectively and to be responsive to the changing needs of stakeholders

2.5 TRANSGRID'S ASSET MANAGEMENT SYSTEM

TransGrid's asset management system provides a framework for managing its transmission network assets over their life cycle. It governs the policy, strategies, objectives, plans, structures, processes and activities that apply to the management of network assets. Of specific relevance to the TAPR is the rigorous and systematic identification of needs as detailed in Appendices 1 and 2, leading to the analysis and justification of the proposed solution including consideration of non-network options. TransGrid's jurisdictional and TNSP requirements are embedded in this overall approach to managing its assets to meet the outcomes of the business, customers, consumers and other stakeholders.

There has been a continual focus of improving the asset management system in areas that bring value to the business, with the use the British Standards Institute's PAS 55:2008 specification as the reference point for good asset management practice.

The asset management landscape has undergone a significant recent shift with the release of the new ISO 55001 asset management standard, which was published in January 2014, and the pending withdrawal of PAS 55.

Following the publication of ISO 55001, TransGrid commissioned an independent review of its asset management system against that standard. The review found only a small number of minor issues and these can be readily addressed. As such, TransGrid's asset management system is expected to be ready for full certification to the ISO 55001 asset management standard in the near future.

TransGrid's Asset Management System is shown in Figure 2.4

2.6 NETWORK INVESTMENT PROCESS

TransGrid's network investment process is designed to enhance its ability to deliver its capital program effectively and to be responsive to the changing needs of stakeholders.

The process incorporates the following key elements:

- An integrated, whole of business approach to capital program management;
- Optimisation of investments, including non-network options, across augmentation and asset replacement/renewal streams;
- Early resolution of key risk areas such as environmental approvals, property acquisition and scope definition in the project delivery process;
- Structured documentation around options evaluation and project scoping to enhance the transparency of decision making; and
- Early engagement with stakeholders throughout the investment planning cycle to involve end users and impacted communities in decisions.

Figure 2.5 shows the Network Investment Process and the optimisation that takes place at each stage.

FIGURE 2.5 – NETWORK INVESTMENT PROCESS

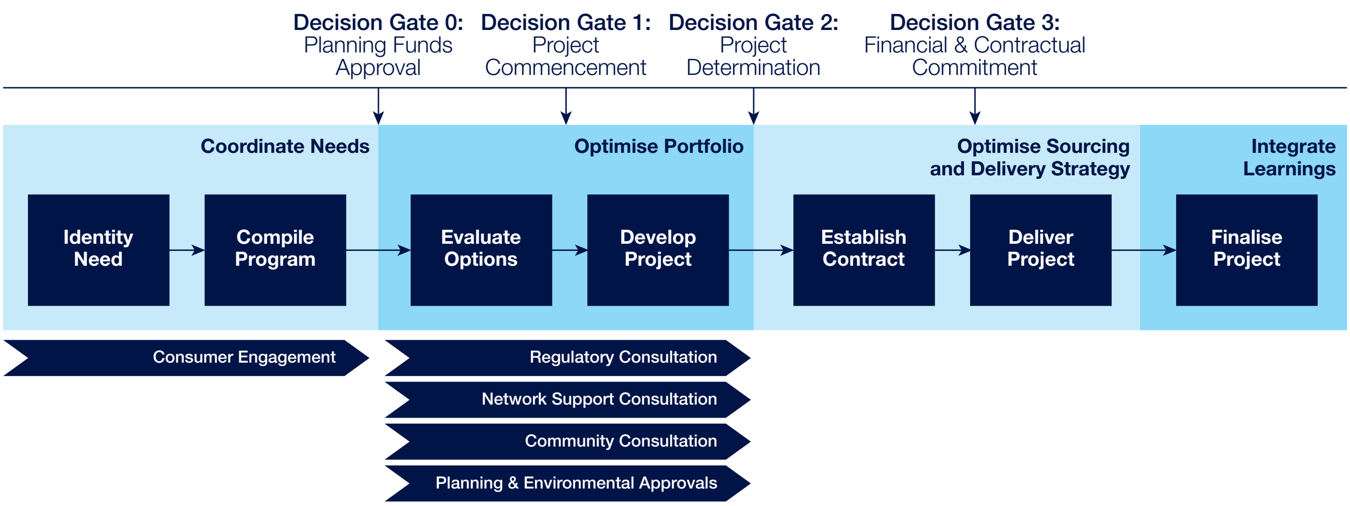


FIGURE 2.6 – HOW TRANSGRID PLANS THE NETWORK – For transmission line, underground cable and substation works

		TRANSGRID PLANNING PROCESS	STAKEHOLDER INVOLVEMENT
STAGE 1	IDENTIFY NEED	Look at future demand forecasts and the condition of existing assets Will there be a shortfall in supply if we do nothing? Review the need annually as part of the Annual Planning Review	Sense-check forecasts with • Distributors and regulators; • Academic and technical experts; and • Local governments. Seek feedback from end users and their representatives on need assessment
STAGE 2	REVIEW OPTIONS	Identify possible network and non-network options to fulfil the need, including • Demand management or energy efficiency; • Local or distributed generation; and • Network infrastructure.	Input from large users, service providers and experts on potential for non-network options Communicate with local community that may be impacted by network infrastructure
STAGE 3	PLAN IN DETAIL	Request proposals and undertake investment analysis on most viable options	Encourage proposals from market participants for non-network options Engage impacted communities in network corridor selection, if relevant Involve end users and their representatives in final investment decision
STAGE 4	IMPLEMENT SOLUTION	Enter into contracts for network or non-network solutions Build network infrastructure, if required	Work with impacted community to support best local outcomes Report progress in meeting identified need to end users and their representatives

Throughout the needs identification, option evaluation and project development stages, the portfolio is optimised by considering dependencies between projects and evaluating options in the context of related needs.

The governance framework for network investments has been strengthened with the implementation of four decision gates (DG):

- **Planning Funds Approval (DG0):** Approval of the statement of need and commencement of a range of activities, including development and evaluation of options required prior to Decision Gate 1.
- **Project Commencement (DG1):** Following desktop evaluation of network and non network options, the most efficient and commercially acceptable feasible solution to address the need is selected for more detailed scoping. This decision gate encompasses approval of the most likely preferred option to progress to commencement of a range of activities, the most important being the appropriate regulatory investment test, preliminary design work, community consultation and environmental assessments (if applicable), and any property acquisitions required prior to Decision Gate 2. This decision gate follows a high level identification of possible options, including:
    - Non-network options. One of these is DM which looks at opportunities to curb demand for electricity;
    - Network options such as a transmission line, underground cable or substation; and
    - Distribution options.

  An initial evaluation of whether it is worth taking action is carried out, including a cost benefit analysis of each option. This initial analysis is used to inform the engagement stage that commences after DG1.
- **Project Determination (DG2):** DG2 confirms the selection of the network or non network option which has been demonstrated to be the most efficient and commercially acceptable feasible solution to address the need. During this phase of the project, a stakeholder engagement plan will be developed and implemented, including community project updates, community forums, website updates and, media releases. This decision gate will follow completion of the relevant regulatory tests and environmental approvals where possible, or progression of the environmental

evaluations such that there is a high level of confidence that environmental approvals will be obtained. Scoping of the project including preliminary design and property investigations will be advanced to a stage that allows reasonable certainty in the scope, cost and timing of the project.

- **Financial and Contractual Commitment (DG3):** This decision gate encompasses the decision which commits TransGrid to full funding for the project, which may involve non-network solutions, and is done in conjunction with and prior to the first major procurement or construction contract on the project.

Although Figure 2.5 shows the process as serial, the inputs that determine the need and viable options will be reviewed each year as part of the annual planning review and, where there is a change that invalidates the previous analysis, a project may go back one or more decision gates.

Engagement with stakeholders is an important part of the overall investment planning process. Figure 2.6 shows the level of stakeholder involvement throughout the planning stages.

2.7 REGULATORY INVESTMENT TEST FOR TRANSMISSION

Subject to some exemptions, particularly for investments relating to maintenance or replacement, the RIT-T applies for transmission network investments where the cost of the most expensive credible option is greater than $5 million. This regulatory consultation process is described in Figure 2.2.

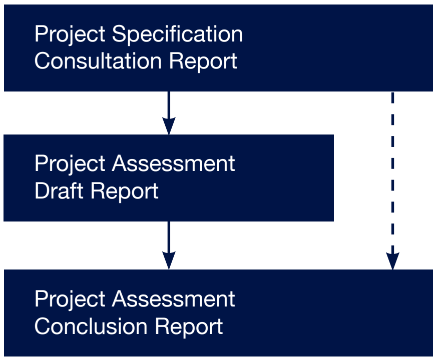
The RIT-T consultation process involves three steps being the issuing of the Project Specification Consultation Report (PSCR), the Project Assessment Draft Report (PADR) and the Project Assessment Conclusion Report (PACR). The PADR can be omitted in certain circumstances where the preferred option is less than $38 million, where there are no material market benefits and where the PSCR has identified the preferred option.

The consultation documents and process is shown in Figure 2.7. Each document has a consultation period specified and there is a requirement for the consideration of submissions received.

The preferred option under the RIT-T is the credible option that maximises the net market benefit taking into account the direct cost of the option and the market benefits arising from that option.

The process considers the available technically and commercially feasible credible options, including non-network options. The technical characteristics of the identified need that a non-network option would be required to deliver, including the size of the load reduction or additional supply required, the location and operating requirements are detailed.

FIGURE 2.7 – RIT-T CONSULTATION DOCUMENTS



2.8 RIT-T COST THRESHOLD AND INFORMATION DISCLOSURE ON NETWORK REPLACEMENTS

The relevant cost thresholds as determined under Rule 5.15.3 are as follows:

- The RIT-T applies to a proposed transmission investment where the estimated capital cost of the most expensive credible option is more than $5 million;
- Exemption from preparing the Project Assessment Draft Report is allowed if the estimated capital cost of the proposed preferred option is less than $38 million, with no material market benefits and where the PSCR has identified the preferred option;
- A new "replacement transmission network asset" category was defined for network replacement projects with costs expected to exceed a threshold of $5 million. For this category there is a requirement to disclose information in TAPRs that includes a brief description, when they are expected to become operational, other reasonable options considered (if any) and the estimated cost; and
- A procedure is defined in the Rules for the review of the thresholds by the AER every three years.

2.9 CONSTRAINT AND REQUEST FOR PROPOSAL INFORMATION

In relation non-network options to address a network constraint, the NER include requirements to indicate:

- When a constraint is expected to occur, and the MW reduction at a connection point required to relieve the constraint for 12 months and the locations at which that reduction could be made; and
- Plans and dates to issue an RfP for a non-network alternative.

This information is included in TAPR 2014 in Chapters 6 and 7. Additional information for three near term augmentation needs is provided in Appendix 4. More general information on TransGrid's approach to non-network options is included in Chapter 4.

2.9.1 Constraint Information Clarifying Statement

The magnitudes and timing of the constraint information are indicative only.

It should be noted that:

- The magnitudes are based on forecast maximum demands. The actual amount of support required would depend on the actual demand at the time, which may differ from the forecast demand;
- As further information becomes available and forecasts are refined, the magnitudes and timings may change;
- The magnitudes are for support at the optimal location. If the support was to be provided at a less than optimal location, the magnitude required would be higher;
- TransGrid sources network support via a competitive process. There is no guarantee that:
  - Sufficient support will be able to be secured;
  - Network support will be cost effective; or
  - Any particular proponent's offer will be accepted.
- In some circumstances the amount of support required depends on factors beyond TransGrid's control, such as generation patterns. In these cases an indicative level of support required has been provided; and
- Typically the loading on transmission networks is highest during summer and winter. Within those periods, the timing of the highest demands (at which times

support may be required) depends on a number of factors including actual weather conditions. Consequently it is not possible to predict the month(s) during which support may be required. Rather, the season in which support is expected to be required is given. Summer is taken to be December to February (although in some cases it is possible that support may be required in late November or early March). Winter is taken to be June, July and August.

In summary, TransGrid's requirements of network support include that:

- It must meet the size and location of support required. This can be by a single provider or in aggregate by more than one provider;
- It must meet the requirement during the time of year specified;
- It must meet reliability requirements;
- It must be able to be delivered by the needs date; and
- A proponent or proponents must be able and willing to enter into a commercial contract to provide the support.

2.9.2 Criteria to Issue RfP

Clause 5.6.2A (b) (3a) (iv) of the Rules requires TransGrid to indicate in the TAPR if it is expecting to issue an RfP for augmentation or non-network alternative, and if so, the expected date the RfP will be issued.

In addition to the need to comply with the NER requirements, TransGrid has statutory, social, environmental and commercial objectives set out in the *Energy Services Corporations Act 1995.* These combine to mean that TransGrid should undertake to minimise the impact of its network where it can otherwise meet its transmission service obligations, including through the use of non-network alternatives.

TransGrid's process for acquiring network support is described in Section 4.2. Prior to undertaking that process TransGrid engages with relevant parties to explore the likelihood of network support being available.

2.10 NETWORK SUPPORT AND CONTROL ANCILLARY SERVICES

Network Support and Control Ancillary Services (NSCAS) are those non-market ancillary services acquired to maintain power system security and reliability and increase the power transfer capability of the transmission network.

The AEMC made an NER rule change shifting the responsibility for planning and procurement of NSCAS from AEMO to the TNSPs. The NER rule change came into effect on 5 April 2012. NSCAS gaps are discussed in Chapter 5 on the NTNDP.

2.11 THE NATURE OF THIS DOCUMENT

TransGrid believes that an important function of the various consultation/information documents it publishes, including the TAPR, is to provide (non-confidential) information to enable interested parties to be able to make informed decisions and/or informed contributions to the matters covered in those documents. Unfortunately, it is not always possible to predict the precise nature and depth of the information that those parties may require.

To manage this uncertainty, TransGrid has adopted a "process improvement" approach whereby comments and submissions received in response to the documents it publishes are used to inform the nature and amount of information included in future documents.

When additional information is requested, TransGrid generally holds discussions with the relevant party to determine what additional information is required. This enables TransGrid to tailor the additional information provided to the specific needs of that party.

TransGrid believes that this approach is well suited to the TAPR which covers a wide range of subjects and cannot, by its nature, provide very detailed information on all subjects covered. In line with this approach, rather than repeating detail which is available in other publicly available documents, the TAPR provides references to those documents.

A less targeted approach which would rely less on comments/submissions by providing additional information initially, was considered but not adopted as:

- It would not be certain that the exact information required would be provided; and
- There is a greater risk that the information required by particular parties may be "obscured" by other information that is not relevant to them.

Comments on any aspect of this TAPR and particularly on TransGrid's approach are welcome. Contact details are provided on the inside of the rear cover.

2.12 AER SUGGESTED CHANGES TO TRANSGRID'S TAPR

In early 2014 the AER undertook a review of the TAPRs produced by all TNSPs within the NEM. That review was based on the AER's interpretation of both the NER requirements and the intentions of the rule makers when the relevant Sections of the NER were being developed. The review led to the AER asking TransGrid to provide additional information in its TAPR and to develop and publish an "Improvement Plan" to achieve that.

While TransGrid does not have an obligation to comply with the AER's request, some changes have been made to this TAPR. Those changes, which accommodate evolving circumstances and some of the AER's requests, are covered in Section 2.13.

As indicated in Section 2.11, TransGrid has a continuous improvement process for its various consultation/ information

documents which is based on feedback from the users of those documents. Feedback from surveys undertaken in September 2011 and August 2013 was that most TAPR users believed that their requirements were being met.

In line with its desire to improve the TAPR, TransGrid intends to seek the opinions of other stakeholders who use the TAPR to determine their views on:

- Whether the additional information requested by the AER would be of use to them; and if so
- Whether its inclusion in the TAPR is the most effective method of providing that information. Other possible mechanisms include:
  - Provision upon request and tailored to the particular party's requirements (as at present); and
  - Inclusion in separate document(s); and
- Any other changes they may believe are appropriate.

That consultation is expected to occur in the second half of 2014. TransGrid intends to consider the results of that consultation when making further changes to the TAPR. That is the first stage of the "Improvement Plan" is to consult with other stakeholders who use the TAPR. A summary of the results of the consultation will be included in TransGrid's next TAPR (TAPR 2015). It will also be shared with the AER.

2.13 CHANGES TO THIS TAPR 2014

TransGrid has made some changes to the structure of this report including provision of additional appendices.

The description of TransGrid's asset management practices has been enhanced in Chapter 2.

Consistent with its increased importance in the present low growth environment and the major initiatives TransGrid is taking, the Section on non-network options has been expanded and moved forward to Chapter 4.

The NSCAS gaps Section has been included in the chapter on the NTNDP.

The AER's request for additional material has been discussed in Chapter 2.

This year the projects Sections are included in Chapters 6 & 7. Within each subsection the items have been arranged on a regional basis. They include additional information in some Sections to provide greater context, particularly for proposed developments and condition based works.

Changes to the appendices include provision of:

- Material on asset management, particularly for assets approaching the end of their serviceable lives in Appendix 2;
- Commentary on load transfers between bulk supply points in Appendix 3;
- Information which may be of use to potential providers of non-network options in Appendix 4;
- information on the utilisation of TransGrid's network in Appendix 5;
- Information on network constraints in Appendix 6; and
- Changes to the projects covered in this TAPR compared to those in the TAPR 2013 in Appendix 8.

The previous appendix on deterministic and probabilistic planning criteria has not been updated this year. Similarly, the appendix on PV connections has not been updated, although some commentary on PV installations has been included in the load forecast Chapter 3.

2.14 TRANSMISSION LINE UTILISATION AND CONSTRAINTS

In Appendix 5 the historical utilisation of TransGrid's transmission lines are presented for the 12 month period, 01 May 2013 to 30 April 2014. It is important to note that since the utilisation is based on the historical generation and load for the 12 month period, load growth or contraction, seasonal load variation and generation pattern variation is not considered.

The utilisation is the proportion of the lines capacity, to the peak power it carried, expressed as a percentage.

The utilisation for each line is given for the system in its normal state, and for an N-1 state. The N-1 state shows the possible highest flow on that line, had the worst contingency occurred.

The utilisation of each line is given on a number of maps. They are also summarised on a single line graph.

The utilisation of the network indicates that some parts of the TransGrid network are heavily loaded and some parts are not. The heavily loaded parts of the network are continuously examined by TransGrid so that options may be investigated to relieve the network at an appropriate time in the future. The options may include non network solutions, investment in transmission infrastructure, or a combination of both. Some parts of the TransGrid network are lightly loaded for a number of reasons. This means that there is existing spare capacity in the network. This capacity could be used to allow the connection of new generation or large industrial loads.

Additionally, in Appendix 6 the results of initial analysis that TransGrid has undertaken of constraints on its network are shown. That analysis identified the constraints that have bound recently and gives an assessment of those which may bind in the near future.

NSW Region Energy and Demand Projections

NSW Region Energy and Demand Projections

3.1 INTRODUCTION

This chapter and Appendix 3 detail projections of energy and demand for the NSW region of the NEM (which includes the state of NSW and the ACT) covering:

- NSW region aggregate energy in GWh;
- NSW region aggregate summer and winter peak demand in MW; and
- Summer and winter peak demand projections for individual bulk supply points in the NSW region in both MW and MVAr.

These projections are used by TransGrid as one of the inputs to identify future transmission constraints and to quantify any associated transmission development proposals.

3.1.1 Explanation of Terms

Energy and demand projections in this TAPR are presented as "native" quantities.

Native energy and native demand projections include load supplied by "Scheduled" generators plus "Semi-scheduled" and "Non-scheduled" generators. Figure 3.1 shows the components of native energy and maximum demand.

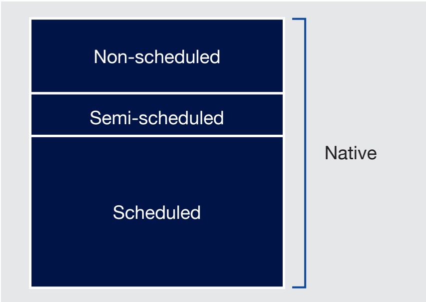
Scheduled generators are non-intermittent generators above 30 MW capacity. They are included in the NEM dispatch process.

Semi-scheduled generators are intermittent generators above 30 MW capacity. They are either presently included in the NEM dispatch process or will eventually be so included. Wind generators above 30 MW capacity fall into this category.

Non-scheduled generators are above 1 MW and below 30 MW capacity and are not included in the NEM dispatch process.

A simplified schematic representation of the flow of electricity from power station to end-use customers is presented in Figure 3.2.

FIGURE 3.1 – COMPONENTS OF NATIVE ENERGY AND MAXIMUM DEMAND



3.1.2 Information Sources

AEMO has provided forecasts for the NSW region which are discussed in this chapter. Interested parties should refer to AEMO's website for further details of AEMO's forecasts and forecasting methodology. AEMO's 2014 National Electricity Forecasting Report (NEFR) document gives forecasts for "operational"[1] quantities. Consequently the forecasts in the NEFR document and this TAPR do not align. AEMO's "native" forecasts which are reported in this chapter are included in a spreadsheet associated with the NEFR document on AEMO's website.

Summer and winter peak demand projections for individual bulk supply points in the NSW region are provided by NSW region DNSPs and other major customers. DNSPs and customers determine the bulk supply point demand projections detailed in Appendix 3. TransGrid also aggregates DNSP bulk supply point and major customer demand projections using this data and assumptions regarding diversity and losses, permitting comparisons to be made between the AEMO top down NSW region forecast, and the bottom up bulk supply point forecasts.

3.1.3 Summary of the NSW Region 2014 Energy and Demand Projections

Table 3.1 summarises historical and projected average annual growth in the NSW region energy as well as summer and winter maximum demands.

TABLE 3.1 – NSW REGION ENERGY AND DEMAND PROJECTIONS (AVERAGE ANNUAL PERCENTAGE CHANGES)

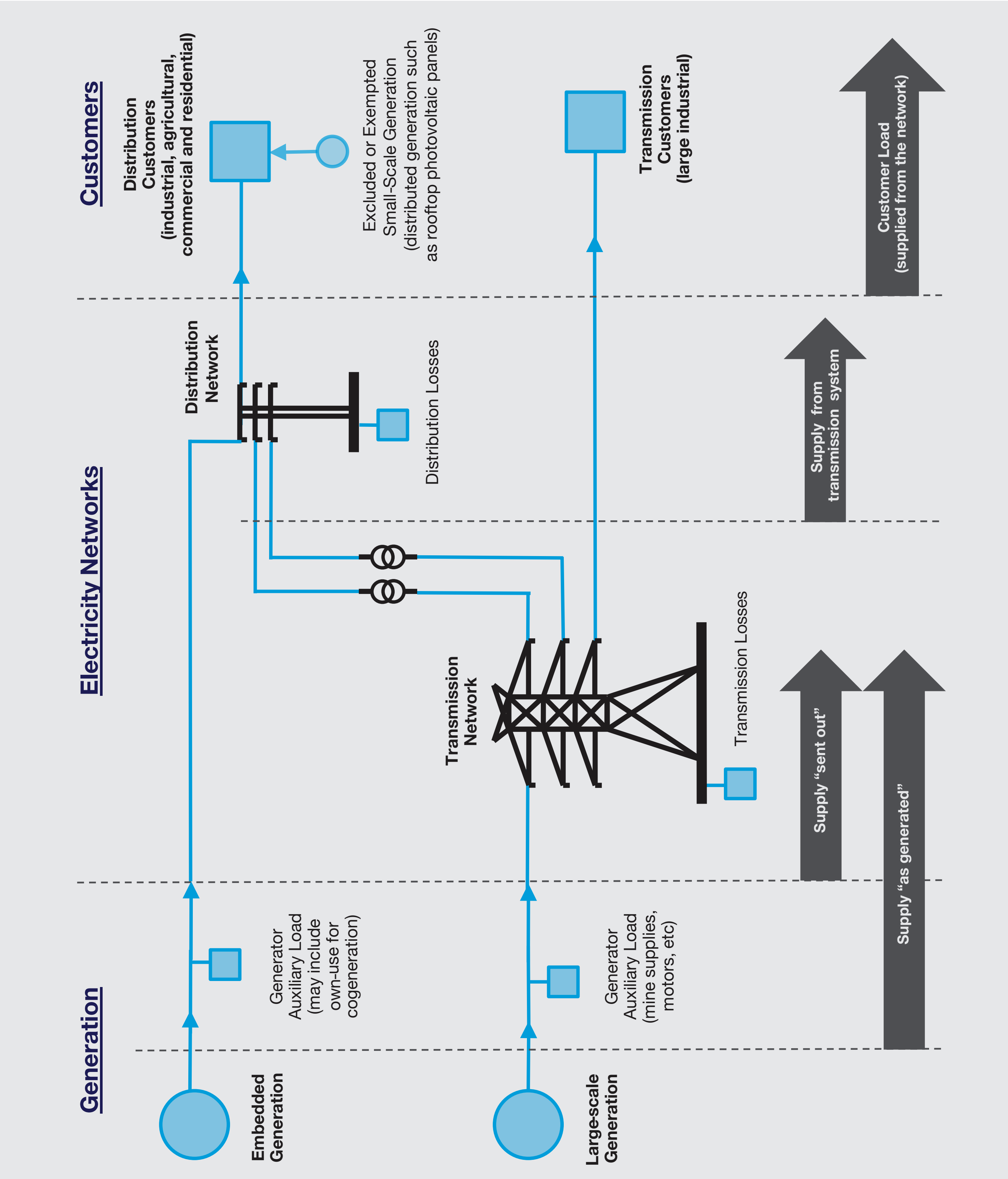
	Actual/ estimated 2005/06 to 2013/14	Projected 2014/15 to 2023/24
Energy Sent out	-1.1%	0.4%

	Actual 2005/06 to 2013/14	Projected 10% POE 2014/15 to 2023/24
Summer Peak Demand	-1.2%	1.2%

	Actual 2006 to 2013	Projected 10% POE 2014 to 2023
Winter Peak Demand	-1.6%	1.1%

1. Operational consumption includes residential, commercial and large industrial consumption. It does not include contribution from small non scheduled generation.

FIGURE 3.2 – ELECTRICITY SUPPLY



Source: Modified version of AEMO diagram in ESOO 2011

NSW annual energy is forecast to increase by an average annual growth rate of 0.4% for the next ten years. The main drivers of this growth are population and state income

3.2 ENERGY PROJECTIONS FOR THE NSW REGION

Table 3.2 and Figure 3.3 show native energy projections on a sent-out basis for the NSW region for each of the AEMO Scenarios: High, Medium and Low. These scenarios were established by Independent Economics and Frontier Economics on behalf of AEMO. Details of the AEMO economic scenarios are provided on the AEMO website.

There has been a steady decline in NSW region energy consumption in the last five years. The quantum of reduction is around 7,900 GWh (estimated) at an annual average rate of - 2.20% between 2008/09 and 2013/14. AEMO has advised that the decrease was due to general slowdown in the economy, increases in electricity prices and rooftop PV output, which reduced residential and commercial annual energy. Additionally, increase in energy efficiency measures and a softening in large industrial annual energy uptake has significantly dented the growth in overall energy consumption in the NSW region.

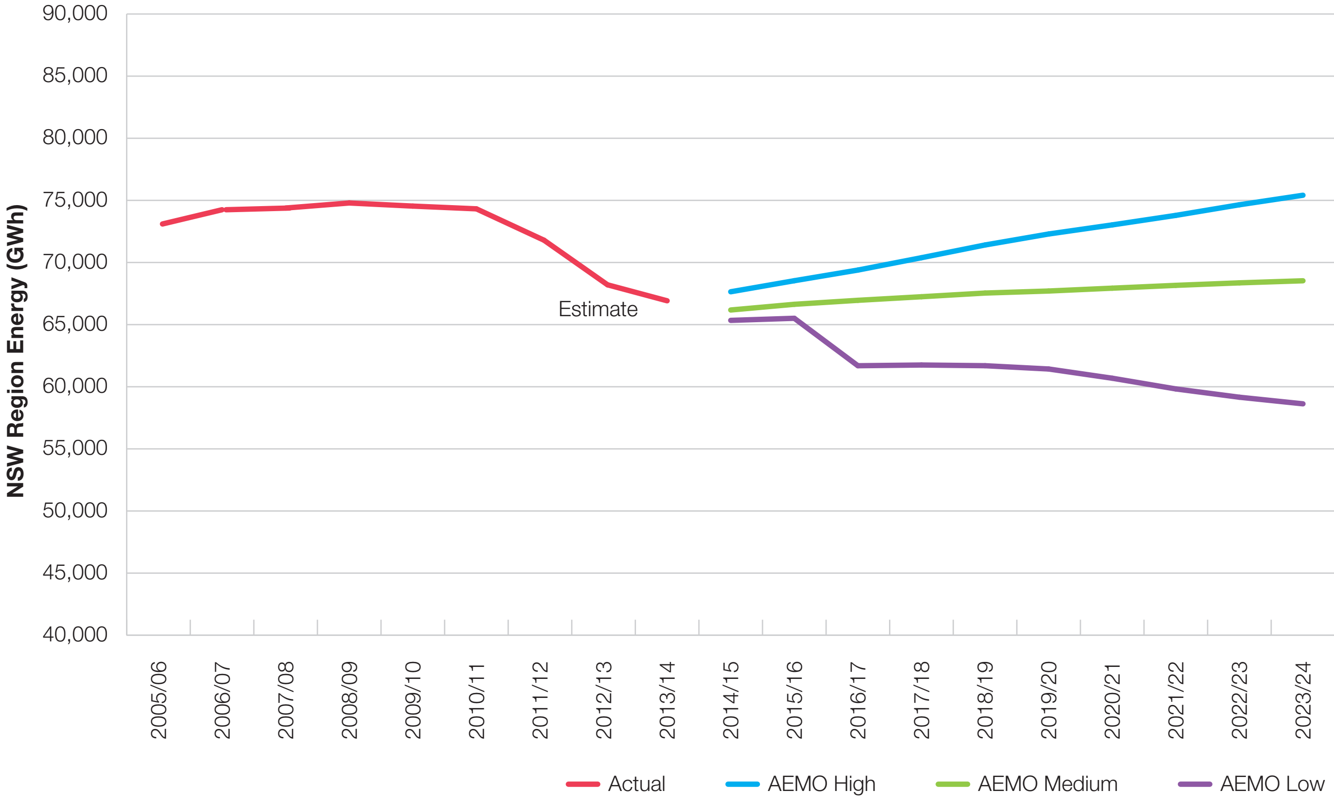
Rooftop PV uptake has increased significantly, driven by short payback periods from reducing rooftop PV system costs coupled with incentives from feed-in tariffs and rebates. Industrial activity and hence industrial annual energy decreased due to the recent decrease in global commodity prices and the sustained elevated levels of the value of the Australian dollar vis a vis other currencies (though there have been recent signs of a downward trend in the exchange rate).

New South Wales' annual energy is forecast to increase by an average annual growth rate of 0.4% for the next ten years. The main drivers of growth are population and state income. This is partially offset by growth in rooftop PV output, additional energy efficiency impacts and electricity price increases.

TABLE 3.2 – NSW REGION ENERGY PROJECTIONS (GWh)

	Actual	AEMO High	AEMO Medium	AEMO Low
2005/06	73,101			
2006/07	74,247			
2007/08	74,384			
2008/09	74,790			
2009/10	74,540			
2010/11	74,319			
2011/12	71,796			
2012/13	68,204			
2013/14 Est.	66,919			
2014/15		67,645	66,178	65,343
2015/16		68,534	66,636	65,510
2016/17		69,391	66,957	61,692
2017/18		70,385	67,245	61,750
2018/19		71,410	67,541	61,694
2019/20		72,294	67,705	61,429
2020/21		73,026	67,934	60,687
2021/22		73,792	68,161	59,825
2022/23		74,646	68,362	59,157
2023/24		75,413	68,529	58,626
Annual Average Growth Rate 2014/15 – 2023/24		1.2%	0.4%	-1.2%

FIGURE 3.3 – NSW REGION ENERGY PROJECTIONS[2]



2. AEMO has advised that the large drop in forecast energy consumption between 2015/16 and 2016/17 for the AEMO Low Scenario reflects the increased risk of reduced production output of aluminium smelters in NSW in response to less favourable economic conditions.

3.3 MAXIMUM DEMAND PROJECTIONS FOR THE NSW REGION

This Section outlines the NSW region native summer and winter demand projections on an as generated basis. Tables 3.3 and 3.4 respectively show actual (not weather corrected) historical summer and winter peak demands and projections of 10%, 50% and 90% Probability of Exceedance (POE) demands for each of the AEMO scenarios: High, Medium and Low for the next 10 years.

TABLE 3.3 – NSW REGION SUMMER MAXIMUM DEMAND PROJECTIONS (MW)

	Actual	AEMO High			AEMO Medium			AEMO Low		
		10% POE	50% POE	90% POE	10% POE	50% POE	90% POE	10% POE	50% POE	90% POE
2005/06	13,327									
2006/07	12,896									
2007/08	12,956									
2008/09	14,176									
2009/10	13,969									
2010/11	14,863									
2011/12	12,141									
2012/13	13,946									
2013/14	12,082									
2014/15		13,896	12,712	11,859	13,600	12,472	11,615	13,497	12,358	11,458
2015/16		14,320	13,033	12,181	13,887	12,698	11,863	13,698	12,552	11,664
2016/17		14,594	13,388	12,453	14,147	12,911	12,047	13,481	12,285	11,395
2017/18		14,947	13,654	12,744	14,274	13,104	12,165	13,661	12,419	11,518
2018/19		15,211	13,919	12,922	14,490	13,231	12,304	13,756	12,504	11,607
2019/20		15,474	14,136	13,175	14,610	13,316	12,394	13,714	12,460	11,557
2020/21		15,737	14,374	13,375	14,713	13,484	12,535	13,401	12,168	11,273
2021/22		15,946	14,529	13,513	14,859	13,516	12,495	13,047	11,881	11,021
2022/23		16,190	14,781	13,722	14,922	13,572	12,610	13,040	11,804	11,010
2023/24		16,467	15,019	13,926	15,075	13,714	12,741	13,061	11,816	10,948
Annual Average Growth Rate 2014/15 – 2023/24		1.9%	1.9%	1.8%	1.2%	1.1%	1.0%	-0.4%	-0.5%	-0.5%

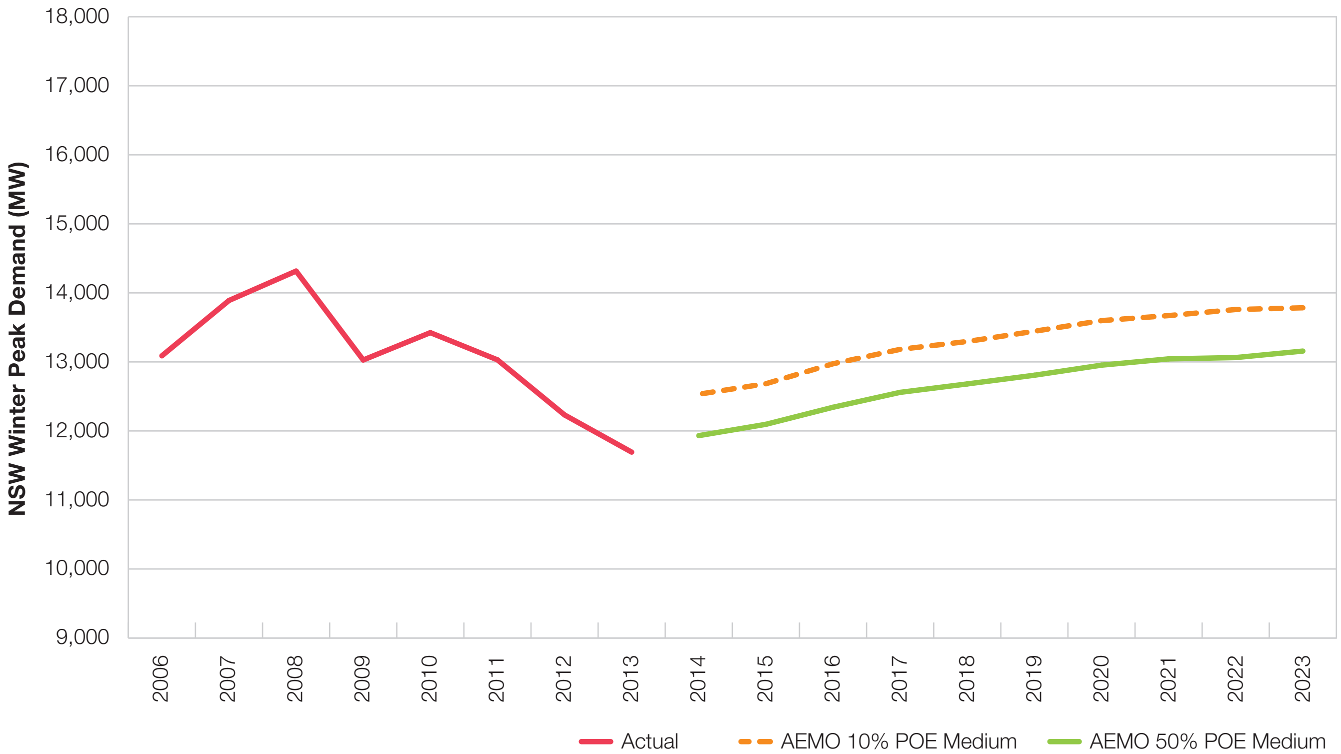
TABLE 3.4 – NSW REGION WINTER MAXIMUM DEMAND PROJECTIONS (MW)

	Actual	AEMO High			AEMO Medium			AEMO Low		
		10% POE	50% POE	90% POE	10% POE	50% POE	90% POE	10% POE	50% POE	90% POE
2006	13,088									
2007	13,890									
2008	14,316									
2009	13,028									
2010	13,424									
2011	13,030									
2012	12,232									
2013	11,693									
2014		12,625	12,053	11,597	12,532	11,932	11,520	12,412	11,823	11,393
2015		12,846	12,267	11,850	12,684	12,096	11,660	12,542	11,924	11,489
2016		13,190	12,594	12,125	12,973	12,343	11,908	12,753	12,143	11,680
2017		13,460	12,867	12,398	13,182	12,559	12,090	12,485	11,883	11,401
2018		13,726	13,086	12,600	13,296	12,681	12,237	12,719	12,100	11,629
2019		13,927	13,309	12,823	13,444	12,807	12,348	12,834	12,172	11,745
2020		14,168	13,523	13,028	13,598	12,953	12,454	12,649	11,997	11,559
2021		14,356	13,693	13,172	13,671	13,044	12,576	12,288	11,629	11,218
2022		14,503	13,837	13,313	13,759	13,063	12,615	12,089	11,433	11,016
2023		14,705	14,020	13,502	13,784	13,157	12,671	12,017	11,387	10,977
Annual Average Growth Rate 2014 – 2023		1.7%	1.7%	1.7%	1.1%	1.1%	1.1%	-0.4%	-0.4%	-0.4%

Figures 3.4 and 3.5 show the AEMO 2014 10% and 50% POE demand projections and the actual summer and winter maximum demands.

FIGURE 3.4 – NSW REGION 2013 SUMMER DEMAND PROJECTIONS AND ACTUAL DEMANDS

FIGURE 3.5 – NSW REGION 2013 WINTER DEMAND PROJECTIONS AND ACTUAL DEMANDS



Rooftop PV can reduce the energy consumed through the electricity network by allowing residences to generate their own electricity during the day

3.4 AEMO ROOFTOP PV AND ENERGY EFFICIENCY PROJECTIONS

In recent years increased uptake of rooftop PV installations across NSW and penetration of energy efficiency measures have significantly contributed to the decline in the energy consumed from the network and the moderation in growth rates of summer and winter maximum demands.

Rooftop 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.

Table 3.5 presents AEMO's projections of rooftop PV uptake and energy efficiency measures. These projections (other than for rooftop PV contribution to maximum demand[3]) are subtracted from the energy and maximum demand forecasts that AEMO obtains from its econometric models. These adjusted forecasts are presented in Tables 3.2, 3.3 and 3.4 above.

TABLE 3.5 – AEMO ROOFTOP PV AND ENERGY EFFICIENCY PROJECTIONS (GWh) (Medium Scenario)

	AEMO Rooftop PV Uptake (GWh)	AEMO Energy Efficiency Uptake (GWh)	AEMO Rooftop PV Contribution to Summer Peak 10% POE (MW)	AEMO Energy Efficiency Contribution to Summer Peak 10% POE (MW)
2005/06	1	-	0	-
2006/07	1	-	0	-
2007/08	3	-	1	-
2008/09	10	-	3	-
2009/10	41	-	8	-
2010/11	266	-	59	-
2011/12	517	-	90	-
2012/13	701	-	179	-
2013/14 Est.	877	226	132	-
2014/15	1,043	1,149	255	187
2015/16	1,219	1,428	298	232
2016/17	1,400	1,780	344	290
2017/18	1,583	2,293	389	375
2018/19	1,767	2,837	434	465
2019/20	1,950	3,390	480	558
2020/21	2,134	3,767	525	620
2021/22	2,320	4,100	571	676
2022/23	2,506	4,511	618	744
2023/24	2,693	4,856	664	802
Annual Average Growth Rate 2014/15 – 2023/24	11.1%	17.4%	11.2%	17.5%

3. The impact of rooftop PV on maximum demand was incorporated directly into AEMO's maximum demand model. The model gives both the demand net of rooftop PV as well as separately identifies the contribution from rooftop PV. Post modelling adjustments are still made to account for the impact energy efficiency on energy and maximum demand forecasts and rooftop PV on energy forecasts only.

3.5 COMPARISON WITH DNSP AND CUSTOMER PROJECTIONS

Projections of summer and winter demand at individual bulk supply points where TransGrid's network connects the relevant customers have been provided by either the responsible DNSP or the direct end-use customer. These projections are given in Appendix 3. These are not necessarily produced on the same basis as the overall NSW projections produced by AEMO. In particular certain bulk supply point projections:

- May not have been assumed on the basis of a reported economic scenario or exact POE condition;
- May have been based on a historical dataset with a timeframe different to that used by AEMO to produce NSW projections;
- Indicate the likely peak at that location, whenever it may occur, rather than the contribution to the overall NSW peak; and
- Generally assume that only scheduled embedded generation is operating at the time of peak.

Unlike the AEMO projections of overall NSW peak demand none of the bulk supply point loads include transmission losses or power used by generator auxiliaries (by definition). Despite this, the individual bulk supply point projections for each season can be aggregated to provide a useful point of comparison with the overall NSW seasonal demand projections. TransGrid therefore attempts to account for some of the aforementioned limitations by:

- Using 50% POE forecasts where they are available and where they are not, assuming that individual bulk supply point projections are likely to have been based on enough historical data to converge towards an approximate 50% POE projection;
- 'Diversifying' individual bulk supply point projections to allow for time diversity observed between historical local seasonal peak demand and NSW peak demand;
- Adding forecast aggregate industrial loads not included in the DNSP forecasts; and
- Incorporating loss factors, which are also derived from historical observations, into the aggregate bulk supply point projections.

Figures 3.6 and 3.7 show the comparison between the aggregated DNSP projections and AEMO's 10% POE and 50% POE medium maximum demand projections for summer and winter respectively.

As could be expected for forecasts developed on different bases, the aggregate DNSP forecasts and AEMO forecasts generally do not align perfectly.

The comparisons cannot determine which of the forecasts is "more accurate". Rather it allows high level comparisons to be made.

In this case, the apparent alignment of the aggregate DNSP 50% PoE summer forecast with the AEMO 10% PoE summer forecast is co-incidence.

FIGURE 3.6 – AEMO AND AGGREGATE DNSP PROJECTIONS OF NSW SUMMER PEAK DEMAND

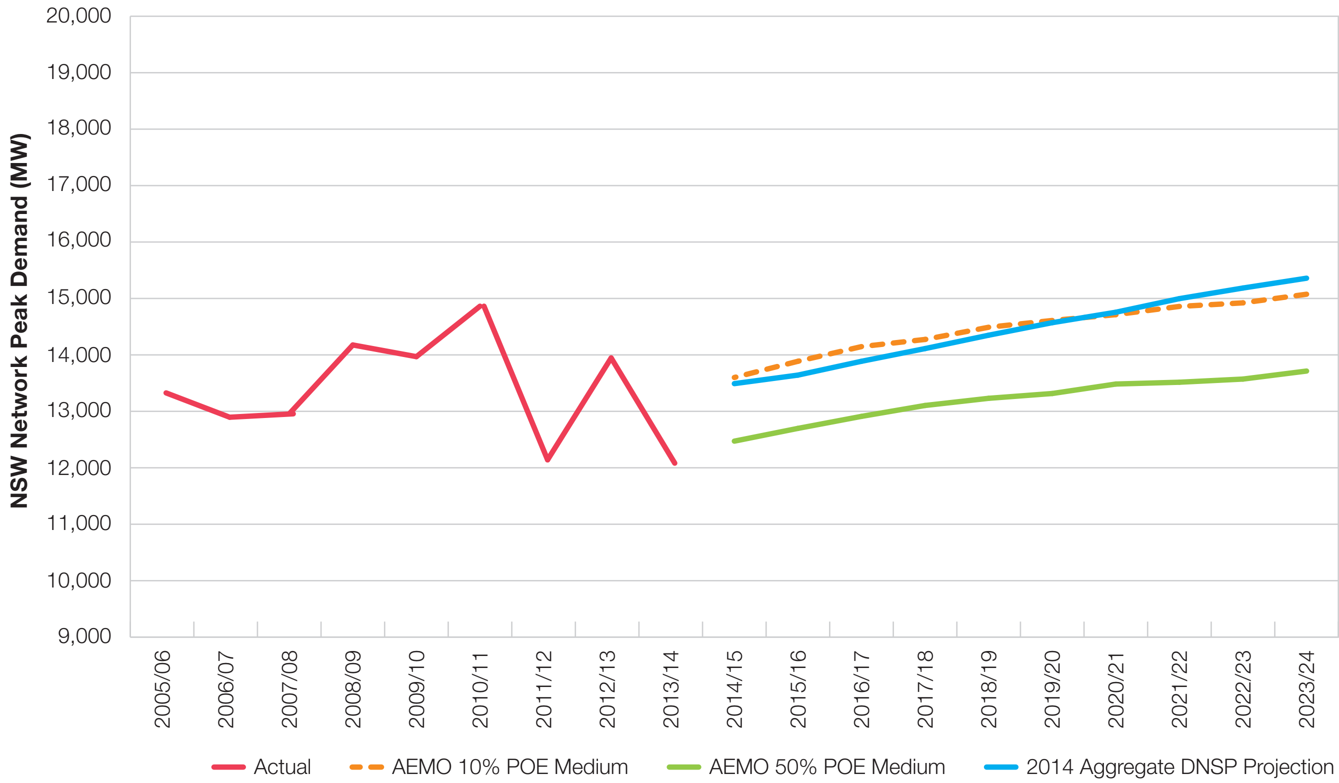
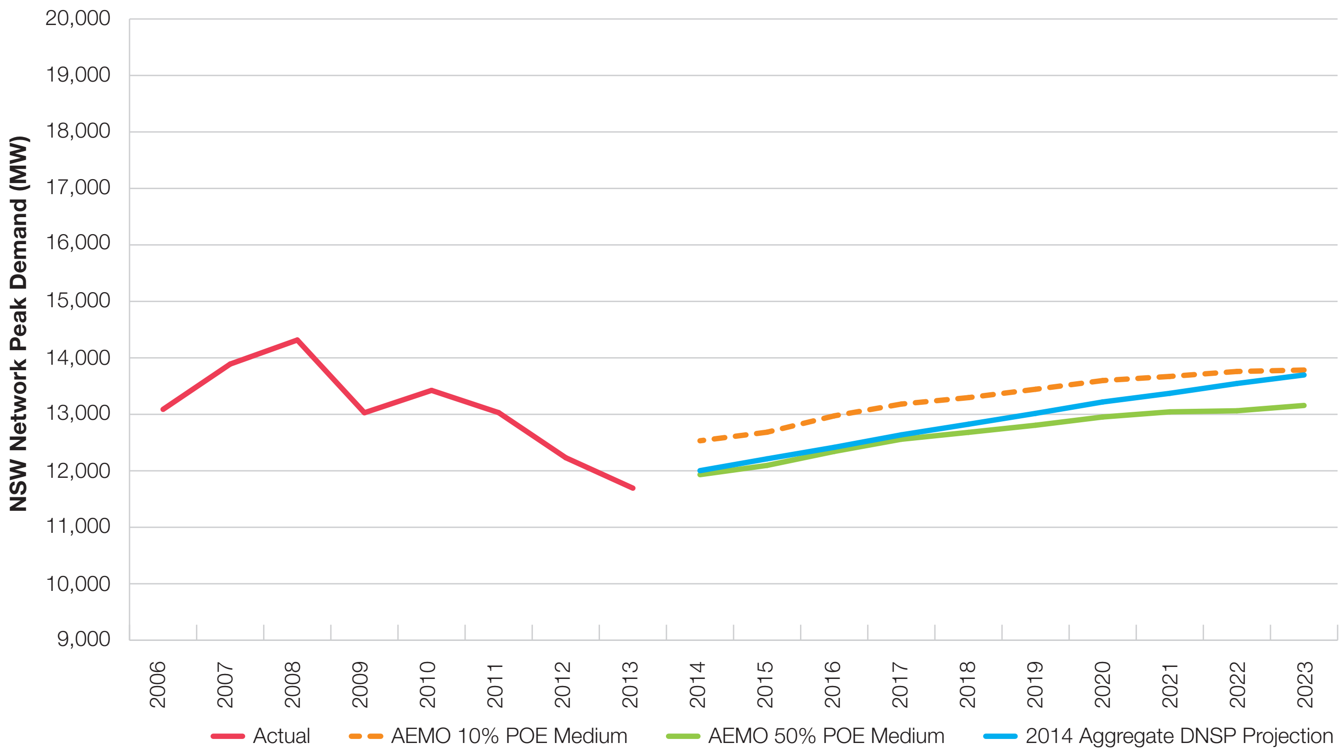


FIGURE 3.7 – AEMO AND AGGREGATE DNSP PROJECTIONS OF NSW WINTER PEAK DEMAND



Demand Management & Other Planning Issues

CHAPTER FOUR

Demand Management & Other Planning Issues

This chapter includes TransGrid's consideration of non-network options and other planning issues including the generation mix, industrial load connections and climate change policies.

TransGrid is committed to using non-network options to address network constraints where it is feasible and cost-effective to do so. Cost-effective non-network options can defer or avoid investment in the network and so deliver benefits to consumers through lower transmission costs.

Demand management is one type of non-network option. It broadly refers to any activity designed to change how consumers use electricity. Demand management includes:

- **Targeted demand management** used by TransGrid to defer or avoid a network investment. This includes, for example, load curtailment or dispatch of embedded generation; and
- **General activities to reduce demand** on the network, including energy efficiency, embedded local generation and use of storage.

As the demand management market is still developing in NSW, TransGrid is also investing in innovation to aid the development of demand management in NSW.

4.1 THE CASE FOR DEMAND MANAGEMENT

The current low demand growth in NSW means that there are relatively few opportunities for demand management on TransGrid's network. However, where constraints are emerging demand management options can be expected to be particularly cost-effective, as they are more incremental and granular than many traditional transmission network options.

Section 4.1.1 explains the various methods of providing demand management, and Sections 4.1.2 to 4.1.4 explain the drivers on TransGrid to use demand management as a non-network alternative to network investment, from an economics, policy and consumer perspective respectively.

4.1.1 The demand management toolbox

Demand management encompasses load curtailment or shifting, embedded generation, energy efficiency and energy conservation measures wherever these factors reduce the loading on the network. Procuring demand management refers to specific arrangements made with electricity users to change their electricity usage at particular times in response to incentives. General demand management activities are less specific in their location, timing or magnitude but still have the potential to reduce the need for investment in network assets, by reducing peak demand.

Demand management can be thought about in terms of the way it is delivered and the different drivers acting on consumers to provide it, as shown in Figure 4.1.

4.1.2 Efficient investment in the electricity supply chain

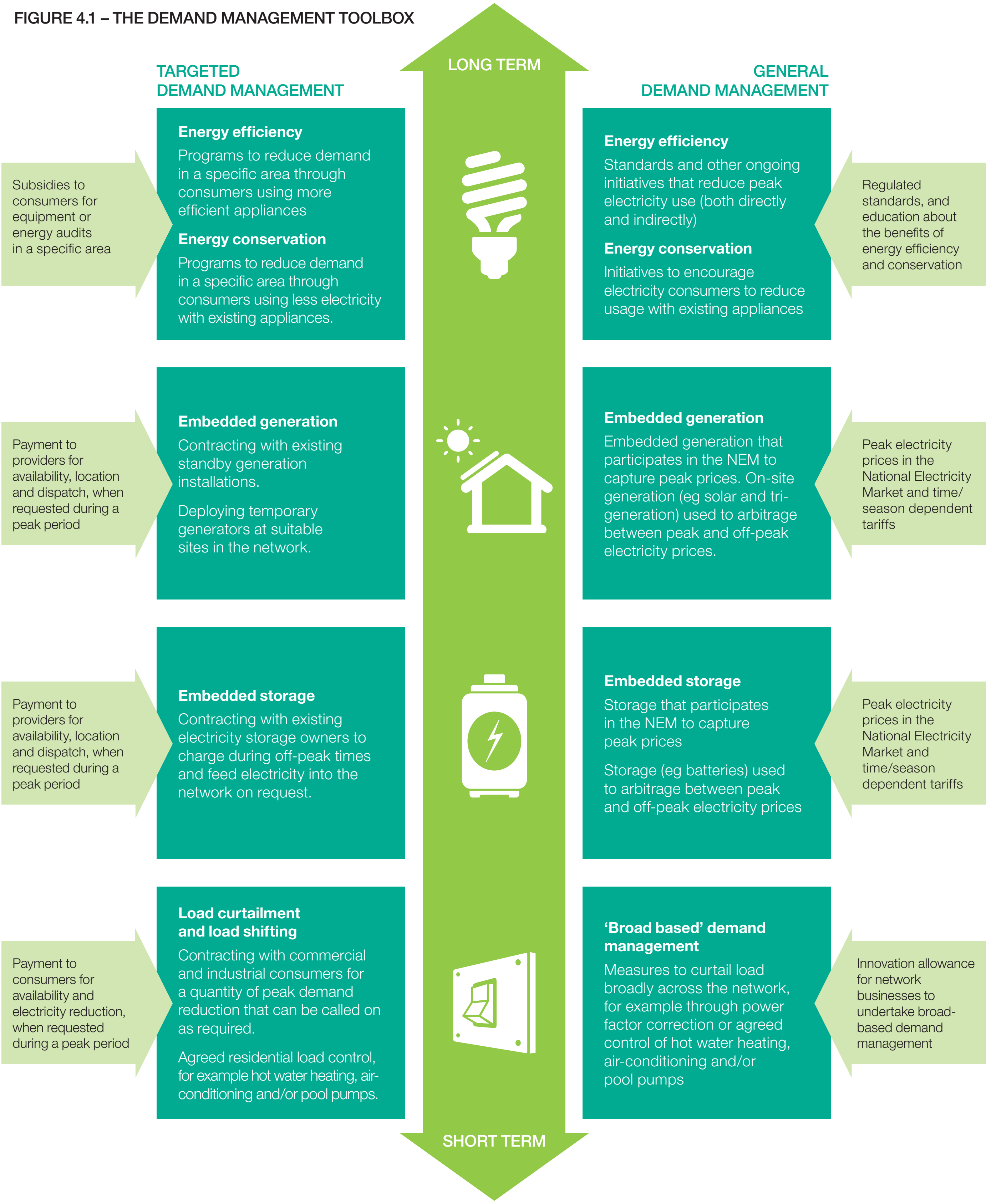
Cost-effective non-network options can allow TransGrid to defer or avoid significant capital costs associated with network investment. Where these avoided costs exceed the cost of demand management there are overall benefits to consumers in the form of lower transmission costs.

Moreover, the use of demand management can lead to benefits throughout the electricity supply chain. In 2013 the Productivity Commission[1] noted these potential benefits of demand management:

- *'avoid an inefficiently high rate of peak demand growth, delaying the need for network augmentation and reducing the size of peak-specific network investments*
- *improve the utilisation (and productivity) of supply side capacity by shifting the timing of electricity use and reducing the gap between average and peak consumption – achieving allocative efficiency*
- *decrease investment in costly peak-generation and reduce generation costs by reducing reliance on higher cost peaking supply (such as open cycle gas turbines)*
- *improve competition and reduce the ability of an individual generator to exercise market power in the wholesale market during congestion at peak periods (Borenstein 2005; Borenstein and Holland 2005; Bushnell 2005; Joskow and Wolfram 2012)*
- *improve supply reliability, including increasing load shedding options and assisting with the restoration of power after loss*
- *reduce volatility in demand (and wholesale prices) allow operational efficiencies for network businesses, including from advanced metering infrastructure, which enables remote access to consumption data, assists with more timely and less costly disconnection and reconnection, and improves network planning and detection of outages*
- *in the short term, provide scope for some consumers to receive reduced electricity bills and, in the longer term, could slow the rate of growth of future electricity bills for all consumers.'*

1. Pp. 353–354, Productivity Commission 2013, Electricity network regulatory frameworks, Report No 62, Canberra.

FIGURE 4.1 – THE DEMAND MANAGEMENT TOOLBOX



4.1.3 Regulatory and policy drivers

The NER specify that transmission network businesses like TransGrid must consider non-network options when undertaking the RIT-T. The RIT-T is a public consultation process and must be undertaken whenever any credible option to address an identified network augmentation need is estimated to cost more than $5 million.

TransGrid's statutory, social, environmental and commercial objectives under the *Energy Services Corporations Act 1995* combine to mean that TransGrid should undertake to minimise the impact of its network where it can otherwise meet its transmission service obligations. Demand management as a non-network option serves to minimise the impact of TransGrid's network through deferring or avoiding network investment.

4.1.4 Consumer Support

In late 2013, TransGrid consulted with consumers and received strong acceptance for investment to find ways to reduce electricity demand and subsequently benefit consumers through reduced network charges. The conclusion regarding sentiment toward non-network alternatives reported by the market research company engaged to facilitate consultations stated:

'Overall participants felt that potential benefits to both the future of the electricity system and, for some, the environment as well, could be well worth an investment that most regarded as trivial.'
(Newgate Research, 2013).

4.2 PROCURING DEMAND MANAGEMENT

TransGrid is committed to demand management where it is a cost-effective alternative to address a network need.

TransGrid is agnostic about the technology used for demand management procured as network support[2] to address a network need, provided that support is cost effective and reliable.

To procure demand management as network support, TransGrid issues an RfP. When issuing an RfP for a particular need, TransGrid considers:

- Size, location and feasibility of expected demand management required;
- Outcomes of consultation with distribution network businesses (through the joint planning process) and directly connected customers about demand management potential;
- The amount of capital investment able to be deferred and its commercial value to TransGrid;
- Length of deferral that is possible and feasible;
- The amount of work required by both TransGrid and demand management providers in issuing and responding to the RfP, balanced against the anticipated feasibility and likelihood of success for a non-network option; and
- The time horizon – that is, the period of time for TransGrid to make the decision to commit to a solution.

When considering the feasibility of demand management as a non-network alternative, the following factors are taken into account:

- Economic efficiency as assessed under the RIT-T;
- Technical performance of the non-network alternative to ensure applicable network reliability standards will be met;
- Risks associated with non-network alternatives vis-à-vis network alternatives, and some quantification of those risks in terms of impact on TransGrid's financial performance and regulatory obligations; and
- Commercial assessment including financial analysis.

4.3 DEMAND MANAGEMENT OPPORTUNITIES

TransGrid's previous demand management procurements and requests for proposals are listed in Section 4.3.1. Section 4.3.2 outlines potential future demand management procurement opportunities.

4.3.1 Past activities

TransGrid has procured demand management as network support twice in the past:

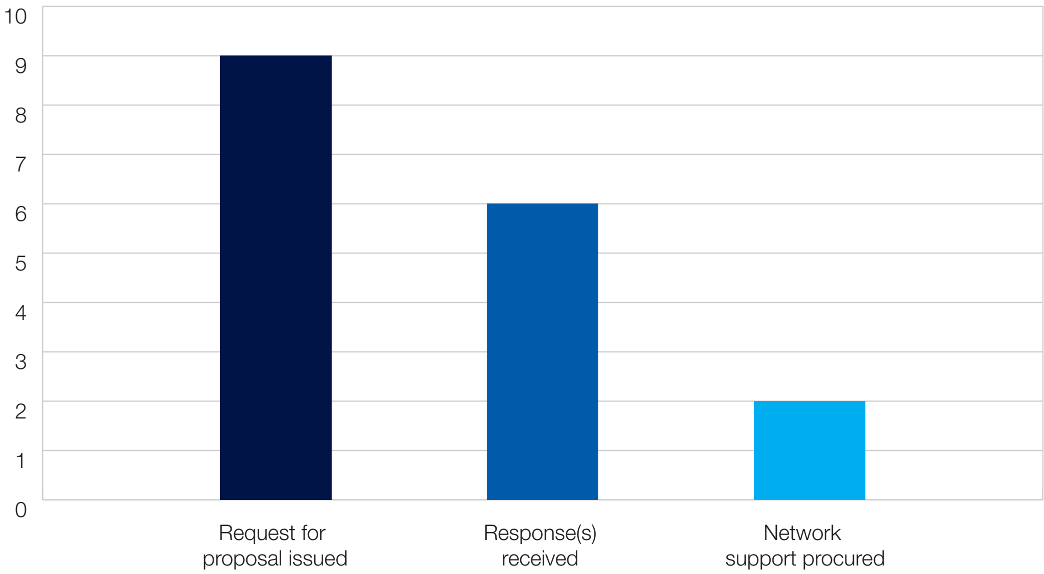
- TransGrid identified a need and secured approximately 350 MW of network support for the summer of 2008/09 in the Newcastle–Sydney–Wollongong area.
- TransGrid and Ausgrid joint planning identified a need for network support for the Sydney inner metropolitan area. TransGrid secured network support to cover 40 MW for operational risk mitigation over the summer of 2012/13.

Since 2000, TransGrid has issued a number of RfPs for network support to avoid or defer network investment, with the following results[3]:

- Sydney inner metropolitan area in 2009 – successful network support agreements with demand response aggregator EnerNOC and distribution business Ausgrid, totalling 40 MW for summer 2012/13 (RfP 105/09);
- Newcastle-Sydney-Wollongong area in 2006 – successful network support agreements with three service providers totalling 350 MW for summer 2008/09 (RFP 104/06);
- Western Area of NSW in 2000 – no responses;
- NSW Central Coast in the early 2000s – no responses;
- South West of NSW in mid 2000 – no responses;
- Mid-North Coast of NSW in 2009 – offers made for 4 MW, but project subsequently deferred (RFP 130/10);
- Far North Coast in 2010 – one response that did not ultimately meet requirements for network support (RFP 51/10);
- South Coast (Nowra) in 2011 – two responses for small capacity, later withdrawn (RFP 62/11); and
- Northwest NSW in 2011 – one proposal, but project later suspended (RFP 63/11).

2. National Electricity Rules version 60 defines a network support agreement as 'An agreement under which a person agrees to provide one or more network support and control ancillary services [NSCAS] to a Network Service Provider, including network support services to improve network capability by providing a non-network alternative to a network augmentation'. A network support and control ancillary service is 'A service with the capability to control the active power or reactive power flow into or out of a transmission network to address an NSCAS need'.
3. In some cases responses were incomplete or offered services other than those sought. This summary considers only those responses which were capable of being analysed.

FIGURE 4.2 – RESPONSES TO TRANSGRID REQUESTS FOR DEMAND RESPONSE PROPOSALS



- The chart covers the period from 2000 to 2014
- Three projects where a request for proposals was issued were subsequently deferred or cancelled without procuring network support

TransGrid's experience seeking network support demonstrates the limited ability of the current demand response market to deliver network support options (refer to Figure 4.2). These results emphasise that for procurement of demand management to be effective as network support, it must be:

- In the right place – the response needs to occur in the area of network constraint, and if support is to be provided at a sub-optimal location its magnitude must be greater;
- At the right time – to be effective the response must occur at the time the network is approaching its capacity limit; and
- Of a sufficiently large magnitude (megawatts).

In 2013 TransGrid commissioned an independent investigation into its own public consultation process, using four recent projects as case studies[4]. In summary, the experience with going to market for network support indicates that:

- There is significant room for development of the demand management market;
- Potential network support proponents need early, clear signals about opportunities; and
- TransGrid must engage effectively with the community and relevant stakeholders early in the planning process.

4.3.2 Future activities

TransGrid is currently assessing whether to issue RfPs for non-network alternatives to address three potential network limitations.

Powering Sydney's Future is a project to address a forecast network limitation in the Sydney inner metropolitan area. TransGrid is considering procuring demand management for the four years between 2019 and 2022 as a non-network alternative to address the constraint. Under one scenario this could be 170 to 220 MW of demand management. In order to be able to procure sufficient demand management, TransGrid intends to proactively develop the demand management capability in the area by procuring 'market-building' pre-emptive demand management from summer 2014/2015. See Section 7.2.2.1 for further detail.

The capacity of the network supplying the **Gunnedah-Narrabri** area in northern NSW is expected to be limited due to the connection of new mining loads in the Boggabri area, and underlying electricity demand. TransGrid is currently assessing whether demand management as an alternative to network investment is a feasible option to pursue. See Section 7.2.1.1 for further detail.

TransGrid and the Queensland transmission business, Powerlink, are presently completing the RIT-T process for development of the Queensland-NSW interconnector (QNI). A fast-response demand management option could present a cost-effective option for delivering market benefits. See Section 7.1.1 for further detail.

Although these constraints are currently under consideration, TransGrid does not presently have any RfPs issued for network support.

4.4 INNOVATION IN DEMAND MANAGEMENT

The demand management market in NSW is still developing. TransGrid is committed to innovating in demand management so as to grow the pool of potential source in NSW, and therefore grow the opportunity for demand management to be used as a non-network alternative to address TransGrid's network constraints.

TransGrid's past activities and findings from investing in innovation for demand management are summarised in Section 4.4.1. TransGrid's future focus for innovation in demand management is described in Section 4.4.2.

4. RPS, 'TransGrid review of public consultation final report', December 2013.

4.4.1 Past activities

During its 2009 to 2014 regulatory control period, TransGrid used its demand management Innovation Allowance to undertake projects in three broad areas:

Engagement and research through joint load reduction trials and research projects in partnership with distribution network businesses and universities. These projects contributed to an in-depth understanding of industrial, commercial and residential consumers, and their potential provision of demand management.

Demand management technology trialling including the iDemand project due for completion in late 2014. iDemand is intended to provide a platform for engaging with consumers about the importance of peak demand reduction as well as facilitating research opportunities and market development for demand management in Australia. iDemand will be installed at TransGrid's western Sydney regional centre at Wallgrove, comprising 99 kW of solar panel capacity, 400 kWh of lithium polymer battery capacity and energy efficient lighting retrofits. An online portal will also be established to allow real-time monitoring and historical data download.

Understanding demand management potential in NSW through development of a 'triage database' for assessing feasibility of non-network options during the early planning stage. The database is now completed, and is populated with data from TransGrid's previous demand management procurements and some publicly-available information. However, acquiring state-wide data has proven more difficult than previously anticipated due to accuracy, integrity, privacy and security of information constraints.

In summary, these activities indicated that:

- Consumers' lack of understanding of the electricity industry generally and peak demand specifically is a barrier to implementation of demand management projects, although willingness to participate increased after consumers learnt about the impact that reducing peak demand has on network charges and other energy users;
- Commercial businesses may not be fully exploiting energy efficiency opportunities because of lack of understanding of technical opportunities and mismatch in incentives acting on owners and tenants
- Early and clear information about network support opportunities could contribute to greater uptake of network support; and
- Industry collaboration and understanding of the demand management ecosystem is needed, to allow synergies to emerge and to prevent duplication of efforts.

4.4.2 Future activities

Building on its experience, TransGrid's future innovation activities focus on the following areas:

- facilitating the growth of the demand management market, in part through open and transparent planning in collaboration with external stakeholders;
- gaining a deeper understanding of the demand management marketplace;
- better understanding the peak demand profile in NSW, for example the link between energy efficiency and peak demand;
- investigating large-scale solutions to facilitate demand management, including the role of storage;
- TransGrid's transmission-specific role in demand management procurement and innovation, given the high voltage meshed nature of the transmission network and role in the overall electricity supply chain;
- improved understanding of the larger-consumption customers (commercial, industrial and agricultural) and their potential provision of demand management; and
- boosting engagement about demand management with the community and other stakeholders.

Leading on from these findings, TransGrid plans to target its demand management innovation activities from 2014 to 2019 in three key areas:

Collaboration. TransGrid proposes projects to improve consumer understanding of demand management, to capture synergies across different industry participants' demand management activities, and to reduce regulatory barriers to demand management uptake. TransGrid's role in the supply chain means that TransGrid has close relationships with the market operator, generators, distributors and large electricity consumers as well as a unique, holistic view of the NSW electricity network itself. As such, TransGrid is well placed to encourage collaboration on an industry approach to demand management.

Market understanding and development. The demand management market is still maturing. To improve understanding of the market, TransGrid proposes projects such as analysis of key drivers of peak demand, and surveys of businesses' energy behaviours and demand response capacity. To help develop the market, TransGrid proposes enabling the development of a spatiotemporal integration of demand response and network constraints. This project would bring together potential demand management providers and anticipated network constraints over the planning horizon in a map-style format. TransGrid considers that this service would go some way to addressing the informational barriers to uptake of demand management in NSW as well as working toward a more automated and coordinated dispatch of demand response in NSW.

Technology trialling. Overcoming practical barriers to application of demand management tools and technologies is the final key focus of TransGrid's demand management innovation activities. Projects could range from capturing the untapped energy efficiency potential in large businesses' space heating and cooling systems to trialling large-scale storage solutions. In particular, TransGrid proposes focusing on larger consumers and grid-scale solutions to capture the latent demand response capability in both areas and to best leverage TransGrid's role in the electricity supply chain as well as the operational requirements for the transmission network.

TransGrid's innovation projects will be subject to a rigorous decision making process intended to assess the value proposition for consumers before a particular project is undertaken.

4.5 OTHER PLANNING ISSUES

4.5.1 The Generation Mix

The supply side of the electricity market in Australia is changing. The nature, location and quantum of future electricity generation is uncertain. TransGrid's network will need to accommodate this uncertainty with flexible planning and operations.

An important part of TransGrid's planning and development function is to provide connections for proposed new generators. In recent years the vast majority of applications to connect generation to TransGrid's network have been from proponents of renewable energy sources including from proponents of large scale photovoltaic (PV) installations as well as wind generation.

Since 2008, TransGrid has successfully been involved in connecting the following new generation:

- Uranquinty gas fired power station, 664 MW;
- Colongra gas fired power station, 667 MW;
- Capital wind farm, 141 MW;
- Woodlawn wind farm, 48 MW; and
- Gullen Range wind farm, 182 MW.

In addition to these new connections, TransGrid has also worked with the NSW distributors to coordinate and assist with the connection of new generating systems of various technologies and scale embedded within the distribution networks. This includes the Tallawarra gas fired power station embedded within Endeavour Energy's 132 kV network, the Cullerin Range wind farm, the Gunning wind farm, the Jounama hydro power station, the Boco Rock wind farm, the Taralga wind farm (under construction) and the Nyngan Solar farm (under construction) all embedded within Essential Energy's network.

During the 2014/15 financial year, an increased level of connection activity is not expected to emerge as energy demand and government sponsored renewable energy support plateaus or reduces.

An area of particular interest has been the funding from the Federal Government's Solar Flagships Program. Projects within NSW under the umbrella of this program are being developed, with some in construction, that will further impact the transmission and distribution networks.

TransGrid is neither a proponent nor a builder of generating plant but is committed to assisting the connection of new generation to its network. The increasing level of interest in grid connections, particularly for gas, wind and solar generation creates challenges in meeting the expectations of intending generators. The timely resolution of connection arrangements is an important component of the overall generation development process.

A key challenge for TransGrid in meeting these expectations is to reconcile the impact of intending generators' technical performance with TransGrid's performance obligations to existing generators and customers.

Under the NER, transmission services associated with connecting new generators to TransGrid's existing network are normally classified as 'Negotiated Transmission Services' and are subject to TransGrid's negotiating framework, which has been approved by the AER. However, where the electricity services required to connect a generator can be provided on a contestable basis (i.e. they are dedicated to the generator and can be readily sourced from providers other than TransGrid) then they are not subject to regulation under the NER. These arrangements are normally classified as 'Non-Regulated Transmission Services' and allow TransGrid and generation proponents scope to negotiate connection arrangements bilaterally and thus provide a degree of flexibility in those arrangements.

4.5.2 Industrial Loads

In parallel with the activity of new generation in NSW, during the year there was an increase in demand for network services to supply energy to new large scale mining and coal seam gas (CSG) operations across the state.

TransGrid is continually engaging directly with the major mining proponents in NSW which require large amounts of energy and who are geographically close to the TransGrid network. Primarily this engagement arises where the load requirements of the new operation exceeds the capacity available from the local distribution network.

In parallel with this direct connection, a group of smaller scale mining and CSG operations are evolving and seeking connection to the distributor's network, ultimately feeding from TransGrid's bulk supply points. This increase in distributor's load is also monitored and managed in order to develop the TransGrid network accordingly.

Recently this increased mining activity has led to two new developments in the Gunnedah basin, which will be directly connected to the TransGrid network.

Mining activities predominantly emerge in rural parts of the state where the existing electricity transmission infrastructure was originally designed and built to supply a typical rural load i.e. farmhouses and small townships. The introduction of large industrial or mining facilities in a region is likely to require network augmentation and extension to both connect and support the load increase. In the short term the introduction of these loads may require special protection schemes or control systems to be installed to quickly enable supply to be provided, and manage the load and its impacts on the network and other connected customers.

In the long term, a large industrial load may require network augmentation. Unless funded by the proponent, any such network augmentation must also complete the appropriate regulatory consultation process required under the NER.

4.5.3 The Impact of Climate Change Policies on NSW Transmission

The Renewable Energy Target (RET) scheme and the Federal Government's emissions control schemes (*Clean Energy Act 2011*) are factors which could promote increased wind and other renewable generation development activity in NSW.

Recent changes to governments and their policies has introduced an additional level of uncertainty into TransGrid's network planning activities and has moved TransGrid to shorten the response and delivery times on new connections.

NSW has a large amount of wind generation resource near existing transmission lines. Generation development connections adjacent to existing lines may not require the construction of new major transmission links and may be developed relatively quickly.

It is expected that the Government's existing and future climate change policies will enhance the prospects of one or several large scale renewable generation projects emerging in NSW. As each project emerges and develops, its impact on the network may be included in TransGrid's regulated planning processes when considering future transmission network augmentations for NSW.

It is also important to recognise the current volatility of the political environment within the energy sector where the level of incentive for the development of renewable energy may move as economic and political circumstances change. This volatility may change the timing of renewable generation development and associated connections.

National Transmission Network Developments

five

CHAPTER FIVE

National Transmission Network Developments

5.1 2013 NATIONAL TRANSMISSION NETWORK DEVELOPMENT PLAN

AEMO published the latest National Transmission Network Development Plan (NTNDP) in 2013.

The 2013 NTNDP modelling used the latest set of electricity consumption and generation cost assumptions published by AEMO for a planning scenario. It modelled current renewable energy policy and two carbon price trajectories:

- A carbon price scenario that reflects the current legislation and a lower expectation of carbon prices from linking to international emission trading schemes. This scenario is a revision of the Australian Treasury core projection used in the 2012 NTNDP; and
- A zero carbon price scenario where the explicit price on carbon emissions is removed from 2014 onwards. This scenario models generation dispatch without an explicit carbon emissions price, recognising the Federal Government's intention to repeal current legislation.

This planning scenario is one scenario out of a total of five scenarios that were developed by AEMO in 2013. The other four scenarios address alternative possible futures and reflect different levels of economic growth, population growth, global carbon policy, fuel prices and a range of demand-side response.

AEMO carried out modelling of the economic planting of generation and interconnector development and assessed the thermal loading on network elements to develop a view of the likely requirement for major transmission developments in the NEM.

In developing the NTNDP, AEMO took into account TransGrid's long-term network development plans and the NSW TAPR 2013. TransGrid provided advice on the need for network augmentation and likely network development options to overcome any shortfalls in transmission system capability. There is thus a strong linkage between the TransGrid plans for the main system development in NSW and the outcomes of the NTNDP.

Due to a significant reduction in the national energy and demand growth since 2010, and lower growth in the future economic outlook, the 2013 NTNDP identified less need for additional capacity on single interconnectors and intra-regional network augmentations.

The 2013 NTNDP also addressed the potential impact on the network of large scale investments in renewable generation development. The Integrating Renewable Energy – Wind Integration Studies Report in September 2013, outline power system security issues and recommending short-term actions to support the integration of forecast wind generation.

5.2 FUTURE GENERATION DEVELOPMENT

Renewable wind generation development in NSW will dominate the extent and location of any network development over the next 10 years. Significant gas-fired and coal-fired generation developments are no longer expected in NSW which reduces the need for augmentation of capacity for 330 kV transmission lines in NSW.

The key generation findings of the 2013 NTNDP are:

- Renewable generation (mostly wind generation) driven by Large-Scale Renewable Energy Target (LRET) will dominate the generation mix out to 2020; and
- Baseload gas-powered generation output is reduced under both carbon price scenarios, driven by gas price assumptions that reach $12/GJ by 2025.

5.2.1 NTNDP Outcomes

The generation planting for the scenarios analysed in the 2013 NTNDP was based on the NTNDP generator cost data assumptions out to 2037. Table 5.1 shows the new generation and retirements for the Planning Scenario with core carbon price and zero carbon price policies.

Generally there has been a slowdown in new generation projects proceeding to a significant stage of development

TABLE 5.1 – NTNDP MAJOR GENERATION EXPANSION

NTNDP Scenario	Carbon Price Trajectory	Northern NSW (MW)	Central NSW (MW)	Southern NSW (MW)
Planning Scenario	Core	Biomass: 100 Wind: 522	Biomass: 100 OCGT: 1028 Solar: 105 Wind: 313 Retirements: 2144	Biomass: 100 OCGT: 0 Wind: 1446 Solar: 50
	Zero	Wind: 626	Biomass: 100 OCGT: 2007 Solar: 105 Wind: 626 Retirements: 2820	Biomass: 42 Wind: 2444 Solar: 50

5.2.2 NSW Generation Connection Enquiries

With respect to new generation in NSW, in general, there is a significant contrast between the generation planting patterns in the NTNDP and the level of generation investment interest in various areas of NSW. The following table provides an indication of the interest in various generating sources in NSW, based on connection enquiries to TransGrid recently received under the NER process.

TABLE 5.2 – INDICATIVE NSW GENERATION INVESTMENT INTEREST FOR NEW GENERATION

Region	Generation Capacity		
	Solar MW	Wind MW	Other
Far West	50	400	
Mid West (i.e. around Canberra area)	40	1400	150
Far North	90	600	
Mid North		1100	
South			600

Even though there has been a good number of initial connection enquiries in NSW for new generation, generally there has been a slowdown in new generation projects proceeding to a significant stage of development. In particular a greater interest in wind generation has been experienced compared to other technologies.

5.3 TRANSMISSION AUGMENTATION PROJECTS IN THE NTNDP

The AEMO 2013 NTNDP identified three transmission limitations arising from the load and generation modelling associated with the two NTNDP scenarios across NSW region within 5 years.

- A new supply to the Beaconsfield West Substation from another 330 kV supply point (L–N1);
- Reinforce the transmission network connecting Hunter Valley to the Newcastle area (L–N2); and
- Reinforce the supply to far north coast (L–N3).

The limitations of supplying the Sydney Metropolitan area (L–N1) are being addressed by TransGrid. Details can be found in Section 7.2.2.1.

TransGrid believes that the generation scenario which leads to the reinforcement of capacity between the Hunter Valley and Newcastle (L–N2) is unlikely.

Due to lower load forecasts, the identified overload of the 132 kV transmission network supplying the north coast load area is not expected to occur within 10 years. See Section 7.4.1.1 for details.

The 2013 NTNDP also considers other limitations identified in the TAPR 2013 against the NTNDP scenarios. A comparison of the 2013 NTNDP projects relevant to New South Wales and TAPR 2014 is shown in Table 5.3.

TABLE 5.3 – NTNDP COMPARISON

Category	Ref	Project	TAPR 2014
Committed Main Transmission Projects	C–N1	Armidale SVC power oscillation damper	Completed in Section 6.1.1.3
	C–N2	Western Sydney Supply Project (Holroyd and Rookwood Road)	Partially completed in Section 6.2.1.2
	C–N3	Second supply to ACT (Wallaroo)	Planned in Section 6.3.2.1
	C–N4	Beaconsfield West to Haymarket 330 kV cable (initially operated at 132 kV)	Completed in Section 6.1.2.2
	C–N5	New Reactors: 3 x 150 MVAr at Yass substation and 3 x 150 MVAr at Murray substation	Completed in Section 6.1.3.1
Transmission Limitations	L–N1	A new supply to the Beaconsfield West Substation from another 330 kV supply point	Discussed in Section 7.2.2.1
	L–N2	Reinforce the transmission network connecting Hunter Valley to the Newcastle area	The need is not expected to arise within 10 years
	L–N3	Reinforce the supply to far north coast	The need is not expected to arise within 10 years
Potential Economic Dispatch Limitations	M–N1	Reinforce of capacity between Yass/Canberra and Sydney areas	Discussed in Sections 7.2.3.1 and 7.3.3.1

TransGrid is investigating transmission augmentations which may lead to increased competition in the NEM

The 2012 NTNDP NSCAS assessment identified a potential NSCAS gap in relieving the New South Wales to Victoria voltage stability limitation. The status of this potential NSCAS gap is updated in the 2013 NTNDP.

This voltage stability limitation constrains electricity transfer from New South Wales to Victoria. AEMO has been managing this limitation by provision of reactive power support procured through a contract between AEMO and a generator. This contract is primarily for maintaining system security, but also used for achieving net market benefit. In 2013-2014 AEMO procured reactive power support using this contract during winter and summer high demand days. AEMO and TransGrid will continue to jointly investigate further economical options for filling the NSCAS gap. TransGrid's planned installation of capacitor banks at Yass and Canberra may reduce the gap as discussed in Section 6.2.6.

In addition to the national transmission network developments in the 2013 NTNDP, TransGrid together with Powerlink, is investigating reinforcements of QNI. See Section 7.1.1 for details.

In terms of transmission constraints that may lead to market benefits, TransGrid is presently investigating augmenting Snowy – Sydney transmission system capacities (see Sections 7.2.3.1 and 7.3.3.1) which may lead to increased competition in the NEM and hence may provide net benefits to market participants.

TransGrid is also investigating the benefits of a number of strategic property acquisitions to accommodate future end of life asset replacements and/or network developments.

Completed, Committed and Planned Developments

CHAPTER SIX

Completed, Committed and Planned Developments

This chapter of the TAPR contains details of completed, committed[1] and planned developments that have completed the regulatory process.

Completed developments include those that have been completed since publication of the TAPR 2013.

Committed developments include those that have reached financial and contractual commitment, are under development and have passed Decision Gate 3 (DG3) of TransGrid's network investment process described in Section 2.6. These developments are the subject of proposals that were documented in previous TAPRs or regulatory consultations.

Planned developments have completed the regulatory process but have not progressed to the point where they can be considered committed.

As indicated in Section 2.11 it is not always possible to predict the precise nature and depth of the information required by particular interested parties. Should additional information be required, interested parties are encouraged to contact TransGrid so that information tailored to their particular needs can be provided. Contact details are provided on the inside of the rear cover.

6.1 RECENTLY COMPLETED DEVELOPMENTS

This Section describes developments that have been completed since publication of the TAPR 2013.

6.1.1 Northern System

6.1.1.1 Supply to the Lower Mid North Coast

TransGrid and Essential Energy have increased the capacity of the transmission system supplying the Lower Mid North Coast to meet present limitations by:

- Construction of short sections of single circuit and double circuit 330 kV transmission line, to initially operate at 132 kV, between TransGrid's Tomago 330 kV Substation and the Tarro area;
- Construction of a new double circuit 132 kV transmission line between Tarro and Essential Energy's Stroud Substation; and
- Connections to establish a new Tomago – Stroud 132 kV circuit and a Tomago – Brandy Hill 132 kV circuit.

These works were completed in January 2014.

6.1.1.2 Supply to the Kew and Laurieton Areas

Essential Energy's Herons Creek 132/66 kV Substation has been tee connected to TransGrid's 964 Taree – Port Macquarie 132 kV transmission line. It now provides the normal supply to the Kew/Laurieton area with a backup from Taree.

The work was completed in November 2013.

The previous backup supply from Kempsey, including the 66/33 kV transformers at Kempsey, has now been retired.

6.1.1.3 Armidale SVC: Power Oscillation Damping Control

In 2013, a power oscillation damping control was installed on the Armidale Static VAr Compensator (SVC) to improve the damping of system oscillations.

6.1.2 Central System

6.1.2.1 Wallerawang 132/66 kV Substation Replacement

The old Wallerawang 132/66 kV Substation is in the process of being decommissioned at the end of its serviceable life.

Construction of the new Wallerawang 132/66 kV Substation was completed in May 2013, and was reported as such in TAPR 2013.

Reconnection of the 132 kV and 66 kV transmission lines from the old substation to the new substation was completed in March 2014. Removal of the old substation is presently underway.

6.1.2.2 Reinforcement of Supply within the Sydney Inner Metropolitan Area

To relieve limitations within the Sydney inner metropolitan area, TransGrid and Ausgrid have established an additional cable link between Beaconsfield West and Haymarket 330/132 kV Substations. To meet potential longer-term requirements this link is comprised primarily of a 330 kV cable, initially operating at 132 kV, with some sections of 132 kV cable. These works were completed in July 2013.

1. Information on completed and committed projects is provided for completeness. The limitations which these projects address are no longer expected to arise. As such, there is no NER obligation to report on them.

TABLE 6.1 – COMPLETED LINE SWITCHBAYS FOR DISTRIBUTOR REQUIREMENTS

Location	Installation	Completion	Comments
Wellington 330/132 kV Substation	One 132 kV switchbay	June 2014	Essential Energy request for supply to the Dubbo area

TABLE 6.2 – COMPLETED TRANSFORMER REPLACEMENTS AND CAPACITY UPGRADES

Location	Installation	Completion	Comments
Northern System			
Armidale 330/132 kV Substation	No 1 Reactor replacement	April 2014	Condition based replacement
Narrabri 132/66 kV Substation (Northern Subsystem)	Replacement of three 30 MVA 132/66 kV transformers by two 60 MVA units released from Coffs Harbour	July 2013	Condition based replacement
Central System			
Wallerawang 330/132 kV Substation	Replacement of Nos 1 and 2 330/132 kV transformers with 375 MVA units	May 2014	Condition based replacement as part of the substation replacement
Sydney East 330/132 kV Substation	Installation of a 375 MVA 330/132 kV transformer to replace an existing transformer which was reaching the end of its serviceable life	Jan 2014	Condition based replacement
Southern System			
Yass 132/66 kV Substation	Replacement of No 3 132/66 kV transformer which was reaching the end of its serviceable life	Dec 2013	Condition based replacement

6.1.3 Southern System

6.1.3.1 Voltage Control in the Snowy Area

The NTNDP 2012 identified a gap in the Network Support and Control of Ancillary Services (NSCAS) capability in NSW. TransGrid was successful in its tender to AEMO for the provision of these services in NSW.

To meet the shortfall in voltage control ancillary services identified, TransGrid has installed

- 3 x 181 MVAr 362 kV shunt reactors at Murray Switching Station; and
- 3 x 181 MVAr 362 kV shunt reactors at Yass 330/132 kV Substation.

The installations were completed in May 2014. More information on NSCAS is included in Section 2.10.

6.1.3.2 Kangaroo Valley Voltage Levels

Kangaroo Valley 330 kV Switching Station effectively connects the 240 MW of Kangaroo Valley and Bendeela generators to the system. The voltage levels at Kangaroo Valley must be restricted to within the 346 kV rating of the generator transformers. This previously imposed an overall constraint on the voltage levels in the Canberra – Kangaroo Valley 330 kV system. The constraint arose at light load periods coinciding with limited generators in service in the Kangaroo Valley system and during line outages for maintenance.

The constraint has now been removed due to the completion of the shunt reactor installations at Yass in March 2014.

6.1.3.3 Connection of Gullen Range Wind Farm

In November 2013 TransGrid connected the first stage (166 MW) of Epuron's 240 MW wind farm near Gullen Range to a new switching station in the 61 Bannaby – Yass 330 kV transmission line.

6.1.4 Completed Line Switchbays for Distributor Requirements

Table 6.1 summarises projects for the provision of line switchbays to meet NSW distributors' requirements that were included as proposals in previous TAPRs and completed since the publication of the TAPR 2013.

6.1.5 Completed Substation Fault Rating Upgrades

There were no substation fault rating upgrades completed since publication of the TAPR 2013.

6.1.6 Completed Transformer and Reactor Replacements and Capacity Upgrades

Table 6.6 summarises transformer replacements and capacity upgrades that were included as proposals in previous TAPRs and completed since publication of the TAPR 2013.

6.1.7 Completed Reactive Plant Installations

The following table summarises reactive plant installations that were included as proposals in previous TAPRs and completed since publication of the TAPR 2013.

TABLE 6.3 – COMPLETED REACTIVE PLANT INSTALLATIONS

Location	Installation	Completion	Comments
Central System			
Sydney South 330/132 kV Substation	Installation of a new 200 MVAr 330 kV capacitor bank	December 2013	To maintain adequate power transfer and voltage control capability to the loads of southern Sydney

6.1.8 Other Completed Works

The following table summarises other replacement and upgrade works that were included in previous TAPRs and completed since the publication of the TAPR 2013.

TABLE 6.4 – OTHER COMPLETED WORKS

Location	Installation	Completion	Comments
Central System			
Sydney South 330 kV Substation	Provide 330 kV bus coupler circuit breaker	2014	Sydney South is a critical substation supplying large urban loads
Sydney West 330 kV Substation	Provide 330 kV bus coupler circuit breaker	Sept 2013	Sydney West is a critical major substation supplying large urban loads. The bus coupler work is being combined with the connection of 330 kV lines to Holroyd Substation
Newcastle 330 kV Substation	Provide 330 kV bus coupler circuit breaker	May 2014	Newcastle is a critical substation supplying large urban loads. The work is being combined with the transformer replacement work
Southern System			
Tumut 132/66 kV Substation	Secondary systems replacement	Jun 2014	Condition based replacement

6.2 COMMITTED DEVELOPMENTS

This Section describes network constraints or asset condition requirements within NSW that are being relieved by committed developments. For a development to be considered committed it must have reached financial and contractual commitment, be under development and have passed Decision Gate 3 (DG3) of TransGrid's network investment process described in Section 2.6. These developments are the subject of regulatory consultations or documented in previous TAPRs.

6.2.1 Central System

6.2.1.1 Redevelopment of Orange 132/66 kV Substation (Western Subsystem)

Orange 132/66 kV Substation was commissioned in 1954 and the 66 kV equipment and secondary systems are nearing the end of their serviceable lives. Now that Orange North 132 kV Switching Station is completed most of the 132 kV equipment from Orange Substation will be removed and the 66 kV equipment and secondary systems will be replaced. The opportunity will also be taken to install an additional 66 kV capacitor.

The work is expected to be completed in April 2017.

6.2.1.2 Western Sydney Supply Project

TransGrid and Ausgrid are undertaking work to increase the capacity of the transmission system supplying the Sydney inner metropolitan area to meet present and emerging limitations. The major components include:

- Construction of sections of a new double circuit 330 kV line and conversion of parts of an existing double circuit line to operate at 330 kV between Sydney West 330/132 kV Substation and the new Holroyd 330/132 kV Substation;
- Construction of the new Holroyd Substation and associated connections to the existing 132 kV network;
- Construction of the new Rookwood Road 330/132 kV Substation and associated connections to the existing 132 kV network; and
- Installation of two 330 kV cables between the new Holroyd Substation and the new Rookwood Road Substation.

Holroyd Substation and the double circuit 330 kV line work was completed in March 2014.

Installation of the two 330 kV cables and construction of the new Rookwood Road 330/132 kV Substation is expected to be completed around September 2014.

6.2.1.3 Disconnection of Munmorah Power Station

Delta Electricity has announced the retirement of Munmorah Power Station. The disconnection of the 330 kV generator connections is expected to be completed in mid to late 2014.

6.2.2 Southern System

6.2.2.1 Upper Tumut Switching Station Rehabilitation

Most of the rehabilitation works at Upper Tumut Switching Station have been completed including replacement of high voltage equipment. Replacement of the secondary systems is programmed for completion progressively through to January 2015.

6.2.2.2 97G 132 kV Transmission Line Remediation Works

The 97G Murray – Guthega 132 kV line was originally constructed by the Snowy Mountains Hydro Electricity Authority in the 1960s and supplies Guthega power station and Jindabyne pumping station. The line also supplies Munyang during outages of the 132 kV line between Cooma and Munyang. The 97G line is being remediated to restore the line to its original capacity by raising the conductors.

The remediation of 97G line is expected to be completed in November 2014.

6.2.2.3 Cooma Substation Replacement

Cooma 132/66/11 kV Substation was established in 1954 and supplies the Cooma area, the NSW alpine region and the NSW far south coast.

The substation and its equipment are approaching the end of their serviceable life and are in need of replacement. The majority of the high voltage plant items and secondary systems are also approaching the end of their serviceable life and are being replaced to maintain reliability of supply.

A new Cooma 132/66 kV Substation will be established in close proximity to the existing substation. The existing Cooma Substation will be transferred to Essential Energy and converted to a 66/11 kV substation.

The establishment of the new Cooma 132/66 kV Substation is expected to be completed in November 2015. The conversion of the existing Cooma substation to a 66/11 kV substation by Essential Energy is expected to be completed soon after.

6.2.2.4 Yanco Substation Refurbishment

Yanco 132/33 kV Substation was commissioned in 1969 and supplies Essential Energy's Narrandera Zone Substation at 66 kV and several local 33 kV feeders. The majority of the substation's equipment is nearing the end of its serviceable life and will be replaced to maintain reliability of supply.

The refurbishment of Yanco Substation is expected to be completed in September 2015.

6.2.2.5 Uprating of Lines 61 and 3J Lines

Lines 61 and 3J can be uprated to an operating temperature of 100°C by undertaking relatively minor works. Those works are to be completed by summer 2014/15.

6.2.3 Committed Line Switchbays for Distributor Requirements

The following table summarises projects for the provision of line switchbays to meet NSW distributors' requirements that were included as proposals in previous TAPRs and completed since the publication of the TAPR 2013.

TABLE 6.5 – COMMITTED LINE SWITCHBAYS FOR DISTRIBUTOR REQUIREMENTS

Location	Installation	Completion	Comments
Wagga North Substation	One 132 kV switchbay	May 2015	Supply to Temora. Essential Energy is constructing a second 132 kV transmission line between Wagga North and Temora to provide reliability of supply. TransGrid is providing an additional 132 kV switchbay for the connection of the second circuit.

6.2.4 Committed Substation Fault Rating Upgrades

There were no substation fault rating upgrades committed since the publication of the TAPR 2013.

6.2.5 Committed Transformer and Reactor Replacements and Upgrades

The following table summarises committed transformer replacements and upgrades.

TABLE 6.6 – COMMITTED TRANSFORMER AND REACTOR REPLACEMENTS AND UPGRADES

Location	Installation	Completion	Comments
Central System			
Newcastle 330/132 kV Substation	Condition based replacement of two of the three remaining banks of single phase 330/132 kV transformers with new 375 MVA three phase units	Late 2014 (replacement of the first transformer was completed in April 2014)	The existing assets are nearing the end of their serviceable life. Due to lower demand in the area following closure of the Kurri Kurri aluminium smelter, one bank of single phase units will be retired but not replaced.
Southern System			
Griffith 132/33 kV Substation	Replacement of three 45 MVA 132/33 kV transformers by three new 60 MVA units	November 2014	Condition based replacement
Yanco 132/33 kV Substation	Replacement of two 45 MVA 132/33 kV transformers by two new 60 MVA units	August 2014	Condition based replacement

6.2.6 Committed Capacitor Bank Replacements and Upgrades

The following table summarises committed capacitor bank replacements and upgrades.

TABLE 6.7 – COMMITTED CAPACITOR BANK INSTALLATIONS

Location	Installation	Completion	Comments
Canberra 330/132 kV Substation	Expansion of existing 80 MVAr bank to a 120 MVAr 132 kV capacitor bank	November 2014	To maintain adequate power transfer capability from the southern generators towards Sydney and the NSW south coast
Yass 330/132 kV Substation	One new 80 MVAr 132 kV capacitor bank	Summer 2014/15	To maintain adequate power transfer capability from the southern generators towards Sydney and the NSW south coast
Orange 132/66 kV Substation	Additional 66 kV capacitor bank	April 2017	To be provided as part of condition based replacement works. Refer Section 6.2.1.1
Canberra 330/132 kV Substation	Additional 120 MVAr 132 kV capacitor	July 2014	To maintain adequate power transfer capability from the southern generators towards Sydney and the NSW south coast

6.2.7 Other Committed Works

The following table summarises other committed replacements and upgrades.

TABLE 6.8 – OTHER COMMITTED WORKS

Location	Installation	Completion	Comments
Various 330 kV substations	Install surge arrestors on various 330 kV line entries to substations. 22 out of 70 sites have been completed.	Progressive completion to 2015.	To provide necessary surge protection for substation equipment. Some high priority sites have been completed.
Northern System			
Armidale 330/132 kV Substation	SVC control system replacement	Late 2015	Condition based replacement
Tamworth 132/66 kV Substation	Substation rebuild	2017	Condition based replacement. The new substation is to be constructed on an adjacent site with two 120 MVA 132/66 kV transformers and with no 132 kV busbar initially.
Central System			
Sydney West 330/132 kV Substation	Secondary systems replacement	Late 2015	Condition based replacement
Vineyard or Cattai area	Acquisition of a site to enable a future 500/330 kV substation to be developed	2016	The site is required to meet the long-term needs for supply in the Sydney area
94B Wellington – Beryl 132 kV transmission line	132 kV transmission line wood pole replacement	Summer 2014/15	Condition based replacement
Southern System			
Broken Hill 220/22 kV Substation	SVC control system replacement	Summer 2014/15	Condition based replacement
Dapto 330/132 kV Substation	Secondary systems replacement	Mid 2014	Condition based replacement
Griffith 132/33 kV Substation	Secondary systems replacement	November 2014	Condition based replacement

6.3 DEVELOPMENTS THAT HAVE COMPLETED OR ARE EXEMPT FROM THE REGULATORY PROCESS

This Section briefly describes network constraints within NSW that are being relieved by developments that have completed or are exempt from the regulatory process but have not progressed to the point where they can be considered committed in accordance with the criteria described in Section 6.2.

Information on transmission augmentation projects in the NTNDP is provided in Section 5.3.

None of the developments in this section would have a material inter-network impact.

6.3.1 Central System

6.3.1.1 Transposition Work on Line 76/77 Wallerawang – Sydney South/Ingleburn Double Circuit 330 kV Line

Background	Prior to the establishment of Ingleburn 330/66 kV Substation, the untransposed 330 kV double-circuit lines 76 and 77 connected Sydney South and Wallerawang substations. Following the establishment of Ingleburn 330/66 kV Substation, line 77 (Wallerawang – Sydney South) was cut into Ingleburn 330 kV switchyard resulting in two new lines: • Line 77 (Wallerawang – Ingleburn); and • Line 78 (Ingleburn – Sydney South). System analysis studies identified that at times of high power transfer from Wallerawang the loss of line 78 is expected to produce an unusually high negative-sequence voltage level at Ingleburn substation. This is due to the overall configuration of the 330 kV network and particularly due to the phasing of the Wallerawang – Ingleburn-Sydney South 330 kV double circuit lines 76, 77 and 78. On-site measurements have confirmed that following the opening of line 78 (Sydney South – Ingleburn), a high level of voltage-unbalance can occur at Ingleburn Substation.
Nature of the Limitation	The project is driven by the quality of supply installation to meet NER requirements.
Target Date	October 2014.
MW Load Reduction to Delay Constraint and Non-network Option Requirements	No feasible non-network options have been identified. A non-network option would only be feasible if it can supply all of the load at Ingleburn bulk supply point. (See Appendix 3 for details of the Ingleburn load.) This would then allow that load to be disconnected from Ingleburn, thus isolating it from the unbalanced voltages.
Possible Network Options	The NER prescribes a maximum voltage-unbalance limit including limits following a credible contingency. To control the maximum voltage-unbalance level at Ingleburn Substation to below the limit specified in the NER, for the outage of the Ingleburn – Sydney South 330 kV line No 78, the phase conductors of both circuits of the double-circuit line No 76/77 need to be transposed at two locations.
Preferred Network Option	To ensure compliance with Clause S5.1a.7 of the NER, lines 76 and 77 are to be transposed to mitigate the voltage unbalance at Ingleburn substation when Line 78 is open. The project cost is approximately $1 M.

6.3.2 Southern System

6.3.2.1 Development of Southern Supply to the ACT

Background	The Australian Capital Territory (ACT) and surrounding areas are currently supplied by a 132 kV transmission network emanating from Canberra and Williamsdale 330/132 kV Substations. The ACT jurisdiction's reliability criteria require TransGrid to provide a 330 kV supply independent of Canberra 330/132 kV substation. Williamsdale is presently supplied from Canberra. A separate 330 kV switching station and sections of 330 kV line are required to provide an independent supply to Williamsdale.
Nature of the Limitation	Jurisdictional reliability requirement.
MW Load Reduction to Defer Constraint and Non-network Option Requirements	As the reliability obligation relates to a network solution, there are no feasible non-network options.
Target Date	TransGrid is consulting with the ACT government about the timing of these works.
Possible Network Options	The only feasible option identified is the establishment of Wallaroo switching station and associated 330 kV line connections.
Preferred Network Option	To meet the requirement of the ACT government, TransGrid plans to: • Establish a new 330 kV switching substation at Wallaroo (north-west of Canberra); • Form 330 kV circuits from Yass to Wallaroo and from Wallaroo to Canberra; • Construct a short section of 330 kV line from Wallaroo to the route of the Canberra – Williamsdale 330 kV line; and • Connect the new line at Wallaroo and to the Canberra – Williamsdale 330 kV line.

6.3.3 Other Developments

6.3.3.1 Dynamic Line Ratings

Background	TransGrid is currently in the process of developing real-time monitoring capabilities of its lines. The project looks to monitor weather conditions and conductor temperature in order to make short-term forecasts of load carrying capabilities of transmission lines. TransGrid has already implemented pilot projects with direct methods of measurements of conductor temperature and tension and indirect methods with the use of weather stations. Experience from these projects yielded invaluable insight into the implementation. TransGrid has made use of existing dynamic line rating systems using planned outages resulting in improved transmission system availability. TransGrid has identified a number of parts of its network where dynamic line ratings are likely to be of benefit. They involve the following lines: • Armidale to Tamworth 330 kV transmission line (line 86) • Murray to Upper Tumut 330 kV transmission line (line 65) • Lower Tumut to Murray 330 kV transmission line (line 66) • Upper Tumut to Canberra 330 kV transmission line (line 1) • Lower Tumut to Canberra 330 kV transmission line (line 7) • Bannaby to Sydney West 330 kV transmission line (line 39) • Liddell to Tamworth 330 kV transmission line (line 84) • Liddell to Muswellbrook 330 kV transmission line (line 83) • Muswellbrook to Tamworth 330 kV transmission line (line 88) • Yass to Bannaby 330 kV transmission line (line 61) • Tamworth to Armidale 330 kV transmission line (line 85) • Lower Tumut to Yass 330 kV transmission line (line 03) • Upper Tumut to Yass 330 kV transmission line (line 02) • Yass to Marulan 330 kV transmission line (line 04) • Yass to Marulan 330 kV transmission line (line 05) • Canberra to Yass 330 kV transmission line (line 09) • Lismore to Koolkhan 132 kV transmission line (line 967) • Armidale to Koolkhan 132 kV transmission line (line 966) • Armidale to Glen Innes 132 kV transmission line (line 96T) • Glen Innes to Tenterfield 132 kV transmission line (line 96R) • Tamworth to Gunnedah 132 kV transmission line (line 969)
Nature of the Limitation	This is a market driven project which aims to capture market benefits arising from increased line ratings should favourable weather conditions occur.
Target Date	It is expected to deliver the project as a progressive roll-out of all the above identified lines over the period 2014/15 – 2018/19.
Possible Network Options for Alleviation	Possible options to meet the identified need are: • Implement dynamic line ratings based on information obtained from weather stations along the route of the line; and • Implement dynamic line ratings based on information obtained from on-line tension and conductor temperature monitors.
Preferred Network Option	The preferred option at this stage is to implement dynamic line ratings based on information obtained from weather stations. The estimate total cost of implementation on all the identified lines is approximately $6 M.

6.3.3.2 Multiple Contingency Protection Scheme

Background	Approximately 60 percent of NSW energy is generated west of the Great Dividing Range and must be delivered to the east coast, where most of the state's load is located. The Sydney, Wollongong and Newcastle areas use 75 percent of the energy of NSW. In any large interconnected power system there is a risk that a severe fault or series of faults could result in a widespread failure of some part of the power system. TransGrid designs the power system to withstand credible single contingencies but must also consider non-credible contingencies, including busbar faults and multiple contingencies. As part of TransGrid's normal planning investigations, several critical non-credible contingency events that may result in loss of supply to parts or all of the greater Sydney area have been identified. These contingency events include simultaneous tripping of two or more of the following lines: • Lines 31 and 32, Bayswater – Sydney West/Regentville • Lines 76 and 77, Wallerawang – Sydney South/Ingleburn • Lines 5A1, 5A2 Eraring – Kemps Creek • Line 25, Eraring – Vineyard and Line 26, Munmorah – Sydney West • Line 39, Bannaby – Sydney West • Line 21, Tuggerah – Sydney North and Line 22, Vales Point – Sydney North • Line 11, Dapto – Sydney South There is a need to take corrective action to protect the NSW power system from potential cascading failure in accordance the TransGrid planning criteria and the NER.
Target Date	Summer 2016/17
Nature of the Limitation	This is a regulatory obligation driven project. This project mitigates the impact of multiple continency events which result in voltage instability.
Possible Network Options	Possible options to meet the identified need are: • Implement SCADA based multiple contingency protection scheme Implement protection based multiple contingency protection scheme and • Implement a combination of SCADA and protection optimised multiple contingency scheme
Preferred Network Option	The preferred option at this stage is to implement a combination of SCADA and protection optimised multiple contingency schemes. The project cost is estimated to be approximately $9 M.

6.3.3.3 Quality of Supply Monitoring

Background	The NER requires a TNSP to design and operate its network to ensure that the quality of supply (QoS) of the voltage to it customers (i.e. Generators, DNSPs and large industrial consumers) meets the defined system standards and levels specified in Connection Agreements.
Target Date	2019
Nature of the Limitation	This project addresses the quality of supply installation need to meet NER requirements.
Possible Network Options	Possible options to meet the identified need are: • Installation of QoS monitors at all customer connection points; and • Installation of QoS monitors at 13 strategic customer connection points initially with installations at the remaining connection points proceeding as opportunities allow (such as when secondary systems are being replaced).
Preferred Network Option	The preferred option at this stage is for QoS monitors to be installed at the 13 strategic customer connection points. The project cost for the initial installations is estimated at approximately $3 M.

6.3.3.4 Point on Wave Switching Control

Background	TransGrid's transmission system contains about 110 shunt capacitor banks, each of which is connected to or disconnected from the network by closing or opening its capacitor circuit breaker. Unless the capacitor circuit breaker has special features, energising a shunt capacitor bank can produce high levels of transient distortion. These distorted voltage waveforms are applied to customer loads and can result in mal-operation or failure of customer equipment. Customer loads that include rectifiers are particularly susceptible to the transient distortion produced by the uncontrolled energising of shunt capacitor banks. These loads include controlled motor drives and computer systems. As these types of loads become more widely used, the need to control capacitor-energising transient voltage distortion will increase. Since 2005, new TransGrid capacitor banks have included capacitor circuit breakers fitted with point on wave (POW) closing controls. As well, replacement capacitor circuit breakers have included POW closing controls. There remain 27 TransGrid shunt capacitor banks for which the circuit breakers need to be replaced with circuit breakers fitted with POW closing controls.
Target Date	Progressively from 2015 to 2018
Nature of the Limitation	This project is needed to avoid the mal-operation or failure of customer equipment
Possible Network Options	Possible options to meet the identified need are: • Leave shunt capacitors connected at all times; • Replace capacitor circuit breakers with those fitted with pre-insertion resistors; and • Replace capacitor circuit breakers with point-on-wave closing controls.
Preferred Network Option	The preferred option at this stage is for circuit breakers of the 27 shunt capacitor banks to be replaced with those fitted with point-on-wave closing control. The project cost is estimated at approximately $5 M.

6.3.4 Minor Developments that have Completed the Regulatory Process

There were no new minor developments that have completed the regulatory process since the publication of TAPR 2013.

6.3.5 Substation Fault Rating Upgrades that have Completed the Regulatory Process

There were no substation fault rating upgrades in this category since the publication of TAPR 2013.

6.3.6 Transformer and Reactor Replacements and Upgrades that have Completed the Regulatory Process

There were no transformer or reactor replacements in this category since the publication of TAPR 2013.

6.3.7 Minor Developments Previously Reported

The following table summarises minor development projects that have previously been reported.

TABLE 6.9 – MINOR DEVELOPMENTS PREVIOUSLY REPORTED

Development	Need	Completion	Comments
Transposition works on the 76/77 Wallerawang – Sydney South/Ingleburn double circuit 330 kV line	To meet the NER requirements for balanced voltages	October 2014	Refer Section 6.3.1.1
Multiple Contingency protection scheme	To minimise the possibility of a widespread disturbance to the NSW main system following multiple circuit outages e.g. during bushfires	Summer 2016/17	Refer Section 6.3.3.2
Substation Fault Rating Upgrade: Sydney West 330/132 kV Substation	Installation: Equipment replacements to ensure that the 132 kV fault rating is at least 38 kA	2015/16	Refer Section 7.2.2.12

6.3.8 Line Switchbays for Distributor Requirements Previously Reported

The following table summarises projects for the provision of line switchbays to meet NSW Distributors' requirements that have completed the regulatory process.

TABLE 6.10 – LINE SWITCHBAYS FOR DISTRIBUTOR REQUIREMENTS PREVIOUSLY REPORTED

Location	Installation	Completion	Comments
Sydney West 330/132 kV Substation	Two new 132 kV switchbays	2016-20	
Newcastle 330/132 kV Substation	One new 132 kV switchbay	Beyond ten years	
Tamworth 132/66 kV Substation	One new 66 kV switchbay	Within five to ten years	Refer Section 7.3.4
Williamsdale 330/132 kV Substation	One new 132 kV switchbay	2018	Refer Section 7.2.3.6

6.3.9 Replacement Transmission Network Assets Previously Reported

The following table summarises replacement transmission network assets previously reported.

TABLE 6.11 – REPLACEMENT TRANSMISSION NETWORK ASSETS PREVIOUSLY REPORTED

Location	Installation	Completion	Comments
999 Yass to Cowra 132 kV transmission line	Line rating restoration	Limitation not expected to arise within ten years	Refer Section 7.4.2.6
Sydney North 330/132 kV Substation	Secondary systems	2019	Condition based replacement. Refer Section 7.2.5
Vales Point 330/132 kV Substation	Substation rebuild	2018	Condition based replacement. Refer Section 7.2.2.7
944 Wallerawang to Orange North 132 kV transmission line	Substation works	2016/17	Condition based development. Change of option. Refer Section 7.2.2.8
Albury 132/22 kV Substation	Secondary systems	2016	Condition based replacement. Refer Section 7.2.5
Buronga 220 kV Substation	Replacement of X2 220 kV Reactor	Summer 2015/16	Condition based replacement.
Broken Hill 220/22 kV Substation	Replacement of No 1 and No 2 Reactors	Winter 2016	Condition based replacement.

6.3.10 System Reactive Plant Requirements Previously Reported

There are no system reactive plant requirements in this category since TAPR 2013.

6.4 NETWORK REPLACEMENT PROJECTS SUMMARY

The following Table 6.12 lists a summary of committed and planned network replacement projects covered in this chapter of the TAPR.

TABLE 6.12 – SUMMARY OF COMMITTED AND PLANNED NETWORK REPLACEMENT PROJECTS

Project	Clause	Purpose	Proposed Completion Date
Orange 132/66 kV Substation: 66 kV assets and secondary systems replacement	6.2.1.1	Condition based replacement	2017
Upper Tumut 330 kV Switching Station refurbishment	6.2.2.1	Condition based renewal	January 2015
97G Murray to Guthega 132 kV transmission line remedial work	6.2.2.2	Condition based renewal	November 2014
Cooma 132/66 kV Substation: Substation replacement	6.2.2.3	Condition based replacement	November 2015
Yanco 132/33 kV Substation: Substation refurbishment	6.2.2.4	Condition based replacement	September 2015
Newcastle 330/132 kV Substation transformer replacement, two of the three single phase transformer banks	6.2.5	Condition based replacement	Late 2014
Griffith 132/33 kV Substation: Transformer replacements	6.2.5	Condition based replacement	November 2014
Yanco 132/33 kV Substation: Transformer replacements	6.2.5	Condition based replacement	August 2014
Armidale 330/132 kV Substation: SVC control system replacement	6.2.7	Condition based replacement	Late 2015
Tamworth 132/66 kV: Substation rebuild	6.2.7	Condition based replacement	2017
Sydney West 330/132 kV Substation: secondary systems replacement	6.2.7	Condition based replacement	Late 2015
94B Wellington to Beryl 132 kV transmission line rehabilitation	6.2.7	Condition based replacement	Summer 2014/15
Broken Hill 220/22 kV Substation: SVC control system replacement	6.2.7	Condition based replacement	Summer 2014/15
Dapto 330/132 kV Substation: Secondary system replacement	6.2.7	Condition based replacement	Mid 2014
Griffith 132/33 kV Substation: Secondary systems replacement	6.2.7	Condition based replacement	November 2014
Sydney North 330/132 kV Substation: Secondary systems replacement	6.3.9	Condition based replacement	2019
Buronga 220 kV Substation: Replacement of X2 220 kV reactor	6.3.9	Condition based replacement	Summer 2015/16
Broken Hill 220/22 kV Substation: Replacement of No 1 and No 2 Reactors	6.3.9	Condition based replacement	Winter 2016

Constraints and Possible Network Developments

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CHAPTER SEVEN

Constraints and Possible Network Developments

The following Sections describe specifically identified present and emerging constraints within TransGrid's network over a five year planning horizon.

Where new network assets are proposed to relieve these constraints they are detailed as required by the NER. Where no specific new network asset is proposed, one or more options for relief of the constraint may be described.

Section 7.1 describes constraints for which the regulatory consultation process is underway.

Section 7.2 describes other constraints that are expected to emerge within a five-year planning horizon where there is at present no firm proposal. One or more options for the removal of each constraint are described. They may appear as proposals in future Transmission Annual Planning Reports.

This Section also includes replacement transmission assets in the same timeframe.

Section 7.3 summarises constraints that are expected to arise over a time frame longer than five years. One or more indicative developments to mitigate the constraints are given.

This TAPR provides a "snapshot" of constraints at a particular time. Consequently, the constraints described are subject to change with respect to their number, nature and timing. In some cases changes will occur at short notice. Changes may be brought about by changes in load growth, new load developments as well as generation developments. TransGrid's planning processes encompass reviews of limitations should material changes in circumstances occur. Options for the relief of constraints are then developed to ensure that standards of supply are maintained.

The NER require the TAPR to set out planning proposals for future connection points. These can be initiated by generators or customers or arise as the result of joint planning with a distributor. Developments relating to the capacity of existing bulk supply points and proposals for new bulk supply points are detailed in Appendix 7.

As indicated in Section 2.11 it is not always possible to predict the precise nature and depth of the information required by particular interested parties. Should additional information on any of the possible developments in this Section be required, interested parties are encouraged to contact TransGrid so that information tailored to their particular needs can be provided. Contact details are provided on the inside of the rear cover.

7.1 DEVELOPMENTS WHERE THE REGULATORY CONSULTATION PROCESS IS UNDERWAY

This Section describes constraints for which the regulatory consultation process is underway. For these constraints there will generally be proposed projects.

Information on transmission augmentation projects in the NTNDP is provided in Section 5.3.

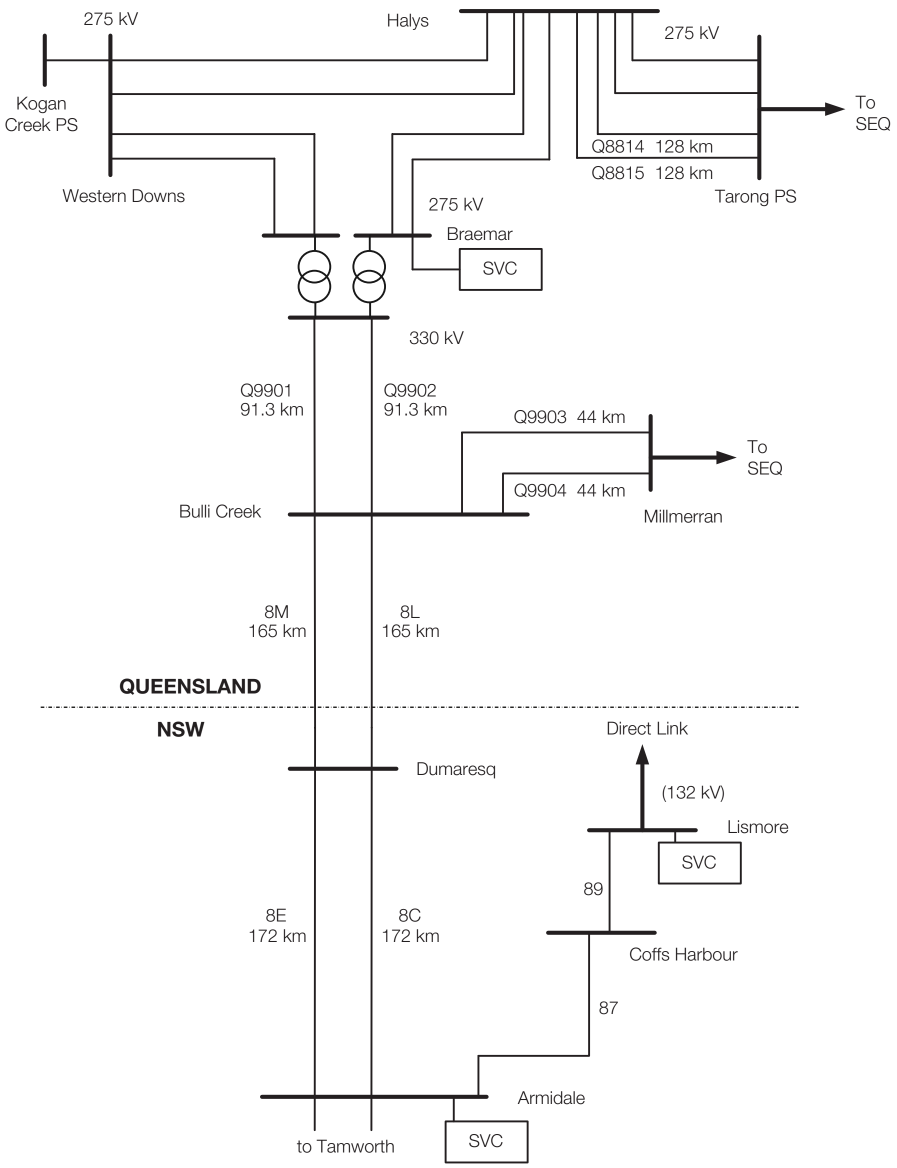
7.1.1 Queensland – NSW Interconnector (QNI) Transmission Capacity

Background

QNI connects the NSW and Queensland power systems. Its power transfer capability is governed by overall system-wide stability limitations and also by voltage control and line rating limitations in the supporting 330 kV systems. Directlink operates in parallel with QNI.

QNI can be heavily loaded depending on the dispatch of generation across the NEM. There is potential for upgrading of the interconnector capability.

In June 2012, TransGrid and Powerlink issued the Project Specification Consultation Report (PSCR). The two organisations published the Project Assessment Draft Report (PADR) in March 2014. These documents are available on TransGrid's and Powerlink's websites. The Project Assessment Conclusions Report is to be published in the next few months.



Nature of the Limitation	This is a market benefit driven project. The limitations are described in the regulatory consultation documents.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	TransGrid and Powerlink have examined the possibility of a non-network option to increase the capability across QNI. Non-network option including demand-side responses would need to be considered on a case by case basis as discussed in the PADR.
Possible Network Options	The following six options have been included as credible options in the RIT-T analysis: • Uprating of the Northern NSW 330 kV transmission lines; • 50% Series Compensation of the interconnecting 330 kV lines between Armidale, Dumaresq and Bulli Creek; • 50% line series compensation and a second Armidale SVC; • 60% Series Compensation of the interconnecting 330 kV lines between Dumaresq and Bulli Creek; • A new SVC at Armidale; and • New SVCs at Dumaresq and Tamworth and Switched Shunt Capacitors at Dumaresq, Armidale and Tamworth substations. The cost estimates for these options can be found in the PADR document on both TransGrid and Powerlink's websites. Each of these options would have a material inter-network impact. The first pass assessment concluded that several credible network options were not considered to be economically viable and as such have not been considered further: • Augmentations to protection systems to improve line fault clearing times; • A second HVAC interconnection at 330 kV between Bayswater and the Queensland Western Downs; • A new Armidale – Dumaresq – Bulli Creek HVAC 330 kV development; • A second HVAC interconnection at 500 kV; • A HVDC back-to-back scheme in QNI; and • A braking resistor in the Hunter Valley.
Preferred Network Option	The RIT-T assessment identified four important factors which influence the market benefit of credible options: 1. future gas prices in Queensland; 2. the possible retirement of Redbank Power Station; 3. the development of wind farms in northern NSW; and 4. load growth. TransGrid and Powerlink also tested the robustness of the net market benefits and ranking of options to a number of other factors, including: a. The exclusion of competition benefits; b. A reduction in QNI capacity provided by the option; c. An increase and decrease in the cost of the credible options; and d. Differences in the discount rate used in the NPV assessment. The results of all this analysis show that the ranking of credible options is inconsistent across the scenarios. Further, many credible options have negative net market benefits under a number of scenarios and hence rank below the 'do nothing' option. Therefore, it is the view of TransGrid and Powerlink that, at this stage, there is too much uncertainty around these factors and that it is prudent to not recommend a preferred credible option but to continue to monitor developments in these key input assumptions.

7.2 POSSIBLE NETWORK DEVELOPMENTS WITHIN FIVE YEARS

This Section describes constraints that are expected to emerge within a five-year planning horizon[1]. For these constraints, there is not yet a proposed project.

This Section also includes replacement transmission network assets in the same timeframe.

7.2.1 Northern System

7.2.1.1 Supply to the Gunnedah/Narrabri Area

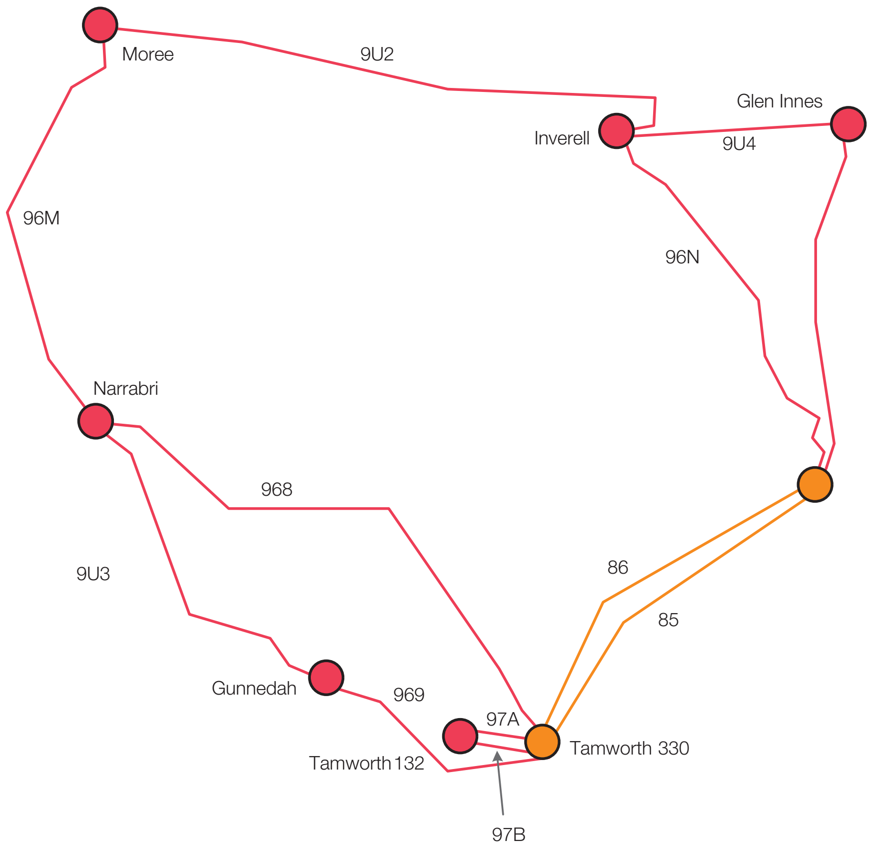
Background

The transmission system supplying the Gunnedah, Narrabri and Moree areas is about 300 kilometres long and is shown in the Figure below. Its capacity is limited by the thermal capacity of the 969 Tamworth – Gunnedah 132 kV line on outage of the 968 Tamworth - Narrabri 132 kV line.

New mines have committed to connect to the transmission network in the next two years. This increase in load would exacerbate the limitations.

To date it has been possible to manage the limitation by operational measures, including increasing the operating voltage of the 132 kV network and opening the 96M Narrabri – Moree 132 kV line (if power is flowing northward) should the critical contingency occur.

The limitation is expected to arise in summer 2014/15, even with operational measures in place.



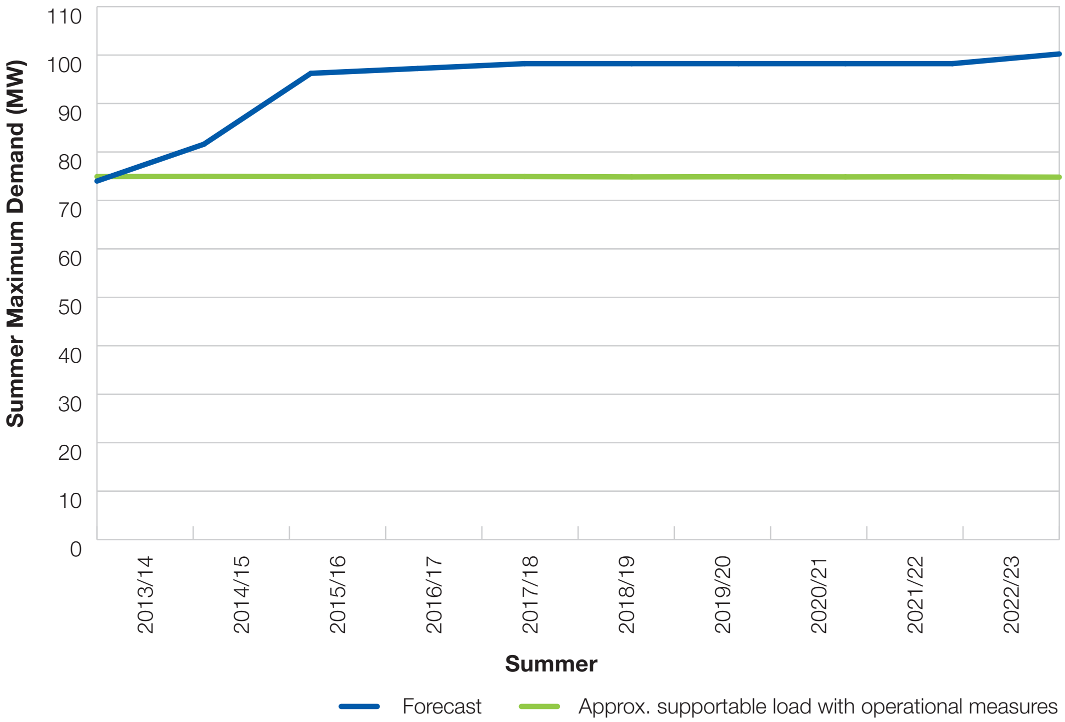
Transmission System Supply Gunnedah and, Narrabri.

1. In addition to reporting limitations which are expected to arise over 1, 3 and 5 years (NER clause 5.12.2(c)(3)) those which are expected to arise in 2 and 4 years are also reported.

Nature of the Limitation

Thermal constraints on 969 line when there is an outage of 968 line.

The graph below shows the forecast summer area load and the approximate supportable load with the operational measures in place.



Possible Network Options

Options available to address these limitations include:

- Construction of a 132 kV line from Tamworth to Gunnedah possibly on the route of the recently dismantled 875 Tamworth – Gunnedah 66 kV line ($34-42 M in 2014);
- Installation of a Phase Shifting Transformer in line 969 ($15 M); and
- Reconductoring of 969 line and 9U3 lines with higher capacity conductor ($15 M).

MW Load Reduction to Delay Limitation and Non-network Option Requirements

A load reduction of 7 MW in the load supplied from Narrabri or Gunnedah substations is expected to delay the onset of this limitation by 12 months. Additional information is provided in Appendix 4.

Preferred Network Option

The preferred network option at this stage is the installation of a phase shifting transformer (connected into the 969 line). It is expected that the regulatory consultation process for this limitation will commence towards the end of 2014.

7.2.1.2 Condition of Tamworth No 2 330/132 kV Transformer

Background	The No 2 330/132 kV 150 MVA transformer at Tamworth 330 kV Substation is nearing the end of its serviceable life and needs to be retired. The transformer shows signs of ageing of paper insulation systems and poor oil quality.
Nature of the Limitation	Tamworth No 2 330/132 kV transformer reaching end of serviceable life. If the transformer is retired and not replaced, the capacity of the two remaining transformers would not be sufficient to supply all of the load should one of them be out of service at times of high load.
Expected Date	2018
Possible Network Options	Options available to address these limitations include: • Replacement of Tamworth No 2 330/132 kV transformer with a unit of similar rating (and addition of 330 kV bus section breaker for system reliability) ($14 M); and • Replacement of Tamworth No 2 330/132 kV transformer with a 375 MVA unit (and associated transformer rearrangements) ($11 M).
MW Load Reduction to Delay Limitation and Non-network Option Requirements	A reduction in load would not address the actual condition of the transformer. However, a reduction of around 70 MW (depending on where that reduction is made) in the Tamworth/Gunnedah/Narrabri area is expected to delay the need to install a replacement transformer by one year.
Preferred Network Option	Replacement of the Tamworth No 2 330/132 kV transformer with a 375 MVA unit in the No 1 position and relocation of the existing No 1 transformer to the No 2 position at a cost of around $11 M.

7.2.2 Central System

7.2.2.1 "Powering Sydney's Future" Supply to the Sydney Inner Metropolitan Area

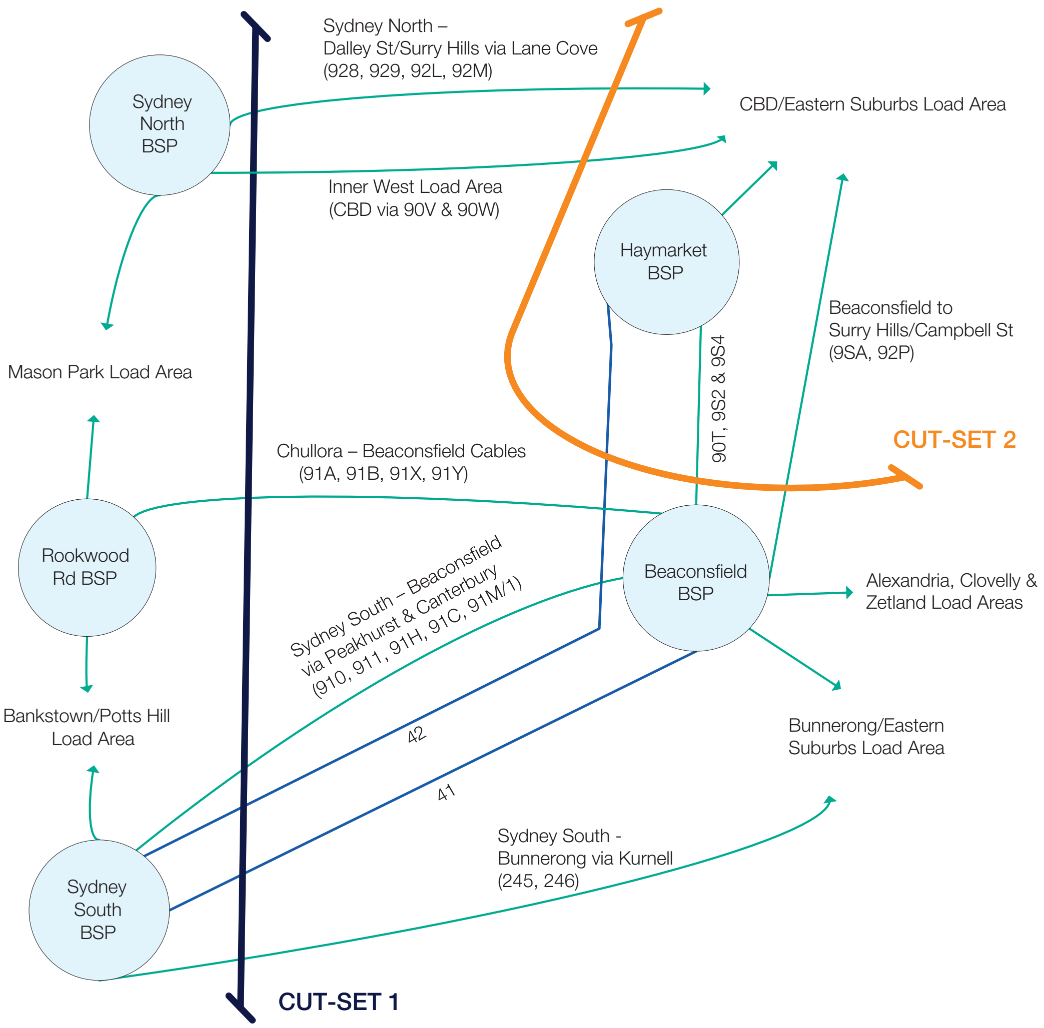
Background

The Sydney inner metropolitan area and CBD are supplied by an integrated network consisting of two 330 kV and a large number of 132 kV cables. Over the coming years, the supply capacity of this network is forecast to decrease as cable assets nearing the end of their serviceable life are retired.

In addition, cable de-ratings resulting from the degraded condition of the backfill of numerous cables has contributed to the decrease in the capacity of the inner metropolitan supply network.

Nature of the Limitation

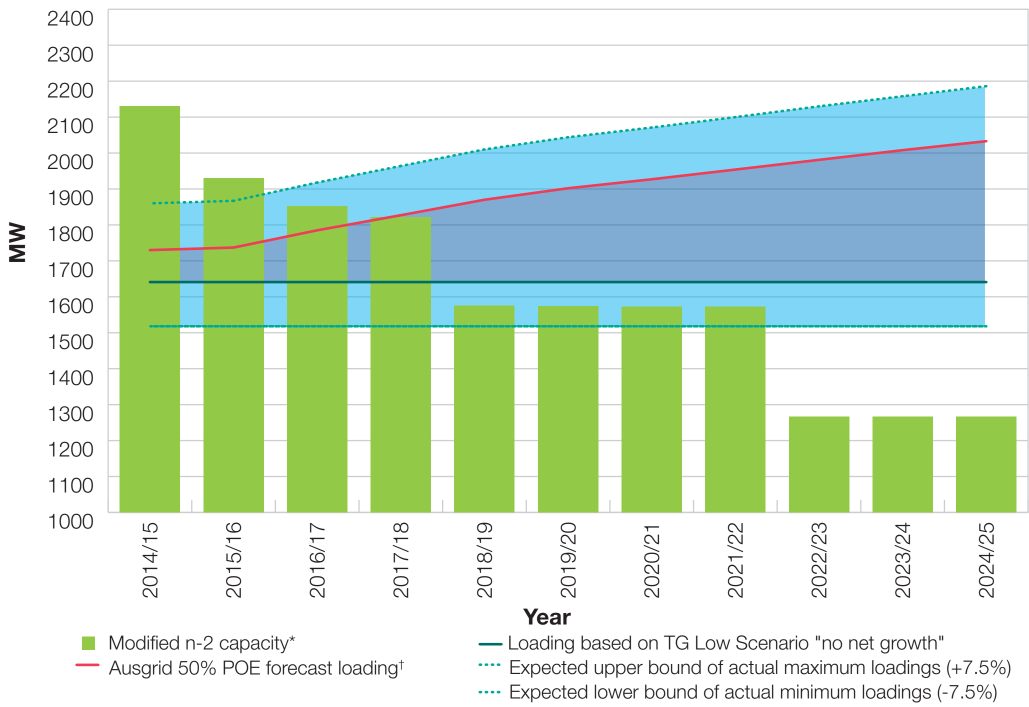
As the planned cable retirements occur, in conjunction with modest forecast load growth in the area, a shortfall in the adequacy of the network to supply the inner metropolitan load at the required level of reliability is forecast to occur. Constraints are expected to arise in two parts of the network shown as cut-set 1 and cut-set 2 in the figure below. The first is a constraint between the bulk supply points located on the perimeter of the metropolitan area and the inner metropolitan area itself. The second is a constraint within the inner metropolitan area between the Beaconsfield bulk supply point and the inner city area.



SYDNEY INNER METROPOLITAN SUPPLY NETWORK CONSTRAINT CUT-SETS 1 & 2

The progressive reduction in network capacity that will occur year-to-year with the expected cable retirements for each of the identified constraint cut-sets is shown against the forecast load across those cut-sets in the following Figures.

CUT-SET 1 NETWORK CAPACITY AND FORECAST LOAD



CUT-SET 2 NETWORK CAPACITY AND FORECAST LOAD

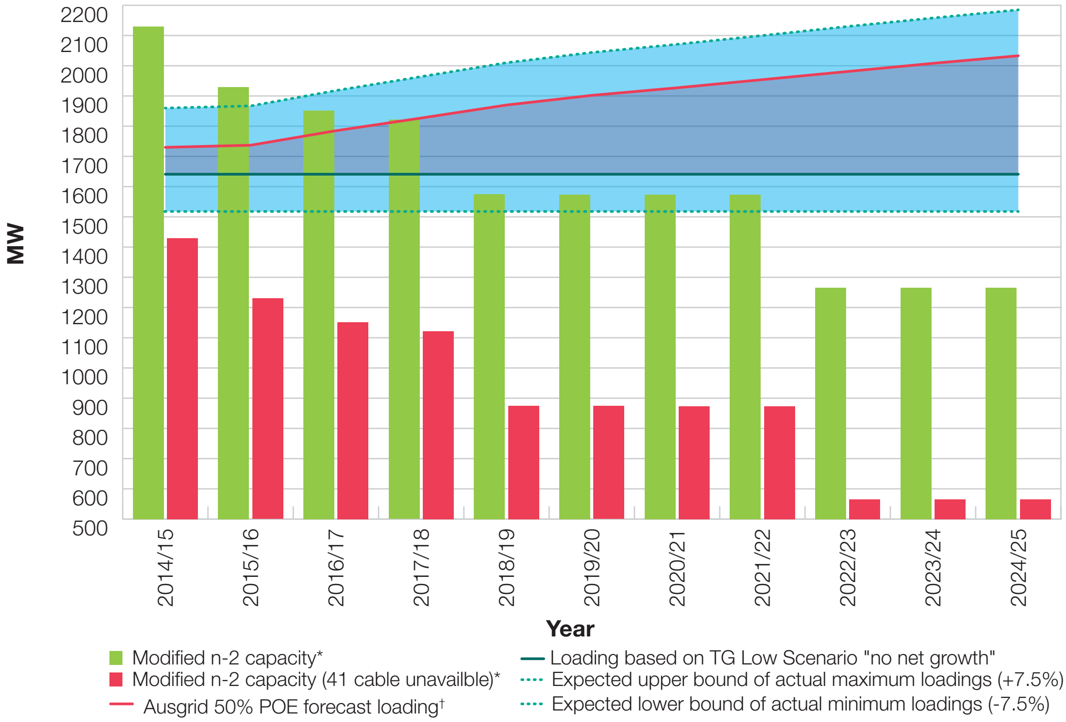
* assumes delayed retirement of 132 kV cables as per agreed long term strategy

† as published in TransGrid's Transmission Annual Planning Report 2014

Possible Options	The following options have been identified: • Establishment of a new 330 kV cable between Rookwood Rd and Beaconsfield and a new 330 kV cable between Beaconsfield and Haymarket a part of which is presently in service at 132 kV. This would require the installation of additional 330 kV GIS switchbays at each of these substations; • Replacement of the retired 132 kV with new 132 kV cables. This would require the establishment of numerous new 132 kV cable routes to achieve the required capacity; and • Non-network options to defer or avoid network investment to address the need.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	The level of demand management required to delay the requirement for a network solution cannot be readily determined at this time given the uncertainty of future load growth and impact of energy efficiency measures currently being applied to new developments within the area. TransGrid is pursuing procurement of demand management to defer or avoid the need for a network option to address the expected retirement of 132 kV cables and potential growth of demand. As part of its recent revenue application Transgrid has proposed the development of the "market" for non-network options in the area by procuring demand management as 'pre-emptive' network support. TransGrid believes that such an approach could lead to a cost effective non-network option being available to manage the impact of the proposed retirement of Ausgrid 132 kV cables for a number of years from summer 2018/19. Further information is provided in Appendix 4.
Preferred Option	TransGrid's preferred option is to procure demand management as a non-network option, to defer or avoid a network investment. Should a network option be required, the preferred network option is to establish new 330 kV cable circuits between Rookwood Road and Beaconsfield, and between Beaconsfield and Haymarket. The use of non-network options, such as demand management, to defer, or if possible avoid, one or both of these cables would be implemented if practical and economic.

7.2.2.2 41 Cable Sydney South – Beaconsfield Capacity

Background	TransGrid's cable 41 is one of two major 330 kV cables that supply the Sydney inner metropolitan area and CBD. Both those cable have series reactors to limit their loading. Recent investigations into the condition of cable 41 have found that the cable backfill has degraded, reducing the thermal performance of the cable. In addition, field measurements have identified ground temperatures exceeding those assumed in the original cable design. This has resulted in an interim de-rating of the cable's continuous cyclic capacity from 663 MVA to 575 MVA. The degraded condition of the backfill has made the cable 41 rating susceptible to variations in soil moisture levels. The interim 575 MVA rating is therefore not guaranteed, and a sustained period of dry weather could reduce the rating of the cable to a level that renders it practically inoperable.
Nature of the Limitation	If the moisture in the cable 41 bedding material was reduced sufficiently to render the cable practically inoperable, the result would be a substantial shortfall in the adequacy of the supply capacity to the Sydney inner metropolitan area and CBD. The following figure shows the inner metropolitan and CBD supply network loading and the network capacity over the coming years both for the interim 575 MVA rating and for when the 41 cable rating is reduced below a practically useful level.



* assumes delayed retirement of 132 kV cables as per agreed long term strategy

† as published in TransGrid's Transmission Annual Planning Report 2014

Possible Network Options

The following options have been identified:

- Monitor cable 41 for signs of rising temperature and manage network capability as necessary;
- Advance the installation of the second Rookwood Rd to Beaconsfield 330 kV cable;
- Remediate the cable 41 backfill in conjunction with the series reactor switching arrangement at Sydney South;
- Install a new series reactor on cable 41 at Sydney South;
- Install a phase shifting transformer on cable 41 at Sydney South; and
- Provide for the cable 42 series reactor to be reconnected in series with the cable 41 series reactor.

MW Load Reduction to Delay Limitation and Non-network Option Requirements

Demand management initiatives are considered as part of the overall strategy to maintain reliability of supply to the inner metropolitan area over the coming years as the expected retirement of ageing 132 kV cable infrastructure occurs. As part of its recent revenue application TransGrid has proposed the development of the "market" for non-network options in the inner metropolitan area through procurement of pre-emptive network support. TransGrid believes that such an approach could lead to a cost effective non-network option being available to manage the impact of the proposed retirement of Ausgrid 132 kV cables for a number of years from summer 2018/19.

However the loss of cable 41 (through its rating being reduced to below a practically useful level) would result in a substantial shortfall in the adequacy of the network to supply the inner metropolitan load. It is not expected that the required levels of demand management would be available to cover the loss of cable 41 capacity, particularly as this would be required in addition to demand management being sought to compensate for the expected 132 kV cable retirements.

Preferred Network Option

The preferred option is to remediate the cable 41 backfill material above the concrete protective slabs and provide a switching arrangement to connect the cable 42 series reactor in series with cable 41 during an outage of cable 42 (the other 330 kV cable). This is expected to cost around $32 M.

It is not possible to predict when the conditions which may lead to a further reduction in the rating of cable 41 may occur. Therefore, there is no specific date by which any remedial actions should be completed, however, it is deemed prudent that they be completed as soon as is reasonably possible.

7.2.2.3 Strategic Land Acquisition at Riley Street

Background

The inner city and CBD load area is serviced by a 132 kV cable network that is supplied from two inner metropolitan TransGrid 330/132 kV substations, Beaconsfield and Haymarket. Both of these substations utilise gas insulated switchgear due to the space constraints of their city locations.

Beaconsfield was recently rebuilt, following approximately 35 years of service, on land adjacent to the existing substation.

Haymarket substation supplies fourteen 132 kV cables that serve the Sydney inner city and CBD areas, via three 400 MVA 330/132 kV transformers. It was commissioned in 2001, and with a service life of approximately 40 years, it is expected that it will require replacement around 2041.

Nature of the Limitation	The Haymarket substation site does not enjoy the characteristics that allowed the Beaconsfield substation to be rebuilt on location. The following factors make an 'on location' replacement of Haymarket substation impractical: • the substation is underground and the installation in heavily restricted space; • the substation site is significantly smaller than the Beaconsfield site; • there is no vacant land available adjacent to the substation, and it is surrounded by medium to high rise buildings; • existing cable routes and connections to the existing site are highly congested. The site does not have the physical space to manage an equipment replacement program while maintaining the substation as an in-service operational facility. A major replacement program would require an alternate supply to be established prior to the replacement. As Haymarket plays a critical role in maintaining reliable supply to the Sydney inner city and CBD areas, an alternate inner city supply would need to be established before the existing Haymarket substation could be replaced or retired. This alternate site would need to be located within close proximity to the existing Haymarket substation to maintain reliable supply to the area. The existing 132 kV cable network presently supplied by Haymarket would need to be re-connected to the 'replacement' site. The future development of a Riley Street 330kV bulk supply point is also consistent with the strategic long term plans for the Sydney electricity supply, providing for both load growth and the expected future retirement of 132kV cables at the end of their serviceable lives. Ausgrid has recently offered for sale a parcel of land in Riley Street, Surry Hills. The property is of a size suitable to build a replacement substation for Haymarket, and the property has immediate access to Ausgrid's inner city 132 kV cable tunnel ring, having been used as an adit for the construction of the tunnels.
Possible Network Options	The following options have been identified: • Purchase the Riley Street property now, and retain the site until the Haymarket substation requires replacement. This land is adjacent to Ausgrid's 132 kV cable tunnel ring, providing easy access for cable connections to the new site. The purchase price is also relatively low, as the land is currently undeveloped. • Purchase the Riley Street property in 2035, providing adequate lead time to build a Haymarket replacement substation by 2041. This land is adjacent to Ausgrid's 132 kV cable tunnel ring, providing easy access for cable connections to the new site, but the land purchase would be considerably more expensive as it is expected to be developed by this time. • Purchase an alternate site in 2035, providing adequate lead time to build a Haymarket replacement substation by 2041. This option would require additional works to route numerous 132 kV cables from Ausgrid's inner city 132 kV cable tunnel ring to the alternate site. It is expected that it would be difficult to obtain a suitably sized parcel of land in a suitable location, and that the land purchase would be expensive as the land would most likely be developed.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	This is a strategic acquisition to allow an existing asset to be replaced at the end of its serviceable life. Demand management initiatives are considered as part of the overall strategy to maintain reliability of supply to the inner metropolitan area over the coming years as the expected retirement of ageing 132 kV cable infrastructure occurs. However, the retirement of Haymarket substation would represent a loss of approximately 800 MVA of supply capability into the inner city and CBD areas. It is not expected that this level of network support would be available within the confines of this area.
Preferred Network Option	At this stage, the preferred option is to purchase the Riley Street property immediately, and retain it as a site for the future replacement of Haymarket substation. This represents the most economic option for providing for the future replacement of Haymarket substation, as the site is currently available at a very modest cost due to its undeveloped nature. The site's proximity to the existing Ausgrid inner city 132 kV cable tunnel ring would negate the need for costly and disruptive capital works that would otherwise be required to provide access to the cable tunnel ring from an alternate site. The purchase represents a unique opportunity to obtain an ideally located site in an area within which it is expected to be increasingly difficult to purchase a suitably sized parcel of land due to the expected rejuvenation and development of the area, and the historic significance of many existing buildings.

7.2.2.4 Supply to the Beryl/Mudgee Area

Background

Beryl 132/66 kV Substation is supplied by two 132 kV transmission lines, the 53 km long 94B line from Wellington 330/132 kV Substation and the 125 km long 94M from Mt Piper 330/132 kV Substation. The 94M Mt Piper to Beryl 132 kV line also supplies 132 kV substations at Ilford and Mudgee via “tee” connection arrangements.

In recent years mines in the area have been developed or expanded. Further expansion is forecast to occur.

Nature of the Limitation

Based on the most recent load forecast, a voltage stability limitation in the network supplying Beryl is expected to emerge by summer 2015/16.

Possible Network Options

The following network options have been identified and considered to address the voltage stability limitation in supplying Beryl:

- Establishment of a 330/132 kV substation near Beryl, connected to the existing Wollar to Wellington 330 kV line;
- Provision of an additional 132 kV line between Wellington and Beryl; and
- Provision of additional reactive support at Beryl substation.

MW Load Reduction to Delay Limitation and Non-network Option Requirements

To defer the preferred network option, the following load reductions in the Beryl area would be required. Load reductions in the Mudgee area would also be effective, although the required magnitudes would be greater.

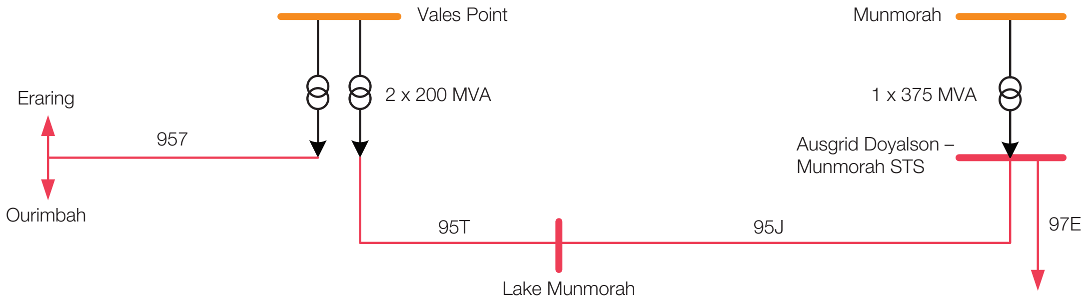
Summer Peak	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23
MW	0	1	1	2	3	3	4	4	5

Additional information is provided in Appendix 4.

Preferred Network Option

The provision of additional reactive support at Beryl substation at an estimated cost of around $2 M is considered to be the most cost effective network option as it is significantly cheaper than the other network options. That is, the other network options are not considered to be economically feasible.

7.2.2.5 Connection of Ausgrid's new subtransmission substation in the Munmorah/Doyalson area

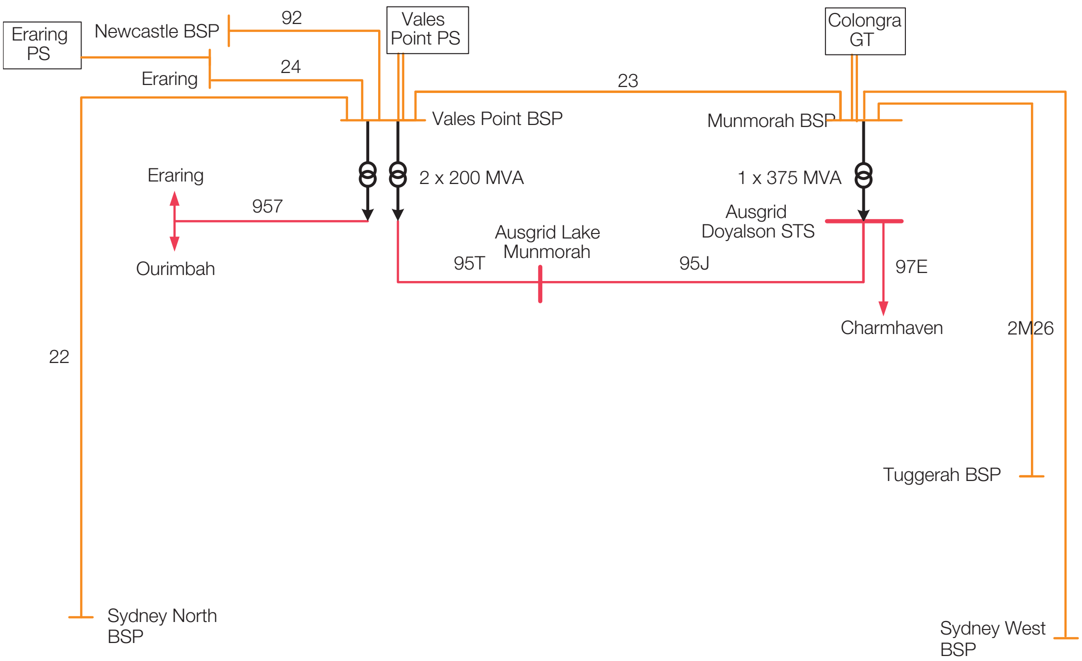
Background	Munmorah Power Station presently supplies the local Ausgrid load at 33 kV, which will be disconnected when the power station is retired in 2017. Ausgrid will need to establish a 33 kV supply, which they plan to do by establishing a new 132/33 kV subtransmission substation (STS) in the Doyalson/Munmorah area. This would also provide for any future 132 kV feeder connections. Neither Munmorah nor Vales Point substations have an established 132 kV busbar, and there is no space to establish a 132 kV busbar within the existing Munmorah Substation. TransGrid will need to provide for the connection of a 132 kV supply for Ausgrid's planned new STS. The final location of the STS is yet to be finalised. 
Nature of the Limitation	Supply to Munmorah/Doyalson once the present 33 kV supply from Munmorah power station is no longer available.
Possible Network Options	Options available to provide for connection for the Doyalson area STS include: • Connection provided at Munmorah Substation, requiring existing 132 kV lines into Munmorah Substation to be rearranged into the new Ausgrid STS, as shown in the figure above; and • Connection provided at Vales Point Substation, requiring TransGrid to establish a 132 kV busbar at Vales Point, and Ausgrid to construct a new 132 kV line between Vales Point and the new Munmorah/Doyalson STS.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	This project is to maintain supply to Ausgrid's 33 kV network, following the planned retirement of the present 33 kV supplies provided by Munmorah power station. A non-network option covering the entire load all of the time is not considered to be feasible.
Preferred Network Option	At this stage, the preferred network option is for Ausgrid's new STS to be connected to Munmorah substation, which will require less line works. Only minor TransGrid works are expected to be required.

7.2.2.6 Condition of Munmorah 330/132 kV Substation

Background

Munmorah Substation forms an integral part of the 330 kV transmission system on the Central Coast. It provides connection for the Colongra Power Station and supplies Ausgrid's 132 kV network through a single 375 MVA transformer.

NORTH CENTRAL COAST NETWORK 2017



Following the recent retirement of Munmorah Power Station, its generator connections to Munmorah Substation will be removed in 2014. The station supply transformer switchbays within Munmorah Substation are required until 2017 to provide supply to Ausgrid's local 33 kV network.

Nature of the Limitation

Asset Condition – Condition assessment of Munmorah Substation and its assets identified numerous items of equipment reaching the end of their serviceable life and substation issues which are required to be addressed.

Possible Network Options

A number of options were considered to address Munmorah Substation condition, including:

- Replacement of Munmorah Substation in-situ, or by a piecemeal approach
- Consolidation of Munmorah connections into Vales Point Substation
- Construction of a new large 330/132 kV substation to consolidate 330 kV and 132 kV connections in the area.

MW Load Reduction to Delay Limitation and Non-network Option Requirements

The replacement of Munmorah Substation is driven by the condition of the substation and its assets. The asset condition is based on assessments and testing carried out on the physical assets. A reduction in load would not defer the retirement dates.

A non-network option which could cost-effectively accommodate the substation load and compensate for the loss of connections on the 330 kV network, particularly those to Colongra power station, is not considered to be feasible.

Preferred Network Option

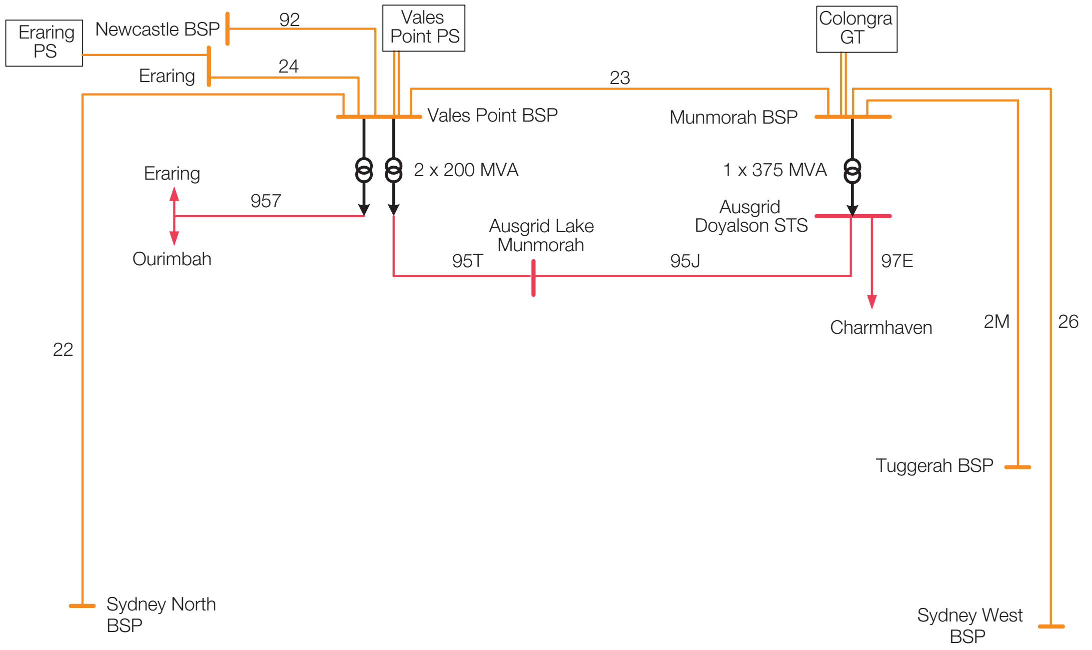
At this stage, the preferred network option is to rebuild the substation using a piecemeal approach. This is expected to cost around $30 M and to be completed in 2019. Future rearrangements may be significant as the network topology is likely to change depending on generation developments.

7.2.2.7 Condition of Vales Point 330/132 kV Substation

Background

Vales Point Substation forms an integral part of the 330 kV transmission system on the Central Coast. It provides connection for Vales Point Power Station and supplies Ausgrid's 132 kV network through two 200 MVA transformers.

NORTH CENTRAL COAST NETWORK 2017



Future connections at Vales Point are expected to supply Ausgrid's 132 kV network.

Nature of the Limitation

Asset Condition – Condition assessment of Vales Point Substation and its assets identified numerous items of equipment reaching the end of their serviceable life and substation issues which are required to be addressed.

Possible Network Options

A number of options were considered to address Vales Point Substation condition, including:

- Replacement of Vales Point Substation in-situ, or by a piecemeal approach;
- Consolidation of Munmorah connections into Vales Point Substation; and
- Construction of a new large 330/132 kV substation to consolidate 330 kV and 132 kV connections in the area.

MW Load Reduction to Delay Limitation and Non-network Option Requirements

The replacement of Vales Point Substation is driven by the condition of the substation and its assets. The asset condition is based on assessments and testing carried out on the physical assets. A reduction in load would not defer the retirement dates.

A non-network option which could cost-effectively accommodate the substation load and compensate for the loss of connections on the 330 kV network, particularly those to the existing Vales Point generators, is not considered to be feasible.

Preferred Network Option

At this stage, the preferred option is to address Vales Point substation condition by rebuilding the substation in-situ at a cost of around $44 M. This is expected to be completed in 2018.

7.2.2.8 Condition of 944 Wallerawang – Orange North 132 kV Transmission Line

Background	The 944 Wallerawang – Orange North wood pole 132 kV line was constructed in 1956/57. A condition assessment has identified that the line is near the end of its serviceable life. It was previously intended to rebuild the line, however with the moderation of peak demand forecasts in Central Western NSW, a cheaper option has become viable.
Nature of the Limitation	If 944 line was to be retired and not replaced, both thermal rating and/or voltage control limitations are expected to arise on parts of the network supplying the area on outage of either the 94X Wallerawang – Panorama or 949 Mt Piper – Orange North 132 kV line.
Possible Network Options	Possible network option include: • Replacement of the 944 line with a new 132 kV line; • Provision of a 330/132 kV substation in the Orange area; and • Substation works entailing the installation of series reactors to limit flows on critical lines together with the installation of shunt capacitors.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	Load reductions would not affect the need to retire the line. However, a load reduction of around 10 MW (depending on where it was located) would delay the onset of the limitations caused by retiring the line by a year.
Preferred Network Option	At this stage, the preferred network option is the substation works which are expected to cost around $15 M. It is expected to be completed in 2016/17 and would involve: • Provision of capacitor banks at Panorama and Orange 132/66 kV Substations and Orange North 132 kV Switching Station; • Provision of a 132 kV series reactor on the 94X Wallerawang – Panorama 132 kV line and later on the 949 Mt Piper – Orange North 132 kV; and • Removal of 944 line. Based on the most recent load forecast, this option is effective in managing the network limitations until beyond 2024.

7.2.2.9 Provision of a 66 kV Line Switchbay at Beryl 132/66 kV Substation

Background	The existing Beryl to Dunedoo supply is provided by a single (radial) 66 kV line.
Nature of the Limitation	Essential Energy plans to reinforce its network supplying Dunedoo and Coonabarabran.
Possible Network Options	The option analysis has been carried out by Essential Energy as part of the regulatory consultation process. The regulatory consultation documents which discuss the options considered are available on Essential Energy's website.
Preferred Network Option	The final report on the regulatory consultation available on Essential Energy's website concludes the most workable and least cost solution to reinforce supply to the Dunedoo and Coonabarabran areas is the construction of a second supply circuit from TransGrid's Beryl 132/66 kV Substation. TransGrid has been requested to provide a 66 kV line switchbay at Beryl Substation for the line connection.

7.2.2.10 Provision of a 66 kV Transformer Switchbay at Molong 132/66 kV Substation

Background	Molong Town is currently supplied by a single 66/11 kV transformer owned by Essential Energy at Molong 132/66 kV Substation. The backup supply is provided by the old Molong 66/11 kV substation owned by Essential Energy.
Nature of the Limitation	The old Molong 66/11 kV substation needs to be retired due to its condition.
Possible Network Options for Alleviation	The option analysis has been carried out by Essential Energy as part of its evaluation process.
Preferred Network Option	Essential Energy has proposed to install a second 66/11 kV transformer at Molong 132/66 kV Substation. The second transformer is to be utilised as a backup supply should the existing transformer be out of service. TransGrid has been requested to provide a 66 kV transformer switchbay at Molong Substation for the transformer connection.

7.2.2.11 Provision of a new 132 kV Line Switchbay at Vineyard 330/132 kV Substation

Background	Endeavour Energy is required to provide electricity supply to the new Marsden Park precinct in the North West Growth Area and has determined that it will be necessary to establish a new Marsden Park zone substation. Endeavour Energy has requested the provision of a 132 kV line switchbay at Vineyard to connect a new 132 kV line supplying its new Marsden Park zone substation.
Nature of the Limitation	The new precinct does not have an existing electricity supply. Endeavour Energy has determined that a new 132 kV feeder from Vineyard is the preferred option to provide supply to a new area.
Possible Network Options	The option analysis has been carried out by Endeavour Energy as part of the regulatory consultation process. The regulatory consultation documents which discuss the options considered are available on Endeavour Energy's website.
Preferred Network Option	Construction of a new 132 kV line switchbay to enable Endeavour Energy's line to be connected.

7.2.2.12 132 kV Fault Rating at Sydney West 330/132 kV Substation

Background	The present 132 kV fault level rating is limited by the rating of the existing 132 kV disconnectors. These disconnectors were installed in 1965 and their condition has been assessed to determine their remaining serviceable lives. The result is that the disconnectors are still functioning satisfactorily, but will likely need replacement by the mid-2020s. Another related project which is under construction, is the replacement of the Sydney West secondary systems. Cost savings can be made by including the preliminary design associated with replacement of the 132 kV disconnectors as part of this project.
Nature of the Limitation	The existing fault level at Sydney West 132 kV switchyard is approaching the design fault level rating of 32.8 kA and the operational arrangement of a split busbar is reducing the level of security compared to operation with a solid busbar. Further, any connection of new generation will increase the fault level of the 132 kV switchyard beyond its present rating (32.8 kA).
Possible Network Options	• Replace disconnectors within five years; • Replace disconnectors at a later stage; and • Install series reactors.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	Not applicable. A reduction in load would not affect the fault level at Sydney West.
Preferred Network Option	Replacement of equipment to ensure that the 132 kV fault rating is at least 38 kA, by 2015/16 at a cost of $5 M. This option removes any entry barriers for new environmentally friendly renewable generation (in particular if they are of small scale) that may be connected to transmission or distribution networks at or near Sydney West. It also recognises the wider shared benefits to all the parties connected to the network, such as improved power quality.

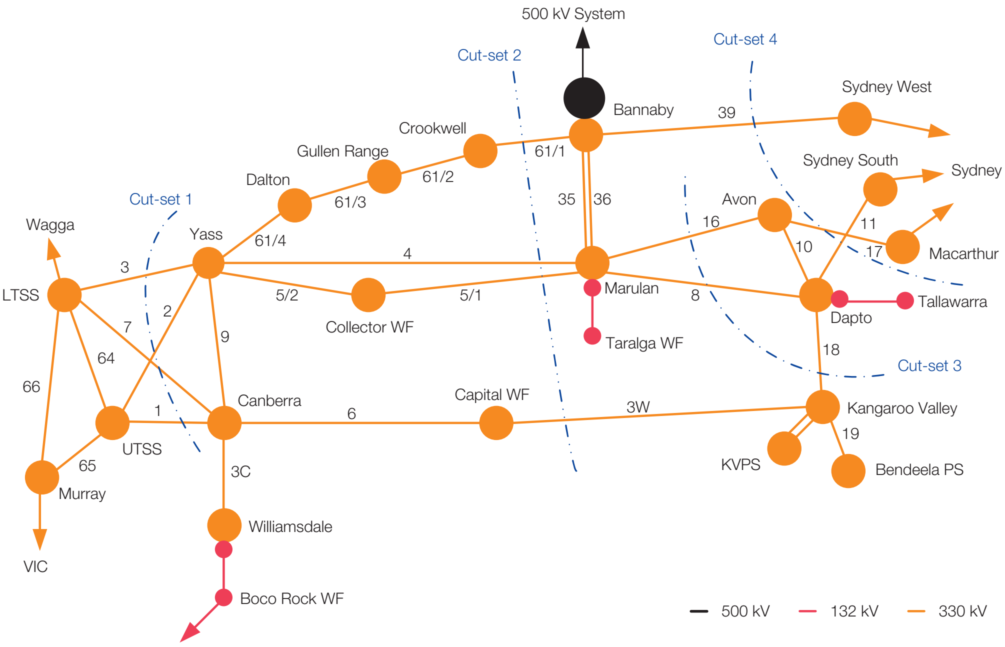
7.2.3 Southern System

7.2.3.1 Snowy to Sydney Network Capacity

Background

Preliminary market modelling indicates that there may be nett market benefits if parts of the network between Snowy and Sydney were to be uprated. The balance of this item considers three parts of the network between Snowy and Sydney (cut-sets 1, 2 and 4 in the Figure below). The remaining section (cut-set 3) is addressed in Section 7.3.3.1.

The Figure below shows existing network connections between Snowy and Sydney as well as existing and possible future generation in the area.



1. Capacity of Snowy to Yass/Canberra (cut-set 1)

The No 01 and 02 330 kV lines were designed to operate at a maximum temperature of 85°C. Recent aerial laser surveys show that remedial work is required on both lines to ensure that they can operate at that temperature.

Should there be a need to transfer higher levels of power across the Snowy to Yass / Canberra lines, uprating those lines may be cost effective. The increased power transfer could arise from:

- Increased Snowy generation;
- Increased import from South Australia and Victoria at times of high NSW and Queensland load;
- Load growth in Queensland and NSW; and
- Decommissioning or reduction of coal fired generation in NSW.

Preliminary market modelling indicates that increased Snowy – Canberra capacity may be cost effective.

2. Capacity of Yass/Canberra to Bannaby/Marulan (cut-set 2)

System studies have identified that the existing Yass/Canberra to Bannaby/Marulan network could be constrained under certain operating conditions if:

- The Snowy – Yass/Canberra network is upgraded and generation from Victoria and Snowy is transferred to NSW to the maximum capacity allowed by those works; and
- The present and future wind farms which are connected to the southern network are generating at or near their maximum capacities.

3. Capacity of Bannaby/Avon/Dapto – Sydney (cut-set 4)

System studies have identified that the capacity of the 39 Bannaby - Sydney West line could be exceeded if the three wind farms presently under construction (Boco Rock, Gullen range and Taralga) are operating at their maximum capacity, even without any increase in the Snowy to Yass/Canberra capacity.

Limitations in this part of the network would increase if some the other proposed generation comes to fruition.

Nature of the Limitation	This is a market benefits driven project, contingent on new generation development in southern NSW. Given the uncertainties presently surrounding generation developments, decommissioning, mothballing and re-powering, it is difficult to predict the most opportune time to increase transmission capacity. Preliminary market modelling indicates that there may be positive market benefits from 2015.
Target Date	This would be determined by detailed market modelling. Should any line upgrades be warranted, it may be possible to undertake them in conjunction with the planned transmission line remediation work in the area.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	The preliminary market modelling is not sufficiently detailed to allow the performance requirements for non-network options to be determined. Consequently, they are not available at this stage.
Possible Network Options	A range of options are being investigated including: 1. Capacity of Snowy to Yass/Canberra (cut-set 1): • Implementation of a system protection scheme and procurement of network support contract with a suitable load and generator; • Upgrading of the Upper Tumut – Yass and Upper Tumut – Canberra 330 kV lines. This requires work in the sensitive national park areas of the Snowy; and • Installation of power flow control plant such as series capacitors or phase shifting transformers (PST) to improve the sharing of power flows in the four lines under contingency conditions. 2. Capacity of Yass/Canberra to Bannaby/Marulan (cut-set 2): • Upgrade of lines 4 and 5 to 100°C operating temperature; • Upgrade of lines 4 and 5 to 100°C operating temperature & Installation of a PST on line 61 at Bannaby; and • Upgrade of lines 4 and 5 to 100°C operating temperature & Installation of PSTs on line 61 at Bannaby and on line 5 at Marulan. 3. Capacity of Bannaby/Avon/Dapto – Sydney (cut-set 4): • Upgrade of line 39 to 100°C operating temperature; • Installation of a PST on line 39 at Bannaby; and • Upgrade of line 39 to 100°C operating temperature and installation of a PST on line 39 at Bannaby.
Preferred Network Option	It is expected that cost effective options to increase the capacity of the network between Snowy and Sydney (if any) would be identified by market modelling. At this stage there is no preferred network option. However, should any upgrading be appropriate, it is presently expected that it could entail one or more of the following: • Uprating of Line 01 to 100°C operating temperature (around $5 M); • Uprating of Line 39 to 100°C operating temperature (around $7 M); • Uprating of Lines 4 and 5 to 100°C operating temperature (around $26 M); • Installation of a PST at Bannaby on Line 39 (around $40 M); and • Replacing terminal equipment on Line 11 at Dapto and Sydney South (around $2 M).

7.2.3.2 Murraylink Runback Control Scheme

Background	There are presently a number of runback schemes on Murraylink covering contingencies in the Victorian and South Australian networks, including: • Murraylink automatic slow runback control (Victoria); • Murraylink very fast runback scheme (Victoria); • Automatic sever trip (South Australia); and • Automatic runback scheme (South Australia). These schemes allow higher pre-contingency flows on Murraylink due to automatic post-contingency action returning the network to a secure state. A fast runback control scheme has been installed for some substations in the NSW network, however this scheme has not yet been placed into service due to the lack of communication link. Without the NSW runback scheme enabled, Murraylink transfers to SA may be limited to near zero under high demand conditions in NSW. The remaining communication works are to be completed by the owner of Murraylink. Murraylink Transmission Company has proposed to complete the communication link works and commission the NSW runback scheme during 2013/14 in their revised revenue proposal for 2013 – 2018.
Nature of the Limitation	This is a reliability driven project.
Target Date	2014
MW Load Reduction to Delay Limitation and Non-network Option Requirements	As this limitation is being addressed by Murraylink, TransGrid has not identified or investigated any other options.
Preferred Network Option	Complete the communication link works and commission the NSW runback scheme. This project would be funded and implemented by the owner of Murraylink.

7.2.3.3 Condition of Canberra Substation

Background	Canberra 330/132 kV Substation was commissioned in 1967 and supplies Queanbeyan substation and the ActewAGL 132 kV sub-transmission network. Canberra substation forms an integral part of the transmission interconnection between the Victorian and Snowy regions to the rest of NSW.
Nature of the Limitation	Asset Condition – Condition assessments of Canberra Substation and its assets identified numerous items of equipment reaching the end of their serviceable life and substation issues which are required to be addressed.
Possible Network Options for Alleviation	A number of options are being considered to address the Canberra substation condition, including: • Replacement of Canberra substation in-situ or by a piecemeal approach; and • Rebuild of Canberra substation across two interconnected sites, on an adjacent site, or at a location remote from the existing substation.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	The replacement of Canberra Substation is driven by the condition of the substation and its assets. The asset condition is based on assessments and testing carried out on the physical assets. A reduction in load would not defer the retirement dates. The retirement of Canberra substation is not a feasible option as the ACT government's requirement for two independent supply points could not then be met. Similarly, non-network options cannot meet this requirement.
Preferred Network Option	At this stage, the preferred option is to address the Canberra substation condition through a program of piecemeal replacements to be completed during 2019 at a cost of around $58 M.

7.2.3.4 Condition of Burrinjuck Substation

Background	Burrinjuck 132/11 kV Substation was commissioned in 1944 and connects Burrinjuck Dam hydro generation to the Yass – Wagga 132 kV sub-transmission system via Tumut, as well as providing supply to the Burrinjuck village.
Nature of the Limitation	Asset Condition – Condition assessments of Burrinjuck substation and its assets identified numerous items of equipment reaching the end of their serviceable life and substation issues which are required to be addressed.
Possible Network Options for Alleviation	A number of options are being considered to address the Burrinjuck substation condition, including: • Replacement of Burrinjuck Substation in-situ by a piecemeal approach; • Rebuild of Burrinjuck Substation across two interconnected sites, on an adjacent site, or at a location remote from the existing substation; • Replacement of Burrinjuck Substation in-situ using gas insulated switchgear; and • Eliminating the need for a 132 kV busbar by either forming a tee connection to the 132/11 kV transformer or rebuilding the 970 Yass – Burrinjuck 132 kV line as a double circuit to provide a dedicated connection from Yass to Burrinjuck.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	The replacement of Burrinjuck Substation is driven by the condition of the substation and its assets. The asset condition is based on assessments and testing carried out on the physical assets. A reduction in load would not defer the need for retirements. In particular, a reduction in load would not remove the need to provide a connection for the hydro generator.
Preferred Network Option	Discussions with affected parties on the various options are ongoing. However, at this stage, the preferred option is to rebuild Burrinjuck substation on the existing site using gas-insulated switchgear. This is expected to cost around $13 M and would be completed in 2019.

7.2.3.5 Condition of Wagga 132/66 kV Substation

Background	Wagga 132 kV Substation was commissioned in 1955 and supplies the Wagga township and the surrounding area load. Wagga 132 kV Substation is supplied by Wagga 330 kV Substation which also supplies Wagga North Substation. Wagga 132 kV Substation also provides a second supply to Wagga North.
Nature of the Limitation	Asset Condition – Condition assessments of Wagga 132 kV Substation and its assets identified numerous items of equipment reaching the end of their serviceable life and substation issues which are required to be addressed. This includes the No 2 and No 3 132/66/11 kV transformers.
Possible Network Options for Alleviation	A number of options are being considered to address the Wagga substation condition, including: • Rebuilding of Wagga substation in-situ or by a piecemeal approach; and • Rebuild of Wagga substation across two interconnected sites, on an adjacent site, or at a location remote from the existing substation.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	The replacement of Wagga substation is driven by the condition of the substation and its assets. The asset condition is based on assessments and testing carried out on the physical assets. A reduction in load would not defer the retirement dates. To allow the substation to be retired, a non-network option would need to accommodate the majority of the load (some would be able to be transferred to Wagga North and Morven) all of the time, which is not considered to be feasible.
Preferred Network Option	At this stage, the preferred option is to address the Wagga 132 kV substation condition by rebuilding on the existing site using air-insulated switchgear by 2020 at a cost of around $52 M. This would entail: • Replacement of the three 60 MVA transformers with two 120 MVA units; • Provision of new transformer compounds, 132 kV and 66 kV busbars and switchbays; • Replacement of the 66 kV capacitor bank; • Stage rebuilding of the remaining switchyard equipment; and • Provision of new control, protection and metering panels and secondary cabling.

7.2.3.6 Provision of a New 132 kV Switchbay at Williamsdale 330/132 kV Substation

Background	Essential Energy is establishing a 132 kV zone substation to supply a new development at Googong. This will initially be supplied by a 132 kV line from TransGrid's Queanbeyan Substation.
Nature of the Limitation	When the Googong town load grows sufficiently, it will require a second 132 kV supply.
Possible Network Options for Alleviation	Essential Energy has advised that a Williamsdale to Googong 132 kV line is planned as the second supply. This is currently expected around 2018 and would require TransGrid to provide a 132 kV switchbay at Williamsdale.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	The connection of Googong to Williamsdale Substation is required to meet the customer's reliability requirements. As the limitation is within Essential Energy's network TransGrid has not developed or assessed options to address it.
Preferred Network Option	The preferred option is to install a switchbay Williamsdale Substation at the request of Essential Energy.

7.2.4 Line Switchbays for Distributor Requirements Within Five Years

The following table summarises possible projects for the provision of line switchbays to meet NSW distributors' requirements within five years.

TABLE 7.1 – POSSIBLE LINE SWITCHBAYS FOR DISTRIBUTOR REQUIREMENTS WITHIN FIVE YEARS

Location	Installation	Indicative Date	Distributor
Beryl 132/66 kV substation	One 66 kV switchbay	2015	Essential Energy
Molong 132/66 kV Substation	One 66 kV switchbay	2015	Essential Energy
Vineyard 132/66 kV Substation	One 132 kV switchbay	2018	Endeavour Energy
Williamsdale 330/132 kV Substation	One 132 kV switchbay	2018	Essential Energy

7.2.5 Other Possible Network Asset Replacements Within Five Years

The following table summarises other possible network asset replacements within five years.

TABLE 7.2 – OTHER POSSIBLE NETWORK ASSET REPLACEMENTS WITHIN FIVE YEARS

Project	Location	Scope of Works	Possible Commissioning Date	Indicative Cost
Sydney North Secondary System Replacement	Sydney North substation Sydney metropolitan area	The secondary systems at Sydney North Substation will be replaced using six yard-based Secondary Systems Buildings (SSBs)	2019	$42 M
Armidale Secondary System Replacement	Armidale substation Northern NSW	In-situ replacement of the existing control and protection panels within the existing control room, retaining the existing LV cabling	2019	$15 M
Sydney North – Tuggerah Line 21 Tower Life Extension	Sydney North – Tuggerah 330 kV line 21 Sydney metropolitan area to Central Coast	Refurbishment of the Sydney North – Tuggerah 330 kV line 21 line, from Sydney North to Sterland	2015	$5 M
Line 959/92Z Tower Life Extension	Sydney metropolitan area	Refurbishment of the Sydney North – Sydney East 132 kV line 959/92Z line	2019	$8 M
Deniliquin Secondary Systems Replacement	Deniliquin substation Southern NSW	In-situ replacement of the existing control and protection panels within the existing control room	2018	$6 M
Uranquinty – Yanco 132 kV line 99F pole replacement	Uranquinty – Yanco 132 kV line 99F Southern NSW	Installation of new line structures and associated equipment on the Uranquinty – Yanco 132 kV line 99F	2018	$27 M
Albury Secondary Systems Replacement	Albury substation Southern NSW	Replace the TransGrid owned secondary systems and associated cabling at Albury 132/22 kV Substation in a new SSB	2016	$11 M
ANM Secondary System Replacement	Australian Newsprint Mills (ANM) Substation Southern NSW	Replacement of secondary systems	2018	$5 M
Dapto – Marulan Line 8 Tower Life Extension	Dapto – Marulan 330 kV line 8. Metropolitan/Central NSW	Refurbishment of the Dapto – Marulan line 8 (between structures 118 to 175)	2016	$3 M
Sydney South – Dapto Line 11 Condition	Sydney South – Dapto 330 kV line 11 Metropolitan/Central NSW	Painting of the remainder of the tension structures and the previously blasted structures	2017	$3 M
Kangaroo Valley Secondary System Replacement	Kangaroo Valley Substation Metropolitan/Central NSW	Replacement of the secondary systems and LV cabling using a SSB	2016	$6 M
Munmorah – Tuggerah Line 2M Tower Life Extension	Munmorah – Tuggerah 330 kV line 2M NSW Central Coast	Refurbishment of Munmorah – Tuggerah 330 kV line 2M (from Munmorah to Sterland)	2019	$1 M
Cooma – Munyang 132 kV Line 97K Rehabilitation	Munyang – Cooma 132 kV line 97K Southern NSW	Remediation of low spans on the Munyang – Cooma line 97K	2018	$16 M
Yanco – Griffith 132 kV Line 99J Rebuild	Yanco – Griffith 132 kV line 99J Southern NSW	Replacement of the Yanco – Griffith 132 kV line 99J	2018	$13 M
Coffs Harbour – Koolkhan 132 kV Line 96H	Coffs Harbour to Koolkhan 132 kV line 96H Northern NSW	Installation of new line structures and associated equipment on the Coffs Harbour – Koolkhan 132 kV line 96H line	2016	$14 M
Taree 132 kV Substation Secondary Systems Condition	Taree Substation. Northern NSW	Replacement of the secondary systems and LV cabling using a SSB for each voltage level	2018	$26 M

Project	Location	Scope of Works	Possible Commissioning Date	Indicative Cost
Taree Substation 33 kV Switchyard Condition	Taree Substation Northern NSW	Replacement of the present air insulated switchgear with gas insulated switchgear in a prefabricated building. The secondary systems associated with the 33 kV switchgear will also be replaced.	2018	$9 M
Snowy – Yass/Canberra 330 kV Lines 1 and 2 Remediation	Upper Tumut – Canberra 330 kV line 1 and Upper Tumut – Yass 330 kV line 2 Southern NSW	Remediation of low spans on the Upper Tumut – Canberra 330 kV line 1 and Upper Tumut – Yass 330 kV line 2 and replacement of some terminal equipment at Upper Tumut	2019	$29 M
Low Spans Northern Tower Lines	Central Coast Hunter Valley Northern NSW.	Remedial works to restore conductor clearances on 137 spans across 12 330 kV transmission lines in the northern region	2019	$6 M[1]
Low Spans Northern Pole Lines	Central Coast Hunter Valley Northern NSW	Remedial works to restore conductor clearances on 263 spans across 14 132 kV transmission lines in the northern region	2019	$12 M[1]
Low Spans Central Tower Lines	NSW metropolitan area	Remedial works to restore conductor clearances on 151 spans across 13 330 kV transmission lines in the central region	2019	$6 M[1]
Low Spans Central Pole Lines	Central West NSW	Remedial works to restore conductor clearances on 152 spans across 10 132 kV transmission lines in the central region	2019	$7 M[1]
Low Spans Southern Tower Lines	Southern NSW	Remedial works to restore conductor clearances on 45 spans across 11 330 kV transmission lines in the southern region	2019	$4 M[1]
Low Spans Southern Pole Lines	Southern NSW	Remedial works to restore conductor clearances on 150 spans across 14 132 kV transmission lines in the southern region	2019	$7 M[1]
Broken Hill 220/22 kV Substation replacement of No 1 and No 2 Reactors	Western NSW	Replacement of the existing 220 kV 25 MVAr No 1 & 2 reactors	2018	$9 M
Forbes No 1 and No 2 132/66 kV transformer replacement	Central Western NSW	Replacement of Forbes 60 MVA transformers with transformers of the same size (TransGrid's smallest standard size)	2018	$8 M
Beaconsfield Transformer No 1 & No 2 replacement	Sydney metropolitan area.	Replacement of the existing transformers with one system spare and one 'factory' refurbished unit	2018	$37 M
Burrinjuck to Yass 132 kV Transmission Line 970 Pole Replacements	Southern NSW	Replacement of all wood pole structures with concrete poles	2016	$13 M
Sydney North to Vales Point 330 kV Transmission Line Tower Life Extension	Central Coast NSW	Replacement of all suspension towers and painting of all tension towers	2017	$9 M

1. Indicative costs of works within the five years

Project	Location	Scope of Works	Possible Commissioning Date	Indicative Cost
Sydney South 330 kV Substation	Sydney metropolitan area	Replacement of all 415 V AC auxiliary supply systems	2017	$6 M
Haymarket 330 kV Substation Secondary Systems Replacement	Haymarket Substation. Sydney metropolitan area	Replacement of the secondary systems	2018	$9 M
Murrumburrah 132 kV Substation Secondary Systems Replacement	Murrumburrah Substation. Southern NSW	Replacement of the secondary systems and cabling	2019	$5 M

7.3 POSSIBLE NETWORK DEVELOPMENTS WITHIN FIVE TO TEN YEARS

7.3.1 Northern System

7.3.1.1 Tamworth and Armidale 330 kV Switchyards

Background

The 330 kV switchyards at Tamworth and Armidale were originally constructed to service the relatively small loads in northern NSW when there was a limited 330 kV network development extending north of Liddell. The switchyards are configured with single busbars and bus section circuit breakers.

The establishment of QNI and the connection of an SVC at Armidale changed the utilisation of the substations from serving local loads to being critical switching stations and, in the case of Armidale, voltage support points for high transfers on QNI.

In the future it is expected that there may be new wind farms and gas-fired generation developments in the area, and higher power transfers between NSW and Queensland.

Nature of the Limitation

This project is market benefit driven and is contingent on QNI being upgraded.

Possible Network Options

A set of options and staging strategies that may be viable for the redevelopment of the Armidale and Tamworth Substations are:

- Expansion of the Tamworth Substation in the form of an additional section on the existing single bus;
- Rebuilding the substation now in a breaker-and-a-half configuration to obtain the level of reliability improvements;
- Rebuilding the substation in a breaker-and-a-half configuration at a time in the future, when the condition of existing assets reach the end of their serviceable life; and
- Staged development of a second switchyard in a breaker-and-a-half configuration adjacent to the existing switchyard.

At this stage, the preferred option, should any development be warranted, is to develop a new 330 kV switchyard with a breaker-and-a-half arrangement to make these switchyards compatible with other major main system switchyards. Consideration is being given to the feasibility of re-constructing the switchyards within the existing site boundaries. TransGrid is also presently in the process of identifying potential sites for the new switchyards should it not be feasible to achieve an in-situ development

7.3.1.2 Hunter Valley – Tamworth – Armidale 330 kV System Capacity

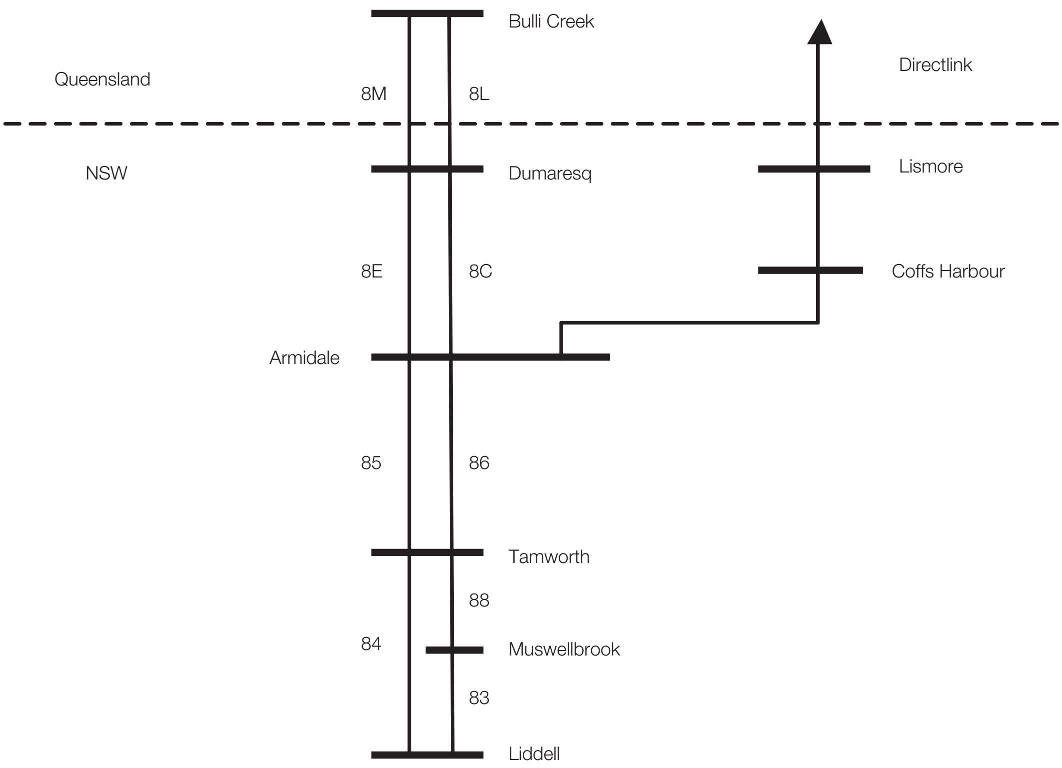
Background

The northern NSW supply system is shown in the following figure. The 330 kV system extends north from Liddell to Armidale via Muswellbrook and Tamworth. The system comprises essentially four 330 kV lines:

- 84 Liddell – Tamworth line;
- 83 and 88 Liddell – Tamworth via Muswellbrook lines;
- 85 Tamworth – Armidale line; and
- 86 Tamworth – Armidale line.

The 330 kV lines are conventional steel tower design, except for the 86 Tamworth – Armidale line, which is a wood pole line with relatively small conductors.

The capacity limitations may arise from increased generation export to / import from Queensland and increased generation developments (gas, solar and wind) in the northern NSW. Recent de-rating on Line 83 and 84 have imposed further thermal limitations on the capability for NSW export to Queensland at times of high northern load.



Nature of the Limitation

This project is contingent on QNI being upgraded and new generation being connected in northern NSW.

Possible Network Options

Should load development in the northern area and upgrading of the power transfer levels with Queensland occur, the augmentation of the transmission system using one or a combination of the following options may be cost effective:

- Uprating the Line 83, 84, 85 and 88 from 85°C to 120°C operating temperature;
- New Single Circuit 330 kV Line from Liddell to Tamworth; and
- New Double Circuit 330 kV Line on a new route from Liddell to Tamworth.

7.3.1.3 Voltage Control in Northern NSW

Background	The 330 kV system extends north beyond Armidale to Dumaresq and forms part of the interconnection with Queensland over the Queensland/New South Wales Interconnector (QNI). The power transfer capability north from Liddell, to supply the northern NSW loads and export of power to Queensland, is partly governed by line thermal ratings, the ability to maintain adequate voltage levels and transient stability limitations. The power transfer capability of the system is dependent on load levels and the dispatch of generators across the NEM. At present, the ability to maintain adequate voltage levels is the most constraining limitation on the NSW export capability to Queensland under a wide range of operating conditions. In particular the ability to maintain adequate voltage levels at Tamworth, Armidale and Dumaresq is critical.
Nature of the Limitation	This project is contingent on QNI being upgraded and new generation being connected in northern NSW.
Possible Network Options	Should QNI be upgraded, it is expected that an effective way of managing voltage stability limitations would be to install additional capacitors in the area.

7.3.1.4 Supply to the Forster/Tuncurry Area

Background	The load in the Forster/Tuncurry area is approaching the capacity of Essential Energy's 66 kV network supplying the area from Taree. The limitation is not expected to arise before 2020.
Possible Network Options	Essential Energy and TransGrid are considering a number of options to relieve the limitation, including: • Local generation and/or demand management • Reinforcing the existing Essential Energy network by providing an additional line from Taree or uprating the existing lines, or • The construction of a 132/66 kV substation in the Hallidays Point area. The substation would be supplied from the existing TransGrid 963 Tomago – Taree 132 kV line. New sections of 132 kV and 66 kV lines would form connections to the new substation.

7.3.2 Central System

7.3.2.1 Newcastle Substation Condition

Background	Newcastle Substation is a focal point for 330 kV connections to generators (Liddell, Eraring, and Vales Point power stations), and major bulk supply points (at Waratah West and Tomago). It also provides significant supply capacity to Ausgrid's 132 kV network through the 330/132 kV transformers. Significant parts of Newcastle Substation (est. 1969) are in poor condition as the original equipment is approaching their end of their serviceable lives. The original transformers were previously identified as being in poor condition and will be replaced under a separate project (refer to Section 6.2.5).
Nature of the Limitation	Condition of Newcastle Substation. The need date to address the condition issues at Newcastle is 2020. The substation is required to meet the present and future demand in the area, and provide a focal point for seven 330 kV connections.
Possible Network Options	Options available to address these limitations include: • Rebuild Newcastle Substation within the existing site in a piecemeal fashion; • Rebuild Newcastle Substation adjacent to the existing site; and • Rebuild Newcastle Substation split between the existing site and an adjacent site. The piecemeal reconstruction is the least cost option to rebuild the substation. It addresses the identified targeted asset replacements and substation condition issues over six years at a cost of around $51 M. The transformers will be replaced prior to this project and will be retained under the rebuild.
MW Load Reduction to Delay Limitation and Non-network Option Requirements	A reduction in load would not affect the retirement dates. Non-network options which would allow Newcastle substation to be retired are not considered to be feasible considering the importance of Newcastle substation to the NSW 330 kV and 500 kV network and to the 132 kV network in the Newcastle area.
Preferred Network Option	The preferred network option at this stage is to rebuild Newcastle Substation. The 132 kV network in the future may change depending on industrial load developments. However, Newcastle is likely to remain the focal point for 330 kV circuits in the area given the number of existing connections.

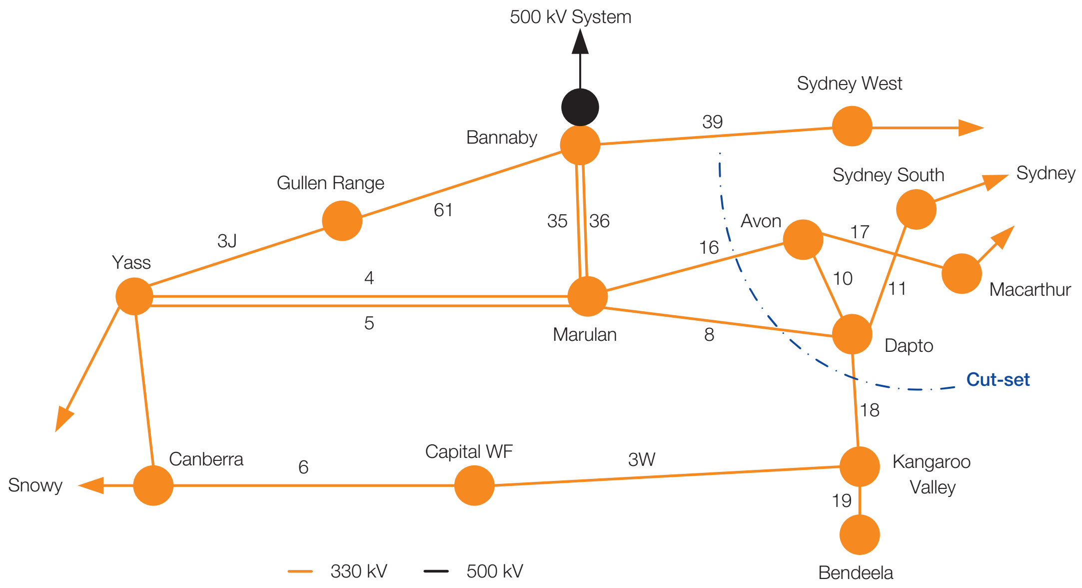
7.3.3 Southern System

7.3.3.1 Capacity of the Marulan – Avon, Marulan – Dapto and Kangaroo Valley – Dapto Lines

Background

The lines 8, 16 and 18 form the cut-set supplying Sydney/Wollongong area from the south of Sydney.

The existing 330 kV connections between Marulan/Kangaroo Valley and Avon/Dapto are shown in the Figure below.



In the long term lines 8, 16 and 18 may all have thermal rating limitations should additional generators be connected to the southern network.

Nature of the Limitation

This is a market driven project.

Target Date

Contingent on generation developments occurring and there being market benefit in relieving the consequent limitations.

Possible Network Options

Various options are to be investigated including:

- Special Protection Scheme (SPS) – Generation runback scheme;
- Upgrading of line 18 to 100°C operating temperature;
- Upgrading of lines 8 and 16 to 100°C operating temperature;
- New line development from KVSS to Dapto; and
- Rebuild line 18 as a double circuit.

Preferred Network Option

Should any development be appropriate, at this stage it is anticipated that it may be to upgrade line 18 to 100°C operating temperature.

7.3.4 Line Switchbays for Distributor Requirements within Five to Ten Years

The following table summarises possible line switchbay for Distributor requirements within five to ten years.

TABLE 7.3 – POSSIBLE LINE SWITCHBAYS FOR DISTRIBUTOR REQUIREMENTS WITHIN FIVE TO TEN YEARS

Location	Installation	Indicative Date	Distributor
Lismore	Two 132 kV switchbays	Beyond 2019	Essential Energy
Tamworth 132/66 kV Substation	One 66 kV switchbay	Beyond 2019	Essential Energy
Tumut 132/66 kV Substation	One 66 kV switchbay	Beyond 2019	Essential Energy

7.3.5 Other Possible Network Asset Replacements within Five to Ten Years

The following table summarises other possible Network Asset Replacements Projects within five to ten years.

TABLE 7.4 – OTHER POSSIBLE NETWORK ASSET REPLACEMENTS WITHIN FIVE TO TEN YEARS

Project	Location	Scope of Works	Possible Commissioning Date	Indicative Cost
Beryl Secondary Systems Replacement	Beryl substation. Central Western NSW.	In-situ replacement of the existing control and protection panels within the existing control room.	2020	$6 M

7.4 POSSIBLE DEVELOPMENTS BEYOND TEN YEARS

7.4.1 Northern System

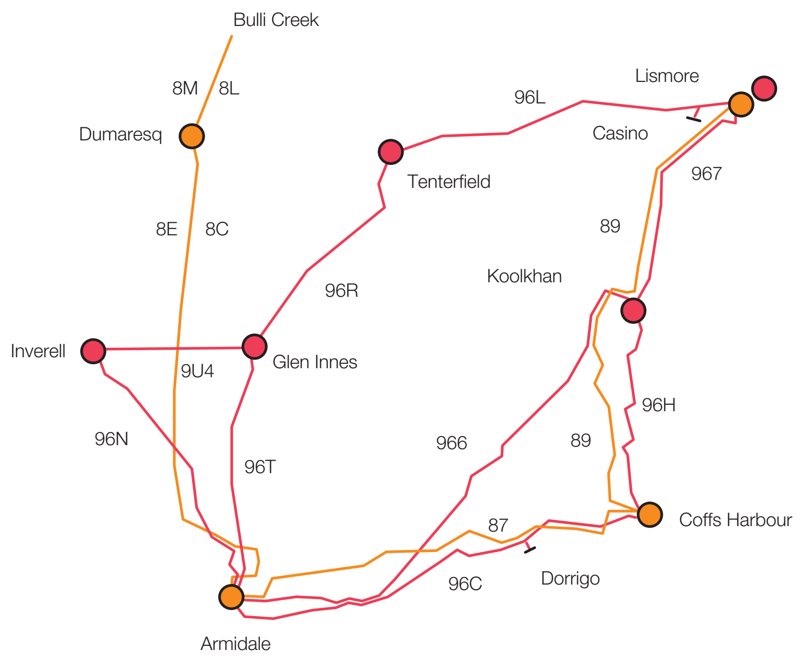
7.4.1.1 Supply to Far North NSW

The far north coast area of NSW includes the Ballina, Bellingen, Byron, Clarence Valley, Coffs Harbour, Kyogle, Lismore and Richmond Valley local government areas.

Supply to the area is limited by the thermal rating limitations on 132 kV lines on outage of the Armidale – Coffs Harbour 330 kV line (refer to the diagram).

The onset and severity of this limitation is dependent on the amount of network support available from Queensland via Directlink and the level of flows on QNI.

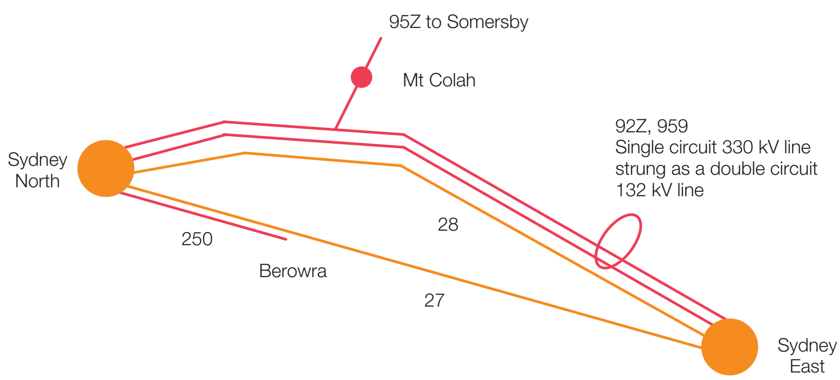
The limitation is not expected to occur within the next ten years.



7.4.2 Central System

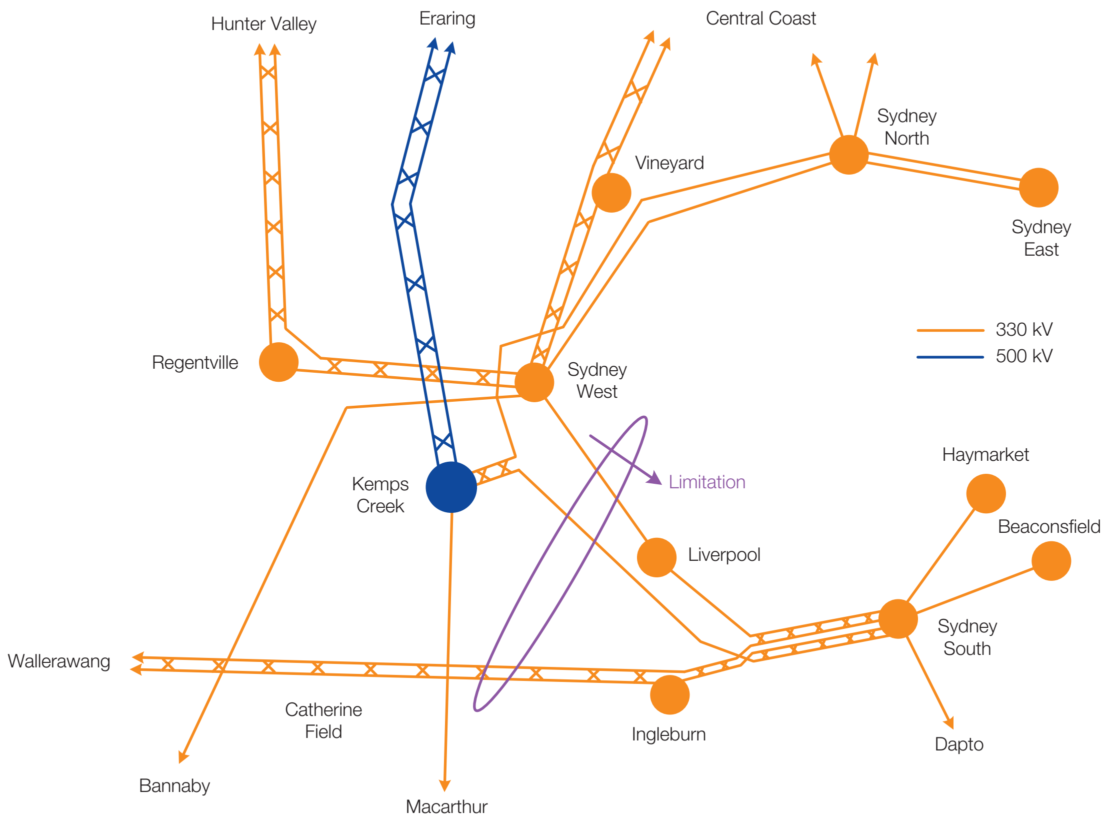
7.4.2.1 Supply to Sydney East

The Sydney East 330/132 kV Substation is supplied via two 330 kV overhead lines from Sydney North. This is supported by a third 330 kV line that is presently operated as two 132 kV circuits. In the longer term, the growing Sydney East load is expected to require augmentation of the capacity of the transmission system. However, this need is not expected to arise within ten years.



CONNECTION BETWEEN SYDNEY NORTH AND SYDNEY EAST

SOUTHERN AND WESTERN SYDNEY MAIN SYSTEM



7.4.2.2 Supply to Southern Sydney

Supply to the greater Sydney area is provided via major 500 kV and 330 kV substations at Kemps Creek, Sydney North, Sydney East, Sydney West, Sydney South, Vineyard, Regentville, Liverpool, Ingleburn, Macarthur, Beaconsfield and Haymarket; as shown in the Figure.

These substations are interconnected with the state's power stations to the north and west of Sydney and the main grid to the south.

The load areas of Sydney South, Liverpool and Ingleburn and the CBD substations at Beaconsfield and Haymarket are, in effect, supplied by four 330 kV overhead circuits from Wallerawang in western NSW and Kemps Creek and Sydney West substations in western Sydney.

In the TAPR 2013, it was identified that following a forced outage of one of the four 330 kV circuits under high system load conditions the remaining circuits would be heavily loaded.

Due to the reduced load growth, this need is now not expected to emerge within ten years.

7.4.2.3 Loading of the Wallerawang – Sydney South/Ingleburn 330 kV Lines

In the TAPR 2013, it was identified that the double circuit 330 kV line (circuits 76 and 77) from Wallerawang across the Blue Mountains to Sydney South and Ingleburn can be heavily loaded at times of high western and northern generation.

There is potential for the loading on the line to reach the rating of the line terminal equipment under future generation development scenarios. TransGrid proposed to review the potential loading conditions and rating of the terminal equipment to determine the need for uprating of that equipment. Based on the most recent forecast, this limitation is not expected to arise within ten years.

7.4.2.4 Kemps Creek 500/330 kV Transformer Capability

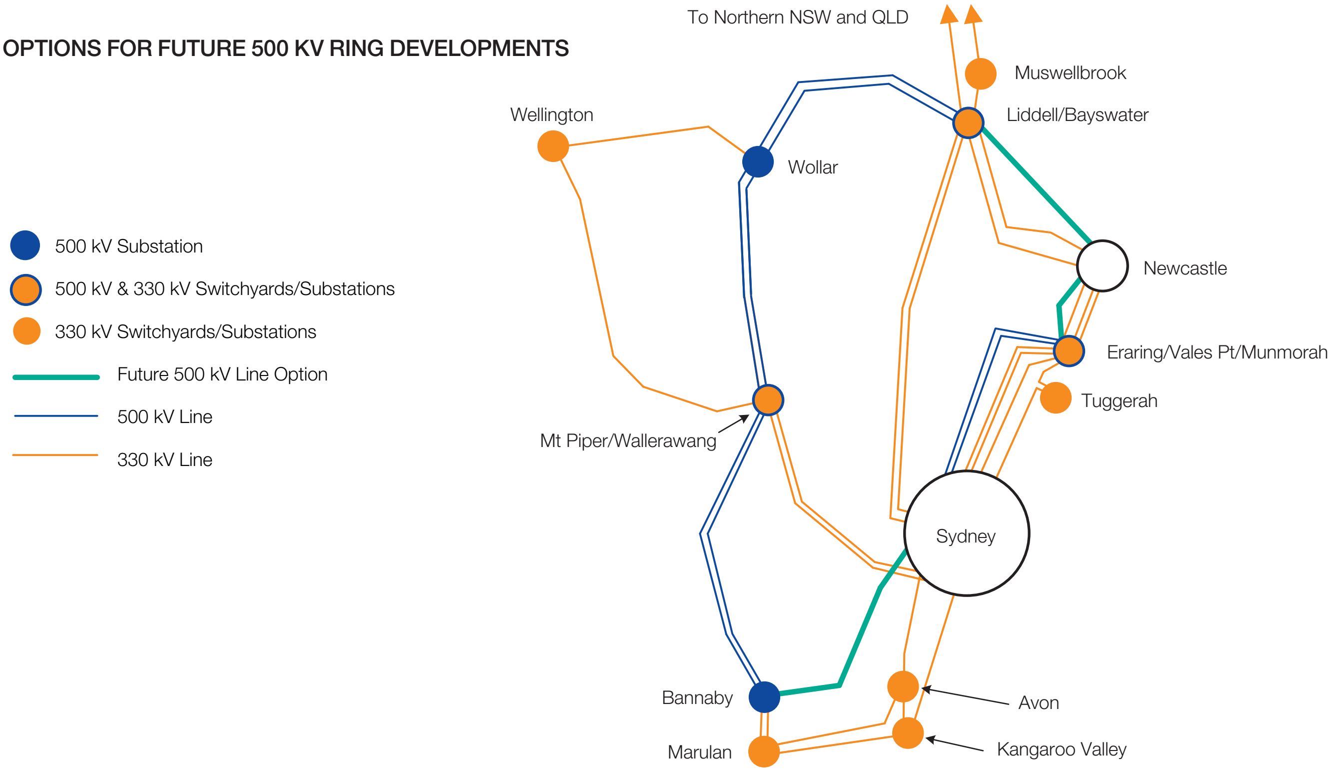
The two 500/330 kV transformers (installed in the early 1980s) at Kemps Creek have a fixed ratio. The voltage levels on the 330 kV system in the Sydney area are then directly tied to the voltage levels on the 500 kV system.

There are opportunities to maximise the reactive power capability of the Sydney supply system by replacing the fixed ratio transformers with transformers with on-load tap changing facilities. Maximising the reactive capability would effectively defer the need for additional line development to the Sydney area.

In the longer term additional 500/330 kV transformer capacity may be required in Sydney. This may be achieved by additional transformers at Kemps Creek or at other sites.

These limitations are not expected to arise within ten years due to the reduced load growth.

OPTIONS FOR FUTURE 500 KV RING DEVELOPMENTS



7.4.2.5 Further Development of Supply to the Newcastle – Sydney – Wollongong Area

The Newcastle – Sydney – Wollongong area includes significant urban, commercial and industrial loads. At the time of peak demand in NSW this area represents about three quarters of the NSW total load and about one-third of the total load across the NEM. The area is supplied from remote power stations in NSW over a 500 kV and 330 kV network and from power stations within the area on the Central Coast, South Coast and Sydney area.

It is expected that this load growth in the area will be partially met by new generation developments within the load area. However, connection of additional generators within the area is technically restricted by limitations in the fault interrupting capability of major substation equipment. Environmental and social constraints also restrict the feasibility of siting significant quantities of new generation near the urbanised areas. With the generation development occurring outside of the load area, there will be a need for network reinforcement or alternative non-network solutions to ensure that there is sufficient network capability to transmit the output of generators to the major load centres in NSW at an acceptable standard of reliability. The network reinforcements are expected to be achieved through sequence installations of reactive plants and power flow control pants followed by the further development of the high voltage transmission lines.

Reactive support and power flow control plants would be used to the maximum extent in order to defer the relatively high cost high voltage transmission network development for as long as possible.

In the future the transmission capability within the core NSW network will be mainly determined by the following two factors:

- The ability to control voltage at all points on the network to within acceptable limits for customers and to maintain the integrity of the overall supply system, particularly with respect to the Sydney area; and
- The thermal rating of transmission lines, particularly under high ambient temperature conditions. Significant network limitations will apply in relation to the thermal capacity of:
  - The two 330 kV transmission lines between the Hunter Valley power stations (Liddell and Bayswater) and the Newcastle area; and
  - The 330 kV transmission lines from the south at Bannaby and Marulan to Sydney and the south coast.

Further development of a strong 500 kV ring around the Newcastle – Sydney – Wollongong area would address future transmission network limitations. It would alter power flows to reduce the loading on the 330 kV lines supplying the area. It would also support voltage control in the Newcastle – Sydney – Wollongong area. Additionally it would facilitate new generation connection over a wide range of feasible locations.

Two links of the 500 kV ring remain to be developed as indicated in the figure above. They are:

- A 500 kV line between Bannaby and Sydney (initially operating at 330 kV), which is the most effective solution to both line rating and voltage control issues under a large set of future scenarios of load and generation development; and
- A 500 kV line between the Hunter Valley and the coast via the Newcastle area, which is the preferred development for particular generation expansion scenarios which lead to significantly increased power flow from the north of the State towards Sydney.

In the absence of definitive information on future generation planting it is necessary to base plans for the immediate future development of the NSW power system on options to meet a range of possible future generation development scenarios. These generation development scenarios cover coal-fired and gas-fired generation developments and wind farm developments across a range of load growth scenarios.

TransGrid's analysis indicates the need to first develop the southern link in the ring, particularly to supply the Sydney area and to accommodate the committed renewable generation and gas-fired generation development in southern NSW. The northern generators at Liddell and Eraring are approaching the end of their lives. The retirement of northern generation is likely to postpone the need for a northern 500 kV link. The northern link would be developed in response to major northern generation or load development.

Some critical properties have been purchased to maintain the viability of options and more may be required to facilitate the development of the Bannaby – Sydney and Hunter Valley – Central Coast 500 kV lines.

Based on the most recent forecast, the need of new 500 kV link is not expected to arise within ten years. However, the augmentation work to the existing 330 kV link between Bannaby and Sydney West may occur within that timeframe depending on new generation connections in the southern area of the state.

7.4.2.6 999 Yass - Cowra 132 kV Transmission Line

Due to reduced load forecasts, the limitation associated with the rating of the 999 Yass - Cowra 132 kV line is able to be managed by operational measures. Consequently, that limitation is not expected to occur within ten years.

7.4.2.7 Supply to Mudgee

Supply to Essential Energy's Mudgee 132/22 kV Substation is presently via a tee connection to the 132 kV line from Beryl to Mt Piper. Essential Energy previously proposed to convert the tee connection to a loop-in connection and this was reported in the TAPR 2013. Based on the most recent forecast, this need is not expected to arise within ten years.

7.4.2.8 Supply to the Tomerong/Nowra Area

As reported in the TAPR 2013, limitations in Endeavour Energy's 132 kV network supplying the Tomerong/Nowra area are to be addressed by works within Endeavour Energy's network. The limitations are then not expected to re-emerge within ten years.

7.4.3 Southern System

7.4.3.1 Supply to the Darlington Point Area

As reported in the TAPR 2013, TransGrid was considering a number of options to address anticipated limitations within the network supplying the Darlington Point area. Those limitations are now not expected to arise within ten years.

7.4.3.2 NSW – South Australia Interconnection

There is significant potential for the development of wind generation in South Australia. There has also been significant attention to the potential for geothermal generation in the Innamincka area of South Australia. The existing South Australia – Victoria interconnection and size of the South Australian load places limitations on the ability to absorb this generation in South Australia.

There is potential for the development of a direct interconnection between South Australia and NSW. This interconnection could be developed as a 500 kV AC link or a HVDC link or a combination of both.

At this stage, such a development is not expected to be cost effective within ten years.

7.4.3.3 NSW – Victoria Interconnection

TransGrid has previously worked with AEMO on options for improving the NSW – Victoria interconnection. It is aimed to improve both the import and export capability. A number of options have been considered:

- Upgrading of Victorian lines and transformers, SVC installation and a braking resistor to improve the Victorian export capability;
- Reactive support in the Jindera area, line series compensation of the Lower Tumut – Wagga – Jindera system or other power flow control devices to improve the Victorian import capability; and
- Major 330 kV line development to provide a significant increase in the Victorian import capability.

A phase shifting transformer between Buronga and Red Cliffs is also an option which may increase the capacity if required in the short term.

At this stage, such a development is not expected to be cost effective within ten years.

7.4.3.4 Supply to the Albury Area

As reported in the TAPR 2013, a tripping scheme has been implemented to manage limitations within the network supplying the Albury area. Those limitations are now not expected to re-emerge within ten years.

7.4.3.5 Supply to Tumut/Gadara

Supply arrangements to the Visy mill at Gadara have been negotiated such that limitations in the network supplying the Tumut/Gadara area are not expected to arise within ten years.

7.5 NER RULE 5.12.2(C) REPORTING

The information required by NER Rule 5.12.2(c)(4) relating to constraints expected to arise in one, three and five years and to indicate our intent to issue an RfP with respect to those constraints is provided in the following two Sections. Constraints that are expected to emerge in two and four years are also included.

7.5.1 Forecast Constraint Information

The required forecast constraint information is provided in Table 7.5. As discussed in Section 2.9, the season in which the limitation is expected to arise is given, rather than the month and year.

TABLE 7 5 – ANTICIPATED ISSUE OF AN RFP FOR NON-NETWORK SERVICES

Anticipated Constraint or Limitation	Reason for Limitation	Bulk Supply Point(s) at which MW reduction would apply	MW at time that limitation is reached
Queensland – NSW Interconnector Capacity	Thermal overload, voltage control, system stability	Refer to Section 7.1.1 and regulatory consultation documents	Refer to Section 7.1.1 and regulatory consultation documents
Supply to the Gunnedah/ Narrabri area	Thermal overload	Gunnedah and/or Narrabri	Refer to Section 7.2.1.1
Supply to the Sydney Inner Metropolitan Area	Thermal Overload	Primarily Beaconsfield and Haymarket	Refer to 7.2.2.1
Sydney South – Beaconsfield Cable Capacity	Thermal overload	Primarily Beaconsfield and Haymarket	Refer to Section 7.2.2.2
Supply to the Beryl/Mudgee area	Voltage control	Beryl and Mudgee	Refer to Section 7.2.2.4
Capacity of the Snowy to Sydney Network	Thermal overload	North of the relevant cut-set. Refer to Section 7.2.3.1	Refer to Section 7.2.3.1

7.5.2 Intent to Issue Request for Proposals

The required indication of TransGrid's intent to issue an RfP for non-network services is indicated in Table 7.6.

TABLE 7 6 – ANTICIPATED ISSUE OF AN RFP FOR NON-NETWORK SERVICES

Anticipated Limitation	Intend to Issue RfP	Date
Queensland – NSW Interconnector Capacity	No	
Supply to the Gunnedah/Narrabri area	To be assessed	
Supply to the Sydney Inner Metropolitan Area	Yes	2014/15
Sydney South – Beaconsfield Cable Capacity	No	
Supply to the Beryl/Mudgee area	No	
Capacity of the Snowy to Sydney Network	To be assessed	

Appendices

TransGrid's Network Planning Approach

A1.1 GENERAL

Under NSW legislation TransGrid has responsibility to plan for future NSW transmission needs, including interconnection with other networks.

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

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

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

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

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

TransGrid also has obligations to meet community expectations in the supply of electricity, including ensuring that developments are undertaken in a socially and environmentally responsible manner. TransGrid plans the network to achieve supply at least community cost, without being constrained by State borders or ownership considerations.

TransGrid's approach to network planning includes consideration of non-network options such as demand side response and DM and/or embedded generation, as an integral part of the planning process. Joint planning with DNSPs, directly supplied industrial customers, generators and interstate TNSPs is carried out to ensure that the most economic options, whether network options or non-network options, consistent with customer and community requirements are identified and implemented.

A1.1.1 Jurisdictional Planning Requirements

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

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

- Where agreed between TransGrid and a distribution network owner or major directly connected end-use customer, agreed levels of supply interruption can be accepted for particular single outages, before augmentation of the network is undertaken (for example the situation with radial supplies);
- Where requested by a distribution network owner or major directly connected end-use customer and agreed with TransGrid there will be no inadvertent loss of load (other than load which is interruptible or dispatchable) following events more onerous than "n–1" such as concurrent outages of two network elements; or
- The main transmission network, which is operated by AEMO, should have sufficient capacity to accommodate AEMO's operating practices without inadvertent loss of load (other than load which is interruptible or dispatchable) or uneconomic constraints on the energy market. At present AEMO's operational practices include the re-dispatch of generation and ancillary services following a first contingency, such that within 30 minutes the system will again be "secure" in anticipation of the next critical credible contingency.

The NSW Government requires TransGrid to provide a level of reliability in its network supplying NSW DNSPs to enable them to meet their reliability obligations.

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

- At all times when the system is either in its normal state with all elements in service or following a credible contingency:
  - Electrical and thermal ratings of equipment will not be exceeded; and
  - Stable control of the interconnected system will be maintained, with system voltages maintained within acceptable levels;

Under NSW legislation TransGrid has responsibility to plan for future NSW transmission needs, including interconnection with other networks

- A quality of electricity supply at least to NER requirements is to be provided;
- A standard of connection to individual customers as specified by Connection Agreements is to be provided;
- As far as possible connection of a customer is to have no adverse effect on other connected customers;
- Environmental and social objectives are to be satisfied;
- Acceptable safety standards are to be maintained; and
- The power system in NSW is to be developed at the lowest cost possible whilst meeting the constraints imposed by the above factors.

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

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

A1.1.2 National Planning Requirements

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

A1.1.3 The Network Planning Process

The network planning process is undertaken at three levels:

1. Connection Planning

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

2. Network Planning within the NSW Region

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

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

3. Inter-regional Planning

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

A1.1.4 Consideration of Non-Network Alternatives

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

A1.1.5 Compliance with NER Requirements

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

A1.1.6 Planning Horizons and Reporting

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

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

A1.1.7 Identifying Network Constraints and Assessing Possible Solutions

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

- TransGrid's planning activities;
- Joint planning with a DNSP;
- The impact of prospective generation developments;
- The occurrence of constraints affecting generation dispatch in the NEM;
- The impact of network developments undertaken by other TNSPs; or
- As a result of a major load development.

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

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

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

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

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

A1.1.8 Application of Power System Controls and Technology

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

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

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

A1.2 PLANNING CRITERIA

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

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

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

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

A1.2.1 Main Transmission Network

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

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

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

The rationale for this approach is that, if operated beyond a defined power transfer level, credible contingency disturbances could potentially lead to system-wide loss of load with severe social and economic impact.

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

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

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

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

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

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

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

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

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

> The system will be able to withstand a single contingency under all reasonably probable patterns of generation dispatch or interconnection power flow. In this context a single contingency is defined as the forced outage of a single transmission circuit, a single generating unit, a single transformer, a single item of reactive plant or a single busbar section.
>
> Provision will be made for a prior outage (following failure) of a single item of reactive plant.
>
> Further the system will be able to be secured by re-dispatching generation (AEMO action), without the need for pre-emptive load shedding, so as to withstand the impact of a second contingency.

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

> The system will be able to withstand a single contingency under a limited set of patterns of generation dispatch or interconnection power flow.
>
> Further the system will be able to be secured by re-dispatching generation (AEMO action), without the need for pre-emptive load shedding, so as to withstand the impact of a second contingency.
>
> These criteria do not apply to radial sections of the main system.

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

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

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

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

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

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

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

A1.2.2 Relationship with Inter-Regional Planning

TransGrid monitors the occurrence of constraints in the main transmission system that affect generator dispatch. TransGrid's planning therefore also considers the scope for network augmentations to reduce constraints that may satisfy the RIT-T.

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

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

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

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

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

A1.2.3 Networks Supplied from the Main Transmission Network

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

A1.2.4 Supply to Major Load Areas and Sensitive Loads

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

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

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

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

A1.2.5 Urban and Suburban Areas

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

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

Consistent with good international practice, supply to high-density urban and central business districts is given special consideration. For example, the inner Sydney metropolitan network serves a large and important part of the State load. Supply to this area is largely via a 330 kV and 132 kV underground cable network. The two 330 kV cables are part of TransGrid's network and the 132 kV cable system is part of Ausgrid's network. The reliability standard for the area specified by the NSW Government in the Transmission Network Design and Reliability Standard is that the system will be capable of meeting the peak load under the following contingencies:

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

Thus an 'n–1' criterion is applied separately to the two networks. The requirement for a reliability criterion for the overall network that is more onerous than 'n–1' reflects:

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

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

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

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

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

A1.2.6 Non Urban Areas

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

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

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

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

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

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

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

A1.2.7 Transformer Augmentation

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

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

A1.2.8 Consideration of Low Probability Events

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

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

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

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

In TransGrid's network appropriate facilities and mechanisms are put in place to minimise the probability of such events and to ameliorate their impact. The decision process considers the underlying economics of facilities or corrective actions, taking account of the low probability of the occurrence of extreme events.

TransGrid will take measures, where practicable, to minimise the impact of disturbances to the power system by implementing power system control systems at minimal cost in accordance with the NER.

A1.3 PROTECTION REQUIREMENTS

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

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

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

A1.4 TRANSIENT STABILITY

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

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

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

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

A1.5 STEADY STATE STABILITY

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

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

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

A1.6 LINE AND EQUIPMENT THERMAL RATINGS

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

TransGrid is presently installing ambient condition monitors on critical transmission lines to enable the application of real-time line conductor ratings in the generation dispatch systems.

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

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

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

A1.7 REACTIVE SUPPORT AND VOLTAGE STABILITY

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

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

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

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

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

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

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

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

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

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

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

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

A1.8 TRANSMISSION LINE VOLTAGE AND CONDUCTOR SIZES DETERMINED BY ECONOMIC CONSIDERATIONS

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

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

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

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

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

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

A1.9 SHORT-CIRCUIT RATING REQUIREMENTS

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

Operating constraints are enforced to ensure equipment is not exposed to fault duties beyond the plant rating.

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

Short circuit duty calculations are based on the following assumptions:

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

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

A1.10 SUBSTATION SWITCHING ARRANGEMENTS

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

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

TransGrid has applied the following arrangements in the past:

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

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

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

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

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

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

A1.11 AUTORECLOSURE

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

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

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

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

A1.12 POWER SYSTEM CONTROL AND COMMUNICATION

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

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

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

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

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

A1.13 SCENARIO PLANNING

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

1. Identification of possible future load growth scenarios. These are developed based on AEMO's forecasts to be used in the next NTNDP. TransGrid uses the key data for each scenario to prepare load forecasts for NSW. These are published in the APR and by AEMO in the forthcoming Electricity Statement of Opportunities. The forecast can also incorporate specific possible local developments such as the establishment of new loads or the expansion of existing industrial loads.
2. Development of a number of generation scenarios for each load growth scenario. These generation scenarios relate to the development of new generators and utilisation of existing generators. This is generally undertaken by a specialist electricity market modelling consultant, using their knowledge of relevant factors, including:
   - Generation costs;
   - Impacts of government policies; and
   - Impacts of energy related developments such as gas pipeline projects.
3. Modelling of the NEM for load and generation scenarios to quantify factors which affect network performance, including:
   - Generation from individual power stations; and
   - Interconnector flows.
4. Modelling of network performance for the load and generation scenarios utilising the data from the market modelling.

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

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

APPENDIX 2

TransGrid's Asset Management Approach

As a TNSP TransGrid has a responsibility to steward its existing assets to meet performance, cost, environmental and safety outcomes.

TransGrid undertakes a variety of performance, cost, risk and compliance analyses to capture the range of current and emerging issues that are apparent with respect to individual assets and asset groups. This analysis considers the inputs provided in Table A2.1, as appropriate.

TABLE A2.1 – CURRENT AND EMERGING ISSUES ANALYSES

Health	Obsolescence	Compliance
• Population age profiling against nominal asset lifespan. • Asset inspection and condition assessments. • Diagnostic testing – such as electrical, structural and oil testing. • Failure and defect rates. • Failure investigations. • Maintenance program outcomes.	• Communication with manufacturers and equipment suppliers.	• Environmental, safety, and operational incidents. • Changes to design standards. • Changes to regulatory requirements.

Once the entire scope of issues are captured and the associated risks have been assessed the Asset Manager will determine the most appropriate course of action to address the risks in consultation with:

- Asset Working Groups – Asset Manager and key maintenance, design, procurement and operational staff.
- Asset Management Committees – Asset Manager and senior management.

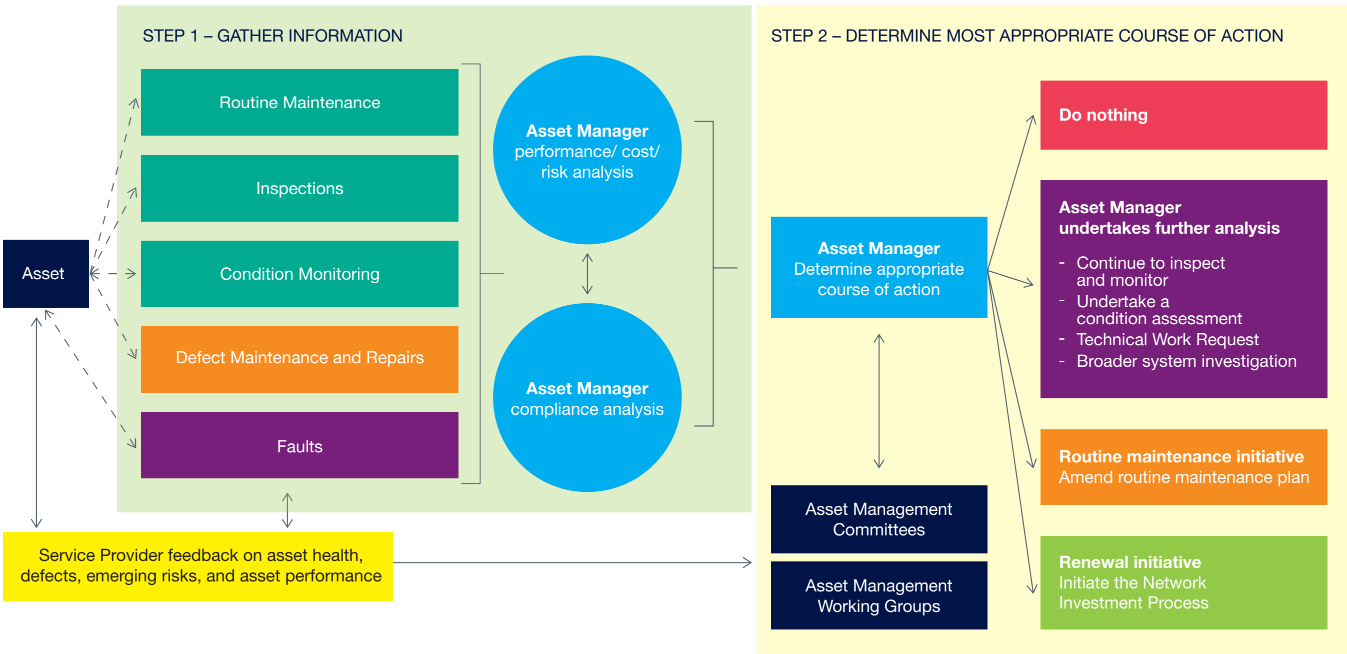
Strategic initiatives are implemented based on the "appropriate courses of action" could include those outlined in Table A2.2 below.

TABLE A2.2 – APPROPRIATE COURSES OF ACTION

Course of Action	Description
Do nothing	No further investigation required – continue to carry out the routine maintenance plan.
Asset Manager to undertake further analysis	Continue to inspect and monitor the identified issues through defect management and defect maintenance.
	Undertake a formal condition assessment.
	Initiate non-routine urgent testing or renewal work; usually arising from the emergence of an unforseen risk such as type faults etc.
	Request broader system investigation requiring input from other business functions such as network planning, operations or design.
Routine maintenance initiative	Identification of appropriate refinements to routine maintenance tasks and schedules to address the identified issues.
Renewal initiative	Initiate Network Investment Process to assess whether renewing the assets is the optimal solution.

The decision process that is applied by the Asset Managers to arrive at the renewal and maintenance strategic initiatives is illustrated in Figure A2.1 below.

FIGURE A2.1 – RENEWAL AND MAINTENANCE DECISION PROCESS



Where the preferred option is a change in the routine maintenance plan, this work is instigated through the works management system and passed through to the maintenance service provider as a program of maintenance tasks.

Where a maintenance solution is not considered cost effective or practical, the need to initiate a renewal project for condition based reasons is then integrated into the Network Investment Process as detailed in Section 2.6. This process aims to ensure an optimal solution considering:

- Decommissioning with no replacement if the asset is no longer required.
- Re-conditioning of the asset if this is technically feasible.
- Replacement of the asset with a similar asset.
- Replacement with a higher rated asset if appropriate, such as where doing so avoids a later augmentation.
- Reconfiguration of the network.
- Non-network solutions.

The following table provides additional details covering these aspects for the projects included in Section 7.2.5.

Project Description	Location	Scope of Works	Non-network Solution Viability	Network Options Considered
Sydney North 330 kV Substation Secondary System Replacement	Sydney North Substation. Sydney metropolitan area	The secondary systems at Sydney North Substation will be replaced using six yard-based Secondary Systems Buildings (SSBs). The SSBs will house secondary systems panels for control, metering, protection, QoS Monitoring, and SAS equipment.	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Replacement of the secondary systems and LV cabling using a SSB for each voltage level 3. Secondary systems replacement in-situ 4. Replacement of the secondary systems and LV cabling using zoned SSBs for each busbar section
Armidale Secondary System Replacement	Armidale Substation. Northern NSW	In-situ replacement of the existing control and protection panels within the existing control room, retaining the existing LV cabling	No non-network options that can completely or partially meet the need have been identified	1. Base case (do nothing) 2. SSB 3. In-situ – retain existing LV cables
Sydney North – Tuggerah 330 kV Line 21 Tower Life Extension	Sydney North – Tuggerah 330 kV Line 21. Sydney metropolitan area to Central Coast	Replacement of corroded nuts, bolts and fittings by TransGrid maintenance staff, and repainting of steel structures by contractor along 21 line, from Sydney North to Sterland, in accordance with appropriate TransGrid standards	No non-network options that can completely or partially meet the need have been identified	1. Base case (do nothing) 2. Paint all towers 3. Replace suspension structures with concrete pole structures at end of life 4. Paint tension towers
Sydney North – Sydney East Line 959/92Z Tower Life Extension	Sydney metropolitan area	Replacement of corroded nuts, bolts and fittings by TransGrid maintenance staff, and repainting of steel structures by contractor along 959/92Z line in accordance with appropriate TransGrid standards	No non-network options that can completely or partially meet the need have been identified	1. Base case (do nothing) 2. Paint all towers 3. Replace suspension structures with concrete pole structures at end of life 4. Paint tension towers
Deniliquin Secondary Systems Replacement	Deniliquin Substation. Southern NSW	In-situ replacement of the existing control and protection panels within the existing control room	No non-network options that can completely or partially meet the need have been identified. A non-network option would need to accommodate all of the substation load all of the time.	1. Base case (do nothing) 2. SSB 3. In-situ – retain LV cables
Uranquinty – Yanco 132 kV Line 99F pole replacement	Uranquinty – Yanco 132 kV Line 99F. Southern NSW	Installation of new structures along Uranquinty to Yanco Line 99F together with new insulators, stringing the existing conductor onto the new structures, and removal and disposal of the old poles in accordance with appropriate TransGrid standards	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Replace all wood pole structures with single concrete pole structures 3. Line rebuild 4. Replace all wood pole structures with single concrete pole structures to ensure a 100°C maximum operating temperature 5. Replace wood poles with single concrete pole structures on a defect basis only
Albury Secondary Systems Replacement	Albury substation. Southern NSW	Replace the TransGrid owned secondary systems and associated cabling at Albury 132/22 kV Substation in a new SSB	No non-network options that can completely or partially meet the need have been identified	1. Base case (do nothing) 2. SSB 3. In-situ

Project Description	Location	Scope of Works	Non-network Solution Viability	Network Options Considered
ANM Secondary Systems Replacement	Australian Newsprint Mills (ANM) Substation. Southern NSW	Replacement of secondary systems	No non-network options that can completely or partially meet the need have been identified. A non-network option would need to accommodate all of the substation load all of the time.	1. Base case (do nothing) 2. SSB 3. In-situ
Dapto – Marulan 330 kV Line 8 Tower Life Extension	Dapto – Marulan 330 kV Line 8. Metropolitan/Central NSW	Replacement of corroded nuts, bolts and fittings by TransGrid maintenance staff, and repainting of steel structures by contractor along line 8 (between structures 118 to 175) in accordance with appropriate TransGrid standards	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Paint all towers 3. Replace suspension structures with concrete pole structures at end of life 4. Paint tension towers
Sydney South – Dapto 330 kV Line 11 Condition	Sydney South – Dapto 330 kV Line 11. Metropolitan/ Central NSW	Painting of the remainder of the tension structures and the previously blasted structures	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Painting of the structures
Kangaroo Valley Secondary Systems Replacement	Kangaroo Valley Substation. Metropolitan /Central NSW	Replacement of the secondary systems and LV cabling using a SSB	No non-network options that can completely or partially meet the need have been identified. Non-network options are unlikely to be feasible as it is necessary to retain the connections for the generators.	1. Base case (do nothing). 2. SSB in the 2014-2019 period 3. In-situ 4. SSB deferred to the 2019–2024 period 5. Replace control systems at a new location local to the switchyard while separate from the already at capacity protection and metering systems building
Munmorah – Tuggerah 330 kV Line 2M Tower Life	Munmorah – Tuggerah 330 kV Line 2M. NSW Central Coast	Replacement of corroded nuts, bolts and fittings by TransGrid maintenance staff, and repainting of all single circuit steel structures by contractor along line 2M (from Munmorah to Sterland) in accordance with appropriate TransGrid standards	No non-network options that would address the corrosion issues associated with line 2M were identified	1. Base case (do nothing) 2. Paint all towers 3. Replace suspension structures with concrete pole structures at end of life 4. Paint tension towers
Cooma – Munyang 132 kV Line 97K Rehabilitation	Cooma – Munyang 132 kV Line 97K. Southern NSW	Remediation of the low spans for the entire length of line 97K at maximum operating temperature to be determined	Non-network options were considered but not pursued due to significant constraints imposed on pumping operations at Jindabyne and the magnitude of local generation required	1. Base case (do nothing) 2. Low span remediation works to a maximum operating temperature of 85°C (current book rating) 3. Low span remediation works to a maximum operating temperature of 75°C 4. Low span remediation works to a maximum operating temperature of 65°C

Project Description	Location	Scope of Works	Non-network Solution Viability	Network Options Considered
Yanco – Griffith 132 kV Line 99J Rebuild	Yanco – Griffith 132 kV Line 99J. Southern NSW	Partial line rebuild of the Yanco – Griffith 132 kV Line 99J. The section of 99J between Yanco and the township of Whitton will be replaced by a new 132 kV line built on a new route, whilst the section of 99J between Whitton and Griffith will be rebuilt	Non-network options were considered but not pursued as non-network options would not meet reliability criteria if line 99J was to be de-commissioned	1. Base case (do nothing) 2. Pole replacements 3. Complete line rebuild, Yanco to Whitton in new alignment 4. Line rebuild in new alignment from Yanco to Whitton, pole replacements from Whitton to Griffith
Coffs Harbour – Koolkhan 132 kV Line 96H Pole Replacement	Coffs Harbour – Koolkhan 132 kV Line 96H. Northern NSW	Installation of new structures along 96H line together with new insulators, stringing the existing conductor onto the new structures, and removal and disposal of the old poles in accordance with appropriate TransGrid standards	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Wood pole replacements with concrete on a defect basis 3. Wood pole replacements with concrete pole structures to meet current standards 4. Line rebuild 5. Pole top rebuild
Taree Substation Secondary Systems Condition	Taree Substation. Northern NSW	Replacement of the secondary systems and LV cabling using a SSB for each voltage level	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Replacement of the secondary systems and LV cabling using a SSB for each voltage level 3. Secondary systems replacement in-situ 4. Replacement of the secondary systems and LV cabling using zoned SSBs for each busbar section
Taree Substation 33 kV Switchyard Condition	Taree Substation. Northern NSW	Replacement of the current AIS switchgear with GIS switchgear in a prefabricated building. The secondary systems associated with the 33 kV switchgear will also be replaced.	No non-network options that can completely or partially meet the need have been identified. A non-network option would need to accommodate all of the substation 33 kV load all of the time.	1. Base case 2. Taree substation 33 kV switchyard renewal – busbar retained 3. Taree substation 33 kV switchyard renewal – busbar replaced 4. Taree substation 33 kV switchyard renewal – GIS switchroom
Snowy – Yass/ Canberra 330 kV Lines 1 and 2 Remediation	Upper Tumut – Canberra 330 kV Line 1. Upper Tumut – Yass 330 kV Line 2. Southern NSW	Installation of insulators, retensioning, raising the span height by replacing suspension towers, landscaping, installing insulated cross arms, replacement of terminal palms on tension structure jumpers and conductor dead ends of No 1 and 2 lines, upgrade of access tracks for construction works, replacement of current transformer and line traps on No 1 and 2 line bay at Upper Tumut Switching Station	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Upgrading of the Upper Tumut – Yass and Upper Tumut – Canberra 330 kV lines 3. New line development – Lower Tumut – Yass single circuit 330 kV line 4. Installation of power flow control plant to improve the sharing of power flows in the four lines under contingency
Low Spans Northern Tower Lines	Central Coast/Hunter Valley/Northern NSW	Remediation of low spans on Northern Region tower lines. Low spans will be remediated to AS7000 clearances. Remediating to TransGrid design clearances is not required because the conductor on these lines is fully crept.	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Remediate low spans on Northern Region tower lines as per overarching strategy 3. Remediate all low spans on Northern Region tower lines

Project Description	Location	Scope of Works	Non-network Solution Viability	Network Options Considered
Low Spans Northern Pole Lines	Central Coast/Hunter Valley/Northern NSW	Remediation of low spans on Northern Region pole lines. Low spans will be remediated to AS7000 clearances. Remediating to TransGrid design clearances is not required because the conductor on these lines is fully crept.	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Remediate low spans on Northern Region pole lines as per overarching strategy 3. Remediate all low spans on Northern Region pole lines
Low Spans Central Tower Lines	NSW metropolitan area	Remediation of low spans on Central Region tower lines. The spans will be remediated to AS7000 clearances. Remediating to TransGrid design clearances is not required because the conductor on this line is fully crept.	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Remediate low spans on Central Region tower lines as per overarching strategy 3. Remediate all low spans on Southern Region tower lines
Low Spans Central Pole Lines	Central West NSW	Remediation of low spans on Central Region pole lines. Low spans will be remediated to AS7000 clearances. Remediating to TransGrid design clearances is not required because the conductor on these lines is fully crept.	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Remediate low spans on Central Region pole lines as per overarching strategy 3. Remediate all low spans on Central Region pole lines
Low Spans Southern Tower Lines	Southern NSW	Remediation of low spans on Southern Region tower lines. The spans will be remediated to AS7000 clearances. Remediating to TransGrid design clearances is not required because the conductor on this line is fully crept.	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Remediate low spans on Southern Region pole lines as overarching strategy 3. Remediate all low spans on Southern Region pole lines
Low Spans Southern Pole Lines	Southern NSW	Remediation of low spans on Southern Region pole lines. Low spans will be remediated to AS7000 clearances. Remediating to TransGrid design clearances is not required because the conductor on these lines is fully crept.	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Remediate low spans on Southern Region pole lines as overarching strategy 3. Remediate all low spans on Southern Region pole lines
Broken Hill 220/22 kV Substation replacement of No 1 and No 2 Reactors	Southern NSW	Demolition and removal of the existing 220 kV 25 MVAr reactors No 1 & 2, the two compounds and associated bunds and the removal of the equipment in the two reactor bays. Design, supply and installation of 24 MVAr 220 kV reactor, reactor bay and associated civil works for reactors No 1 & No 2. Upgrade of the oil containment system to TransGrid standards.	No non-network options that can completely or partially meet the need have been identified	1. No feasible options identified
Forbes No 1 and No 2 132/66 kV Transformer replacement	Central Western NSW	Replacement of Forbes 60 MVA transformers with transformers of the same size	No non-network options that can completely or partially meet the need have been identified. A non-network option would need to accommodate all of the substation load all of the time.	1. Base case (do nothing) 2. Replace Forbes No 1 and No 2 transformers with two new 60 MVA units 3. Replace Forbes No 1 and No 2 transformers with refurbished 60 MVA units

Project Description	Location	Scope of Works	Non-network Solution Viability	Network Options Considered
Beaconsfield Transformer No 1 and No 2 replacement	Sydney metropolitan area	Replacement of the existing transformers with one system spare and one 'factory' refurbished unit	No non-network options that can completely or partially meet the need have been identified	1. Base case 2. Advanced replacement of No 1 and No 2 transformers 3. Replacement of No 1 and No 2 transformers 4. On-site refurbishment of the No 1 and No 2 transformers, replacing one unit with a system spare and returning the other unit to service 5. Off-site refurbishment of the No 1 and No 2 transformers and return to service
Burrinjuck to Yass 132 kV Transmission Line 970 Pole Replacements	Southern NSW	Replacement of all wood pole structures with concrete poles	No non-network options that can completely or partially meet the need have been identified	1. Base case (do nothing) 2. Base case with defect based wood pole replacement as needed 3. Replacement of all wood pole structures with concrete poles 4. Completely rebuild line
Sydney North to Vales Point 330 kV Transmission Line Tower Life Extension	Central Coast NSW	Replacement of all suspension towers and painting of all tension towers	No non-network options that can completely or partially meet the need have been identified	1. Base case (do nothing) 2. Paint all towers 3. Replace all suspension towers 4. Paint tension towers 5. Replace all suspension towers and paint tension towers
Sydney South 330 kV Substation	Sydney metropolitan area	Replacement of all 415 V AC auxiliary supply systems	No non-network options that can completely or partially meet the need have been identified. The low voltage auxiliary system supports the operation of the High Voltage assets.	1. Base case (do nothing) 2. Replace all 415V AC auxiliary supply systems and cabling
Haymarket 330 kV Substation Secondary Systems Replacement	Haymarket Substation. Sydney metropolitan area	Replacement of the secondary systems	No non-network options that can completely or partially meet the need have been identified	1. Base case (do nothing) 2. Replacement of secondary systems using distributed based control 3. In-situ replacement of the secondary systems 4. Replacement of the secondary systems and LV cabling in an SSB 5. Two stage replacement: first to implement mitigation measures so that extended failure of one busbar protection unit does not risk a 132 kV busbar outage, and second to develop strategic approach to replacement of all other secondary systems
Murrumburrah 132 kV Substation Secondary Systems Replacement	Murrumburrah Substation. Southern NSW	Replacement of the secondary systems and cabling	No non-network options that can completely or partially meet the need have been identified	1. Base case (do nothing) 2. Replacement of the secondary systems and cabling 3. In-situ replacement of the secondary systems and retaining the existing LV cabling

APPENDIX 3

Individual Bulk Supply Point Projections

TransGrid's customers have provided peak demand projections, in terms of both MW and MVAr, for individual bulk supply points between the NSW transmission network and the relevant customer's network. These projections are produced using various methodologies which are likely to have been tailored according to several factors including the degree of local knowledge and availability of historical data. These projections are contained in Tables A3.1 to A3.12 of this appendix.

Certain large and relatively stable industrial loads that TransGrid isolates for modelling purposes have also been removed from the bulk supply point projections and aggregated. This impacts the projections shown for Broken Hill. Other industrial loads are included within bulk supply point forecasts provided by distributors. Aggregate projections for all identified major industrial loads (excluding those that are also in the bulk supply point forecasts) are presented in Tables A3.11 and A3.12. The figures in those tables are not directly comparable with those of previous years loads which were previously removed from bulk supply point loads have not been removed this year.

Note that Tables A3.1 to A3.12 represent projections of maximum demand occurring during a particular season at a particular bulk supply point (or group of bulk supply points) to the NSW transmission network. They do not represent projections of demand contributions at these bulk supply points to the overall NSW region peak demand.

Load profile information for critical bulk supply points is provided in Appendix 4.

Information on forecast diversity factors for each bulk supply point with respect to the network (NER Schedule 5.7) have not been provided as:

- The NER definition of "network" is very broad making it unclear what combination of other load(s) the diversities are to be calculated with respect to. The absence of this information could lead to an impossibly large number of diversity combinations[1], many of which are unlikely to be of use; and
- In an interconnected network, the loading on a particular substation can reflect the configuration of the underlying network as well as generation patterns within the NEM. Consequently, there can be considerable variation in diversity factors at a particular location from year to year[2].

In relation to the two near term major load related network limitations in TransGrid's network:

- The planning studies for the Sydney inner metropolitan area have used forecasts of diversified loads, removing the need for individual diversity factors; and
- Diversity between the Gunnedah and Narrabri summer maximum demands has varied between 0% and 3% over the past five summers[3], making it difficult to determine a "typical" value.

When undertaking the comparison between AEMO's NSW region forecasts and the aggregated DNSP forecasts TransGrid uses diversity factors of 4% in both summer and winter[4].

Notwithstanding the above difficulties, should information on particular diversity factors be required, it may be available from TransGrid. Contact details are provided on the inside of the rear cover of this document.

1. For example, in a ten node network there are over 500 diversity figures for each node, covering the ways in which its diversity can be calculated with respect to the various combinations of one or more of the other nine nodes. For larger networks such as TransGrid's, the number of possible diversity figures is immense.
2. For example, over the past five summers, the diversity of the Sydney South load (a major load in TransGrid's network) with respect to that of the NSW region has varied between 0% and 3%. Over the same period, that for the Lismore load (a reasonably large load on the periphery of TransGrid's network) has varied between 6% and 32%. It is likely that some of the variation in diversity factors at Lismore is due to the extent to which adverse weather conditions which affect the Newcastle / Sydney / Wollongong area (where the bulk of the NSW load is located) also affect the NSW far north coast. Longer term weather events can be extremely difficult to forecast.
3. Some of this variation may be due to variations in pumping loads which vary from year to year depending on weather conditions (which affect the need for irrigation) and the availability of water (which can be affected by El Niño and La Niña events). Longer term weather conditions are extremely difficult to forecast.
4. These diversity factors apply at the NSW region level. They represent the difference between the undiversified regional maximum demand (the summated maximum demands of the individual bulk supply points) and the diversified regional maximum demand (the maximum of the summated bulk supply point loads). This "regional" approach was adopted as it is not possible to estimate a "typical" diversity factor for individual bulk supply point loads with respect to the NSW regional load due to the year to year variability of those individual diversity factors.

TABLE A3.1 – AUSGRID BULK SUPPLY POINT SUMMER PEAK DEMAND[5]

	2014/15		2015/16		2016/17		2017/18		2018/19		2019/20		2020/21		2021/22		2022/23		2023/24	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Beaconsfield West 132 kV	368	20	392	28	420	57	420	72	586	109	601	121	595	124	612	143	635	150	645	169
Rookwood Rd 132 kV	253	14	279	20	303	41	284	49	232	43	237	48	242	51	249	58	245	58	255	67
Haymarket 132 kV	458	25	489	35	524	71	528	91	587	109	594	119	604	126	611	143	611	144	617	161
Liddell 33 kV	33	25	33	25	34	25	34	25	34	26	34	26	35	26	35	26	35	26	35	26
Munmorah 132 kV & 33 kV	120	26	104	18	111	23	121	31	127	37	133	44	134	44	136	45	138	46	140	47
Muswellbrook 132 kV	238	117	254	131	251	133	253	134	255	136	257	137	246	133	261	140	261	140	261	140
Newcastle 132 kV	606	186	596	181	513	202	522	207	535	213	548	221	561	229	572	238	573	238	573	238
Sydney East 132 kV	706	203	707	195	722	203	734	212	785	248	810	266	819	273	829	297	847	308	860	318
Sydney North 132 kV	1076	59	938	67	922	125	936	161	833	248	851	301	880	335	913	354	939	379	965	403
Sydney South 132 kV	1119	69	1180	91	1219	172	1299	230	1312	251	1333	275	1356	290	1382	329	1409	339	1426	380
Tomago 132 kV	256	70	252	71	300	66	306	71	314	77	321	83	329	89	337	96	339	97	339	97
Tuggerah 132 kV	210	106	211	107	218	111	221	122	228	126	235	131	239	136	245	139	250	144	255	149
Vales Point 132 kV	88	8	104	17	108	18	115	0	118	0	122	0	127	1	129	1	131	1	133	1
Waratah West 132 kV	143	53	142	54	169	50	171	51	174	51	176	52	179	53	182	54	182	53	182	53

TABLE A3.2 – AUSGRID BULK SUPPLY POINT WINTER PEAK DEMAND[6]

	2014		2015		2016		2017		2018		2019		2020		2021		2022		2023	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Beaconsfield West 132 kV	306	49	321	41	344	47	381	55	386	65	505	63	525	57	526	67	534	44	536	50
Rookwood Rd 132 kV	190	30	198	25	227	31	246	35	244	41	204	26	207	22	215	27	221	18	234	22
Haymarket 132 kV	382	61	391	50	431	59	463	66	476	80	527	66	546	59	552	71	566	47	562	53
Liddell 33 kV	33	25	33	25	33	25	34	25	34	25	34	26	34	26	35	26	35	26	35	27
Munmorah 132 kV & 33 kV	129	30	128	17	123	31	132	29	140	40	148	45	158	56	157	48	160	53	162	49
Muswellbrook 132 kV	210	89	238	111	236	115	237	115	238	116	240	117	241	118	243	119	245	120	245	120
Newcastle 132 kV	477	99	476	96	473	97	408	115	416	119	429	125	440	131	451	137	461	145	462	144
Sydney East 132 kV	696	12	681	30	698	45	712	48	725	82	778	104	804	123	815	119	826	148	844	151
Sydney North 132 kV	905	145	861	110	756	103	743	106	749	126	662	259	672	305	687	320	709	340	722	471
Sydney South 132 kV	1011	172	1041	142	1111	161	1150	175	1198	211	1213	162	1219	143	1242	169	1252	114	1282	131
Tomago 132 kV	194	14	195	14	193	14	232	9	237	12	242	15	248	19	254	23	260	26	261	28
Tuggerah 132 kV	205	41	206	65	217	48	227	73	232	64	241	68	249	71	254	80	260	85	265	86
Vales Point 132 kV	92	16	89	5	92	14	92	7	94	12	99	17	100	16	107	12	109	17	110	12
Waratah West 132 kV	126	55	125	54	125	54	148	51	149	51	151	51	153	52	156	52	158	52	158	52

5. Zone substation projections aggregated to TransGrid bulk supply points using agreed load flow models.
6. Zone substation projections aggregated to TransGrid bulk supply points using agreed load flow models.

TABLE A3.3 – ENDEAVOUR ENERGY BULK SUPPLY POINT SUMMER PEAK DEMAND[7]

	2014/15		2015/16		2016/17		2017/18		2018/19		2019/20		2020/21		2021/22		2022/23		2023/24	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Dapto 132 kV	656	72	678	74	692	76	698	76	704	77	708	77	715	78	720	79	726	79	731	80
Holroyd 132 kV	390	125	391	125	394	126	395	126	395	127	396	127	396	127	397	127	397	127	397	127
Ingleburn 66 kV	129	29	125	28	125	28	126	28	126	28	126	28	126	28	126	28	126	28	127	28
Liverpool 132 kV	376	84	390	87	402	90	411	92	419	94	426	96	434	97	441	99	447	100	452	101
Macarthur 132 kV & 66 kV	266	80	275	83	284	86	293	88	302	91	311	94	320	97	330	100	341	103	352	106
Marulan 132 kV	76	37	77	38	78	38	78	38	79	38	79	39	80	39	80	39	81	40	82	40
Mount Piper 66 kV	45	22	76	37	76	37	76	37	76	37	76	37	76	37	76	37	76	37	76	37
Regentville 132 kV	267	70	276	73	287	76	292	77	296	78	298	79	299	79	300	79	301	79	303	80
Sydney North 132 kV	34	3	34	3	34	3	34	3	34	3	34	3	34	3	34	3	34	3	34	3
Sydney West 132 kV	1171	42	1199	43	1226	44	1252	45	1269	46	1297	47	1326	48	1351	48	1374	49	1397	50
Vineyard 132 kV	457	140	465	142	477	146	487	149	477	146	489	150	501	154	514	158	527	161	540	165
Wallerawang 132 kV & 66 kV	62	23	62	23	62	23	62	23	62	23	62	23	62	23	62	23	62	23	62	23

TABLE A3.4 – ENDEAVOUR ENERGY BULK SUPPLY POINT WINTER PEAK DEMAND[8]

	2014		2015		2016		2017		2018		2019		2020		2021		2022		2023	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Dapto 132 kV	654	77	670	79	685	81	690	82	694	82	695	82	702	83	706	84	714	84	722	85
Holroyd 132 kV	217	57	312	78	313	78	313	78	313	78	313	78	314	78	314	78	313	78	313	78
Ingleburn 66 kV	109	16	109	16	109	16	109	16	109	16	109	16	109	16	109	16	109	16	110	16
Liverpool 132 kV	280	26	287	27	296	28	304	29	311	29	319	30	326	31	332	31	336	32	340	32
Macarthur 132 kV & 66 kV	256	0	277	0	290	0	303	0	316	0	328	0	341	0	354	0	367	0	380	0
Marulan 132 kV	87	26	87	26	89	26	89	26	89	27	89	27	90	27	90	27	90	27	90	27
Mount Piper 66 kV	50	22	50	22	88	38	88	38	88	38	88	38	88	38	88	38	88	38	88	38
Regentville 132 kV	197	47	201	48	209	50	215	51	217	52	219	52	220	53	221	53	223	53	225	54
Sydney North 132 kV	24	2	24	2	24	2	24	2	24	2	24	2	24	2	24	2	24	2	24	2
Sydney West 132 kV	931	35	943	36	969	37	996	38	1021	38	1036	39	1059	40	1080	41	1099	41	1119	42
Vineyard 132 kV	315	67	321	68	327	69	333	71	344	73	329	70	337	72	345	73	354	75	362	77
Wallerawang 132 kV & 66 kV	71	24	71	24	71	24	71	24	71	24	71	24	71	24	71	24	71	24	71	24

7. Marulan 132 kV: Both Endeavour Energy and Essential Energy take supply from Marulan. This forecast is for the Endeavour Energy component. Diversity factors of 3% in summer should be applied to obtain the forecast total summer load at Marulan
8. Marulan 132 kV: Both Endeavour Energy and Essential Energy take supply from Marulan. This forecast is for the Endeavour Energy component. Diversity factors of 2% in winter should be applied to obtain the forecast total winter load at Marulan

TABLE A3.5 – ESSENTIAL ENERGY (NORTH) BULK SUPPLY POINT SUMMER PEAK DEMAND[9]

	2014/15		2015/16		2016/17		2017/18		2018/19		2019/20		2020/21		2021/22		2022/23		2023/24	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Armidale 66 kV	25	5	25	5	26	5	26	5	26	5	26	5	26	5	26	5	27	5	27	5
Boambee South 132 kV	15	3	15	3	15	4	15	4	15	4	16	4	16	4	16	4	16	4	16	4
Casino 132 kV	26	5	26	5	26	5	27	5	27	5	27	5	27	5	27	5	27	5	27	5
Coffs Harbour 66 kV	59	6	60	6	60	6	61	6	61	6	62	6	62	6	63	6	63	6	64	6
Dorrigo 132kV	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1
Dunoon 132kV	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1
Glen Innes 66 kV	9	2	9	2	9	2	9	2	9	2	9	2	9	2	9	2	9	2	9	2
Gunnedah 66 kV	27	5	27	5	27	5	27	5	27	5	27	5	27	5	28	5	28	5	28	5
Hawks Nest 132 kV	8	2	8	2	8	2	8	2	8	2	8	2	9	2	9	2	9	2	9	2
Herons Ck 132 kV	10	3	10	3	10	3	10	3	10	3	10	3	11	3	11	3	11	3	11	3
Inverell 66 kV	31	3	31	3	31	3	31	3	31	3	32	3	32	3	32	3	32	3	32	3
Kempsey 33 kV	26	5	26	5	26	5	26	5	26	5	26	5	26	5	26	5	26	5	26	5
Kempsey 66 kV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Koolkhan 66 kV	50	7	50	7	50	7	50	7	50	7	51	7	51	7	51	7	51	7	52	7
Lismore 132 kV	72	16	73	17	73	17	74	17	74	17	74	17	75	17	75	17	76	17	76	17
Macksville 132 kV	8	1	8	1	8	1	8	1	8	1	8	1	8	1	8	1	9	1	9	2
Moree 66 kV	26	4	26	4	26	4	26	4	26	4	26	4	26	4	26	4	26	4	26	4
Mullumbimby 132 kV	43	13	44	13	44	13	44	13	44	13	45	13	45	13	45	13	45	13	46	13
Nabiac 132 kV	0	0	0	0	0	0	0	0	0	0	33	5	33	5	34	5	34	5	34	5
Nambucca 66 kV	7	2	7	2	7	2	7	2	7	2	7	2	7	2	7	2	7	2	7	2
Narrabri 66 kV	49	4	49	4	49	4	49	4	49	4	50	4	50	4	50	4	50	4	50	4
Port Macquarie 33 kV	62	6	63	6	63	6	64	6	65	7	66	7	67	7	68	7	69	7	69	7
Raleigh 132 kV	9	2	9	2	9	2	9	2	9	2	9	2	9	2	9	2	9	2	9	2
Stroud 132 kV	31	2	31	2	32	2	32	2	32	2	32	2	32	3	33	3	33	3	33	3
Tamworth 66 kV	108	22	110	22	111	23	112	23	114	23	115	23	116	24	118	24	119	24	121	24
Taree 33 kV	29	4	29	4	30	4	30	4	30	4	30	4	30	4	30	4	31	4	31	4
Taree 66 kV	47	13	48	13	48	13	48	13	49	13	16	4	16	4	16	4	16	4	16	4
Tenterfield 22 kV	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1
Terranora 110 kV	76	6	77	6	78	6	79	6	80	6	81	6	82	6	83	6	84	7	85	7

9. Mullumbimby and Lismore forecasts reflect recent network modifications. The future Nabiac load is presently supplied from Taree at 66 kV.

TABLE A3.6 – ESSENTIAL ENERGY (NORTH) BULK SUPPLY POINT WINTER PEAK DEMAND[10]

	2014		2015		2016		2017		2018		2019		2020		2021		2022		2023	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Armidale 66 kV	37	6	38	6	38	6	38	6	38	6	39	6	39	6	39	6	39	6	39	6
Boambee South 132 kV	16	3	16	3	17	3	17	3	17	3	17	3	17	3	17	3	17	3	18	3
Casino 132 kV	22	4	22	4	22	5	22	5	22	5	23	5	23	5	23	5	23	5	23	5
Coffs Harbour 66 kV	60	7	60	7	60	7	61	7	61	7	62	7	62	7	62	7	63	7	63	7
Dorrigo 132 kV	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1
Dunoon 132 kV	6	1	6	1	6	1	6	1	6	1	6	1	6	1	6	1	6	1	6	1
Glen Innes 66 kV	12	2	12	2	12	2	12	2	12	2	12	2	12	2	12	2	12	2	12	2
Gunnedah 66 kV	23	3	23	3	23	3	23	3	23	3	23	3	23	3	24	3	24	3	24	3
Hawks Nest 132 kV	7	1	7	1	7	1	7	1	7	1	7	1	7	1	8	1	8	1	8	1
Herons Ck 132 kV	10	3	10	3	10	3	10	3	10	3	10	3	10	3	10	3	10	3	11	3
Inverell 66 kV	30	5	30	5	30	5	30	5	30	5	30	5	30	5	30	5	30	5	31	5
Kempsey 33 kV	27	5	27	5	27	5	27	5	28	5	28	5	28	5	28	5	28	5	28	5
Kempsey 66 kV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Koolkhan 66 kV	47	5	48	5	48	5	48	5	48	5	48	5	48	5	49	5	49	5	49	5
Lismore 132 kV	75	17	75	17	76	17	76	17	76	17	77	17	77	18	77	18	77	18	78	18
Macksville 132 kV	9	1	9	1	9	2	9	2	9	2	9	2	9	2	9	2	9	2	9	2
Moree 66 kV	39	4	39	4	39	4	39	4	39	4	39	4	39	4	40	4	40	4	40	4
Mullumbimby 132 kV	49	5	49	5	49	5	50	5	50	5	50	5	50	5	50	5	51	5	51	5
Nabiac 132 kV	0	0	0	0	0	0	0	0	0	0	36	6	36	6	36	6	37	6	37	6
Nambucca 66 kV	9	1	9	1	9	1	9	1	9	1	9	1	9	1	9	1	9	1	9	1
Narrabri 66 kV	47	4	47	4	48	4	48	4	48	4	48	4	48	4	48	4	48	4	48	4
Port Macquarie 33 kV	69	8	69	8	70	8	71	8	72	9	72	9	73	9	74	9	75	9	76	9
Raleigh 132 kV	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2
Stroud 132 kV	26	5	27	5	27	5	27	5	27	5	27	5	27	5	27	5	27	5	27	5
Tamworth 66 kV	94	15	95	15	96	16	96	16	97	16	98	16	99	16	99	16	100	16	101	16
Taree 33 kV	24	4	24	4	24	4	24	4	24	4	24	4	24	4	24	4	25	4	25	4
Taree 66 kV	51	10	51	10	52	10	52	11	52	11	16	3	17	3	17	3	17	3	17	3
Tenterfield 22 kV	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6	2
Terranora 110 kV	83	6	84	6	84	7	85	7	86	7	86	7	87	7	88	7	88	7	89	7

10.Mullumbimby and Lismore forecasts reflect recent network modifications. The future Nabiac load is presently supplied from Taree at 66 kV.

TABLE A3.7 – ESSENTIAL ENERGY (CENTRAL) BULK SUPPLY POINT SUMMER PEAK DEMAND

	2014/15		2015/16		2016/17		2017/18		2018/19		2019/20		2020/21		2021/22		2022/23		2023/24	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Beryl 66 kV	68	21	74	23	75	23	75	23	76	24	77	24	78	24	78	24	79	25	80	25
Cowra 66 kV	32	5	32	5	32	5	32	5	32	5	32	5	32	5	32	5	32	5	32	5
Forbes 66 kV	32	1	32	1	32	1	32	1	32	1	32	1	32	1	32	1	32	1	32	1
Manildra 132 kV	10	4	10	4	10	4	10	4	10	4	10	4	10	4	10	4	10	4	10	4
Molong 66 kV	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0
Mudgee 132 kV	21	3	21	3	21	3	21	3	22	3	22	3	22	3	22	3	22	3	22	3
Orange 66 kV	50	20	50	20	50	20	50	20	50	20	50	20	50	20	50	20	50	20	50	20
Orange 132 kV	144	34	147	34	146	35	146	35	146	36	146	36	147	37	155	37	155	38	155	38
Panorama 66 kV	67	27	67	27	67	27	67	27	67	27	67	27	67	27	67	27	67	27	67	27
Parkes 66 kV	27	0	27	0	27	0	27	0	27	0	27	0	27	0	27	0	27	0	27	0
Parkes 132 kV	30	13	30	13	30	13	30	13	30	13	30	13	30	13	30	13	30	13	30	13
Wallerawang 66 kV	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2
Wallerawang 132 kV	20	12	20	12	20	12	20	12	20	12	20	12	20	12	20	12	20	12	20	12
Wellington 66 kV	11	4	11	4	11	4	11	4	11	4	11	4	11	4	11	4	11	4	11	4
Wellington 132 kV	175	20	177	20	178	20	179	20	181	20	182	20	183	20	185	20	186	20	188	20

TABLE A3.8 – ESSENTIAL ENERGY (CENTRAL) BULK SUPPLY POINT WINTER PEAK DEMAND

	2014		2015		2016		2017		2018		2019		2020		2021		2022		2023	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Beryl 66 kV	63	18	77	19	78	20	79	20	79	20	80	20	81	20	81	20	82	21	83	21
Cowra 66 kV	23	1	23	1	23	1	23	1	23	1	23	1	23	1	23	1	23	1	23	1
Forbes 66 kV	25	0	25	0	25	0	25	0	25	0	25	0	25	0	25	0	25	0	25	0
Manildra 132 kV	10	4	10	3	10	3	10	3	10	3	10	3	10	3	10	3	10	4	10	4
Molong 66 kV	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0
Mudgee 132 kV	20	0	20	0	20	0	20	0	20	0	20	0	20	0	20	0	20	0	20	0
Orange 66 kV	61	18	61	18	61	18	61	18	61	18	61	18	61	18	61	18	61	18	61	18
Orange 132 kV	144	36	146	37	149	38	148	38	148	39	149	39	149	40	150	40	158	41	159	41
Panorama 66 kV	75	21	75	21	75	21	75	21	75	21	75	21	75	21	75	21	75	21	75	21
Parkes 66 kV	22	0	22	0	22	0	22	0	22	0	22	0	22	0	22	0	22	0	22	0
Parkes 132 kV	30	13	30	13	30	13	30	13	30	13	30	13	30	13	30	13	30	13	30	13
Wallerawang 66 kV	6	1	6	1	6	1	6	1	6	1	6	1	6	1	6	1	6	1	6	1
Wallerawang 132 kV	20	12	20	11	20	11	20	11	20	11	20	11	20	11	20	11	20	11	20	11
Wellington 66 kV	9	1	9	0	9	0	9	0	9	0	9	0	9	0	9	0	9	0	9	0
Wellington 132 kV	147	9	147	9	148	9	148	9	148	9	149	9	149	9	150	9	150	9	150	9

TABLE A3.9 – ESSENTIAL ENERGY (SOUTH AND FAR WEST) AND ACTEWAGL BULK SUPPLY POINT SUMMER PEAK DEMAND[11]

	2014/15		2015/16		2016/17		2017/18		2018/19		2019/20		2020/21		2021/22		2022/23		2023/24	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Albury 132 kV	123	33	123	33	123	33	124	33	124	33	124	33	124	33	124	33	124	33	124	33
Balranald 22 kV	4	1	4	1	4	1	4	1	4	1	4	1	4	1	4	1	4	1	4	1
Broken Hill 22 kV	35	13	35	13	35	13	36	13	36	14	36	14	36	14	36	14	37	14	37	14
Canberra 132 kV	451	173	459	176	466	180	473	183	481	186	488	189	495	193	503	196	511	199	518	203
Coleambally 33 kV	10	6	10	6	10	6	10	6	10	6	10	6	10	6	10	6	10	6	10	6
Cooma 11 kV	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2
Cooma 66 kV	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0
Cooma 132 kV	45	3	44	3	44	3	44	3	44	3	44	3	45	3	45	3	45	3	45	3
Darlington Pt 132 kV	19	3	19	4	20	4	20	4	20	4	21	4	21	4	21	4	22	4	22	4
Deniliquin 66 kV	48	15	48	15	48	15	49	15	49	15	49	15	49	15	49	16	50	16	50	16
Finley 66 kV	19	6	19	6	19	6	19	6	19	6	19	6	19	6	19	6	19	6	19	6
Griffith 66 kV	77	19	77	19	78	19	78	19	79	19	79	19	79	19	80	19	80	19	80	19
Marulan 132 kV	40	13	40	13	40	13	40	13	40	13	40	13	40	13	40	13	40	13	40	13
Munyang 33 kV	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Murrumbateman 132 kV	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0
Murrumburrah 66 kV	37	17	37	17	37	17	37	17	37	17	37	17	37	17	37	17	37	17	37	17
Queanbeyan 66 kV	80	24	81	24	81	24	83	26	84	26	84	26	85	26	86	27	86	27	87	27
Snowy Adit 132 kV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tumut 66 kV	34	15	34	15	34	15	34	15	34	15	34	15	34	15	34	15	34	15	34	15
Wagga 66 kV	94	33	95	33	96	33	96	34	97	34	97	34	98	34	98	34	99	35	99	35
Wagga North 132 kV	53	3	63	3	63	3	63	3	63	3	63	3	63	3	63	3	63	3	63	3
Wagga North 66 kV	28	10	17	9	17	9	17	9	18	9	18	9	18	9	18	9	19	9	19	9
Williamsdale 132 kV	119	84	122	86	125	87	128	89	130	90	133	92	136	93	138	95	141	96	144	98
Yanco 33 kV	39	7	39	7	39	7	39	7	39	7	39	7	39	7	39	7	39	7	40	8
Yass 66 kV	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0

11. Load transfer from Wagga North 66 kV to Wagga North 132 kV for Summer 2015-16.
Marulan 132 kV: Both Endeavour Energy and Essential Energy take supply from Marulan. This forecast is for the Essential Energy component. Diversity factors of 3% in summer should be applied to obtain the forecast total summer load at Marulan

TABLE A3.10 – ESSENTIAL ENERGY (SOUTH AND FAR WEST) AND ACTEWAGL BULK SUPPLY POINT WINTER PEAK DEMAND[12]

	2014		2015		2016		2017		2018		2019		2020		2021		2022		2023	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Albury 132 kV	89	14	89	14	89	14	89	14	89	14	90	14	90	14	90	14	90	14	90	14
Balranald 22 kV	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Broken Hill 22 kV	33	6	33	6	33	6	33	6	33	6	33	6	34	6	34	6	34	6	34	6
Canberra 132 kV	480	122	480	122	480	122	480	122	481	122	481	122	489	122	480	122	480	122	480	122
Coleambally 33 kV	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4
Cooma 11 kV	13	2	13	2	13	2	13	2	13	2	13	2	13	2	13	2	13	2	13	2
Cooma 66 kV	19	0	19	0	19	0	19	0	19	0	19	0	19	0	19	0	19	0	19	0
Cooma 132 kV	51	-1	51	-1	51	-1	51	-1	51	-1	51	-1	51	-1	51	-1	51	-1	51	-1
Darlington Pt 132 kV	14	2	14	2	14	2	14	2	14	2	14	2	14	2	14	2	14	2	14	2
Deniliquin 66 kV	35	4	35	4	35	4	35	4	35	4	35	4	35	4	35	4	35	4	35	4
Finley 66 kV	17	3	17	3	17	3	17	3	17	3	17	3	17	3	17	3	17	3	17	3
Griffith 66 kV	51	8	52	8	52	8	52	8	52	8	53	8	53	8	53	8	54	8	54	8
Marulan 132 kV	50	7	50	7	50	7	50	7	50	7	50	7	50	7	50	7	50	7	50	7
Munyang 33 kV	30	18	30	18	30	18	30	18	30	18	30	18	30	18	30	18	30	18	30	18
Murrumbateman 132 kV	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0
Murrumburrah 66 kV	31	9	31	9	31	9	31	9	31	9	31	9	31	9	31	9	31	9	31	9
Queanbeyan 66 kV	82	15	81	15	81	15	82	15	82	15	82	15	82	15	83	15	83	15	83	15
Snowy Adit 132 kV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tumut 66 kV	33	8	33	8	33	8	33	8	33	8	33	8	33	8	33	8	33	8	33	8
Wagga 66 kV	72	14	73	13	73	13	73	13	74	13	74	13	74	13	74	13	75	14	75	14
Wagga North 132 kV	48	-4	48	-4	58	-4	58	-4	58	-4	58	-4	58	-4	58	-4	58	-4	58	-4
Wagga North 66 kV	25	7	25	7	16	6	17	6	17	6	17	6	17	6	17	7	17	7	18	7
Williamsdale 132 kV	100	65	100	64	100	64	100	64	100	65	100	64	100	65	100	64	100	64	101	65
Yanco 33 kV	31	3	31	3	31	3	31	4	31	4	31	4	31	4	31	4	31	4	32	4
Yass 66 kV	12	-2	12	-2	12	-2	12	-2	12	-2	12	-2	12	-2	12	-2	12	-2	12	-2

TABLE A3.11 – MAJOR INDUSTRIAL CUSTOMERS – SUM OF INDIVIDUAL SUMMER PEAK DEMANDS

	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Industrial Loads	982	982	982	982	982	982	982	982	982	982

TABLE A3.12 – MAJOR INDUSTRIAL CUSTOMERS – SUM OF INDIVIDUAL WINTER PEAK DEMANDS

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Industrial Loads	995	995	995	995	995	995	995	995	995	995

12. Load transfer from Wagga North 66 kV to Wagga North 132 kV for Winter 2016.
Marulan 132 kV: Both Endeavour Energy and Essential Energy take supply from Marulan. This forecast is for the Essential Energy component. Diversity factors of 2% in winter should be applied to obtain the forecast total winter load at Marulan

APPENDIX 4

Load Profiles and Load at Risk

This appendix provides information which may be useful to potential providers of network support. It covers the three network limitations where network support may be feasible. For those limitations it provides forecasts of loads and the magnitude of load at risk for the critical season(s) as well as “typical” load profiles for the day of maximum demand in the relevant season(s).

In addition, it provides general information about the possible variations in the periods over which network support may be required. As indicated in Section 2.11 it is not always possible to predict the precise nature and depth of the information required by particular interested parties. Should additional information be required, interested parties are encouraged to contact TransGrid so that information tailored to their particular needs can be provided. Contact details are provided on the inside of the rear cover.

SUPPLY TO THE GUNNEDAH/NARRABRI AREA

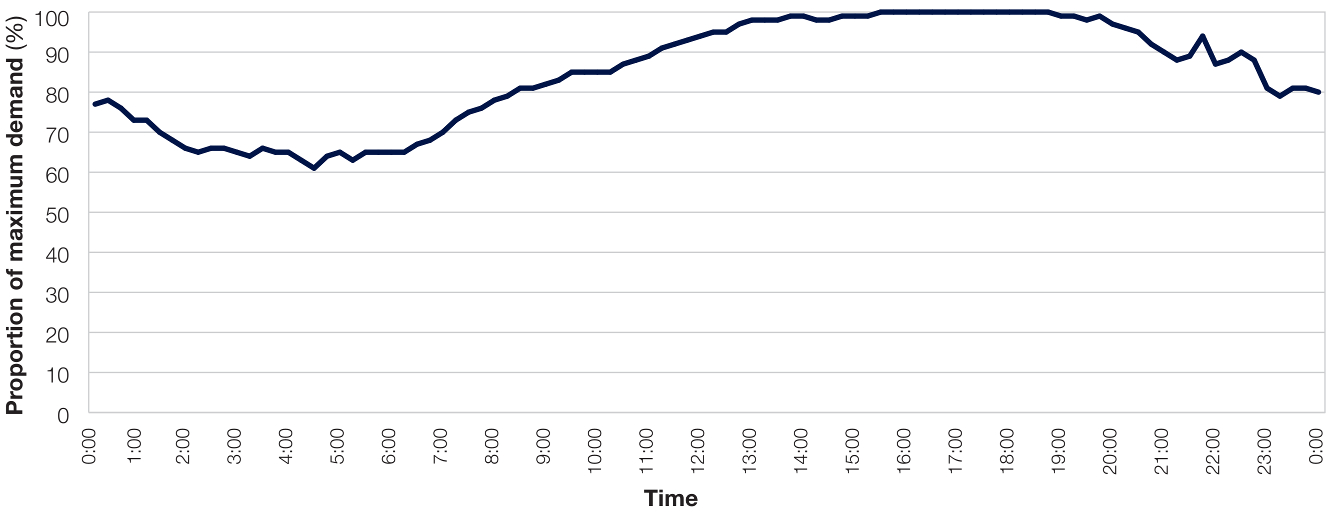
The nature of the limitations in the network supplying the Gunnedah/Narrabri area are described in Section 7.2.1.1. The forecast summer loads in the area together with the expected amount of load at risk are given in Table A4.1.

TABLE A4.1 – GUNNEDAH/NARRABRI AREA SUMMER LOAD FORECAST AND EXPECTED LOAD AT RISK (MW)

	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Gunnedah	27	27	27	27	27	27	27	28	28
Narrabri	49	49	49	49	49	50	50	50	50
Boggabri area mines	6	20	20	20	20	20	20	20	20
Total	82	96	97	98	98	98	98	98	100
Expected load at risk	7	33	35	37	37	38	38	38	41

In recent years there have been minor variations in the load profiles on the day of summer maximum demand. Figure A4.1 shows the envelope within which the profiles for the past five years fit. As the impact of the patterns of the expected additional mining loads are not known, this is the present best estimate of future load profiles.

FIGURE A4.1 – GUNNEDAH AND NARRABRI LOAD PROFILE ON DAY OF MAXIMUM DEMAND



SUPPLY TO THE BERYL/MUDGEE AREA

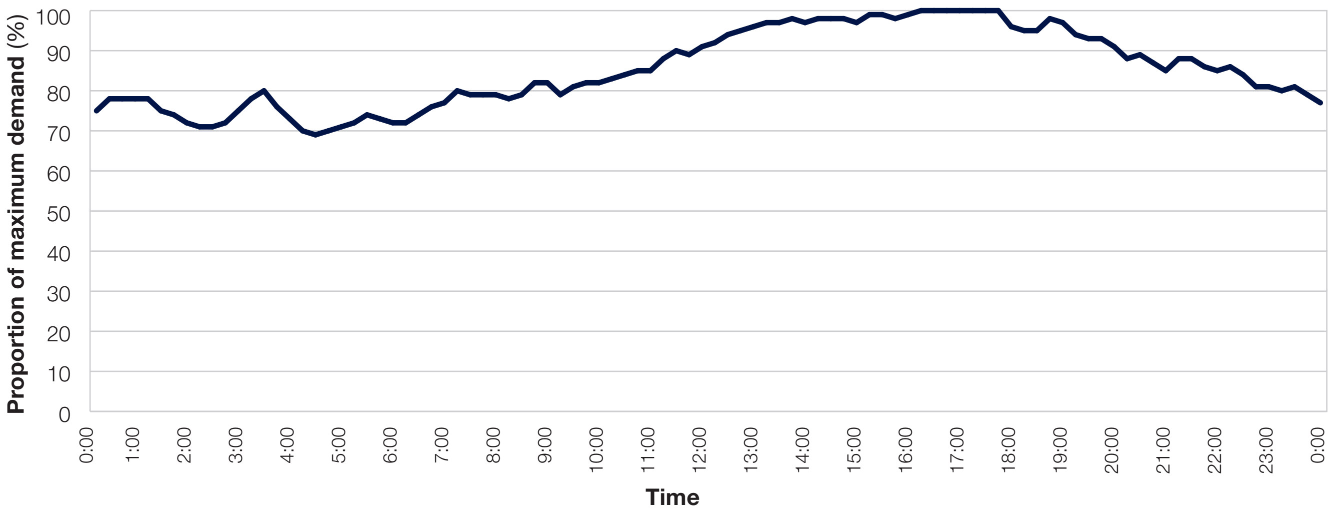
The nature of the limitations in the network supplying the Beryl/Mudgee area are described in Section 7.2.2.4. The forecast summer loads in the area together with the expected amount of load at risk are given in Table A4.2.

TABLE A4.2 – BERYL/MUDGEE SUMMER LOAD FORECAST AND EXPECTED LOAD AT RISK (MW)

	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Beryl	68	74	75	75	76	77	78	78	79
Mudgee	21	21	21	21	22	22	22	22	22
Total	89	95	96	96	98	99	100	100	101
Expected load at risk	0	1	1	2	3	3	4	4	5

In recent years there has been some variation in the load profiles on the day of summer maximum demand, most probably due to the mining loads. Figure A4.2 shows the envelope within which the profiles for the past five years fit. As the impacts of patterns of the expected additional mining loads are not known, this is the present best estimate of future load profiles.

FIGURE A4.2 – BERYL AND MUDGEE LOAD PROFILE ON DAY OF MAXIMUM DEMAND



SUPPLY TO THE SYDNEY INNER METROPOLITAN AREA

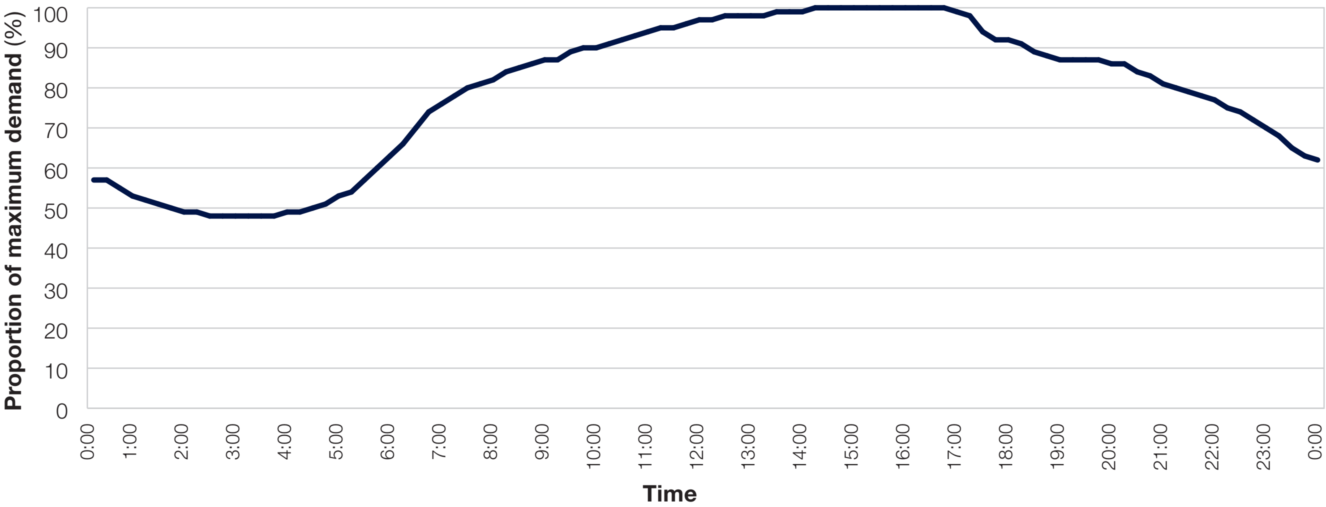
The nature of the limitations in the network supplying the Sydney inner metropolitan area are described in Section 7.2.2.1. The forecast summer loads across two critical sections of the network supplying the area together with the corresponding expected amount of load at risk are given in Table A4.3.

TABLE A4. 3 – SYDNEY INNER METROPOLITAN AREA SUMMER LOAD FORECAST AND EXPECTED LOAD AT RISK (MW)

	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Critical section 1 load	1,730	1,737	1,785	1,827	1,870	1,902	1,927	1,954	1,981
Expected section 1 load at risk	0	0	0	6	295	328	354	381	715
Critical section 2 load	988	995	1,014	1,037	1,049	1,059	1,064	1,075	1,084
Expected section 2 load at risk	0	0	0	0	84	115	115	134	143

In recent years there have been minor variations in the load profiles on the day of summer maximum demand. Figure A4.3 shows the envelope within which the profiles for the past five years fit.

FIGURE A4. 3 – SYDNEY INNER METROPOLITAN AREA LOAD PROFILE ON DAY OF MAXIMUM DEMAND



VARIABILITY IN THE PERIODS OVER WHICH NETWORK SUPPORT MAY BE REQUIRED

There can be considerable variation in weather conditions over seasons, which can affect the number and duration of periods of high loads (during which network support may be required). For example, the weather is generally hotter and drier than usual under El Niño conditions and cooler and wetter under La Niña conditions[1].

As a broad indication of the potential variability in the number and duration of periods when network support may be required, an analysis of winter and summer temperature data for Wagga[2] was undertaken. The analysis considered the number of "adverse temperature[3] days" in each season (days on which the 50% probability of exceedence (PoE) summer maximum or winter minimum temperature was exceeded).

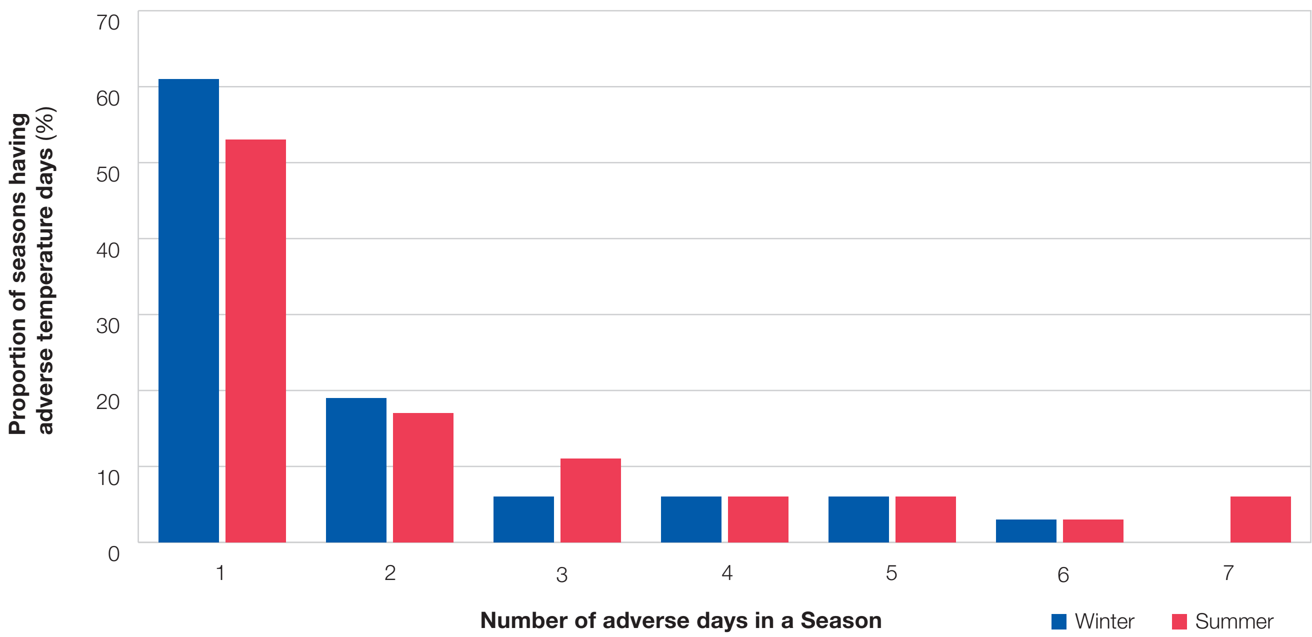
Consistent with the way that they were defined, adverse temperature days occurred in only half the seasons.

In the seasons having adverse temperature days it is most likely that there will be only one or two although there could be several (refer to Figure A4.4).

"Groups" of consecutive adverse temperature days can occur. When they do occur, shorter durations are more likely (refer to Figure A4.5).

Occasionally there can be more than one "group" of consecutive adverse temperature days in a season (refer to Figure A4.6).

FIGURE A4. 4 – NUMBER OF ADVERSE TEMPERATURE DAYS IN A SEASON



1. The Bureau of Meteorology provides extensive information on Australia's climate at www.bom.gov.au/climate. Information on El Niño Southern Oscillation events is available at www.bom.gov.au/climate/enso.
2. Wagga was selected due to the amount of temperature data available (over 70 years) and the "quality" of those data (all from the same location, Wagga airport, with relatively few days of "missing" data). Winter was taken to be June, July and August and summer to be December, January and February.
3. The summer temperature measure used was "cooling degrees" which is based on a two day weighted average temperature, relative to a threshold above which "discretionary" cooling loads could be expected to occur. Where the weighted average temperature exceeds the threshold, the "cooling degrees" are the extent to which it does so, otherwise it is zero. As the highest demands for electricity generally occur on working weekdays, days on which high demands are unlikely to occur (weekends, public holidays and the Christmas – New Year – early January period) were excluded.
A similar measure, "heating degrees" which was based on a three day weighted average temperature, was used for winter. As for summer, days on which high demands are unlikely to occur (weekends) were excluded.

FIGURE A4. 5 – MAXIMUM NUMBER OF CONSECUTIVE ADVERSE TEMPERATURE DAYS IN A SEASON

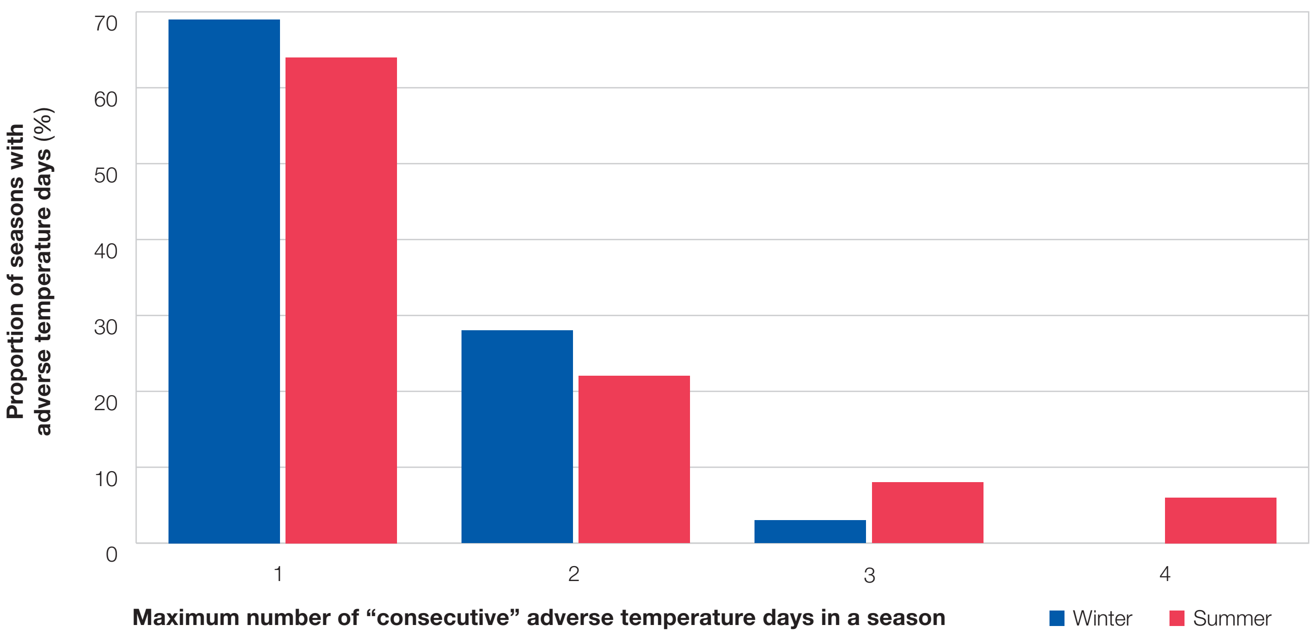
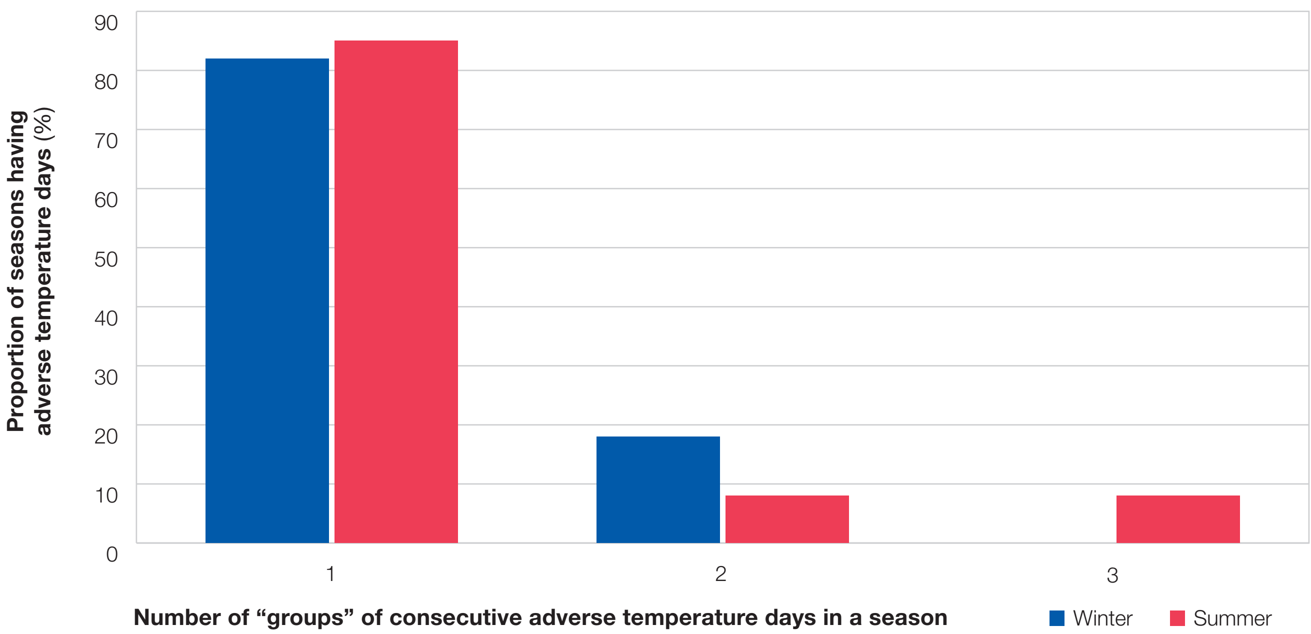


FIGURE A4. 6 – NUMBER OF GROUPS OF CONSECUTIVE DAYS OF ADVERSE TEMPERATURE IN A SEASON



The above analysis is intended to give a broad indication of how parameters related to the magnitude and duration of high load events may vary due to variations in weather within a season and between seasons. The results should not be taken to be "precise". For example they could be expected to vary depending on the measure used to identify potential high load days and the location at which the weather data are measured. It is also possible that climate change may result in more frequent or more severe extreme weather events.

Given the extent of the potential variations and considering that it is not possible to accurately forecast weather more than a few days in advance, any feedback on additional information which may be of use to potential providers of network support is welcome. Contact details are provided on the inside of the rear cover.

Line Utilisation Report

This appendix details the utilisation of TransGrid's transmission lines for the 12 month period, 01 May 2013 to 30 April 2014.

The line loading information over the analysis period was obtained from AEMO's Operation Planning and Data Management System (OPDMS). This system produces half hourly system loadflow models (snapshots) of the NEM.

For each half hour period, the utilisation (loading) of each line was calculated as a proportion of the relevant rating. The highest values of these proportions have been reported here.

The utilisation of each line was calculated using two conditions:

- With all network elements in service, referred to as the "N utilisation". These utilisation figures are based on normal line ratings; and
- With the most critical credible contingency (usually an outage of another line in the area), referred to as the "N-1 utilisation". These utilisation figures are based on the line emergency ratings.

The N utilisation and N-1 utilisation of the transmission lines in the NSW transmission network are shown in Figures A5.2 to A5.10.

For each line, the utilisations are shown in the white coloured box placed adjacent to the line. The box shows:

A. The transmission line number.

B. The maximum N utilisation of the transmission line.

C. The maximum N-1 utilisation of the transmission line.

D. The number of the line, an outage of which is the critical contingency.

This is shown in Figure A5.1

There are a number of situations where the N-1 utilisation has been estimated to be more than 100%. These situations could be because of:

- A higher level of line loading being allowed taking into consideration the operational line overloading control schemes and run back schemes available for managing the line loadings; or
- The predicted dispatch conditions having changed over the 5 minute dispatch period causing the line loadings to increase above the predicted values.

FIGURE A5.1: KEY TO INTERPRETATION OF THE INFORMATION SHOWN IN FIGURES A5.2 TO A5.10

A – Line Number: B – Maximum N Utilisation %
C – Maximum N-1 Utilisation % [D – Line number out for N-1]

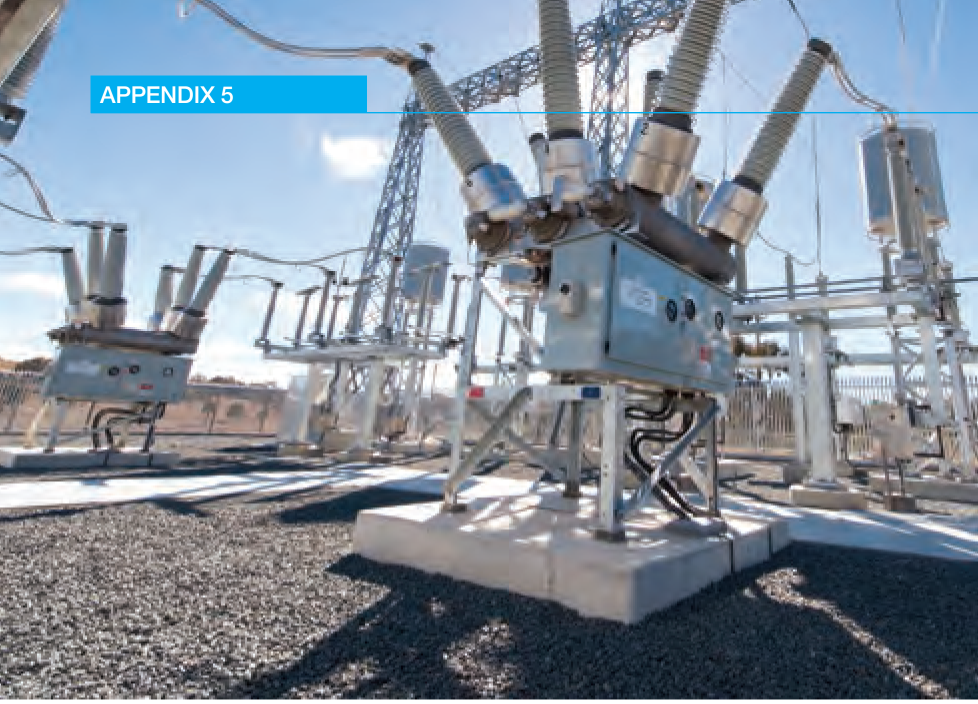


FIGURE A5. 2 – TRANSGRID N AND N–1 LINE UTILISATIONS – MAP 1

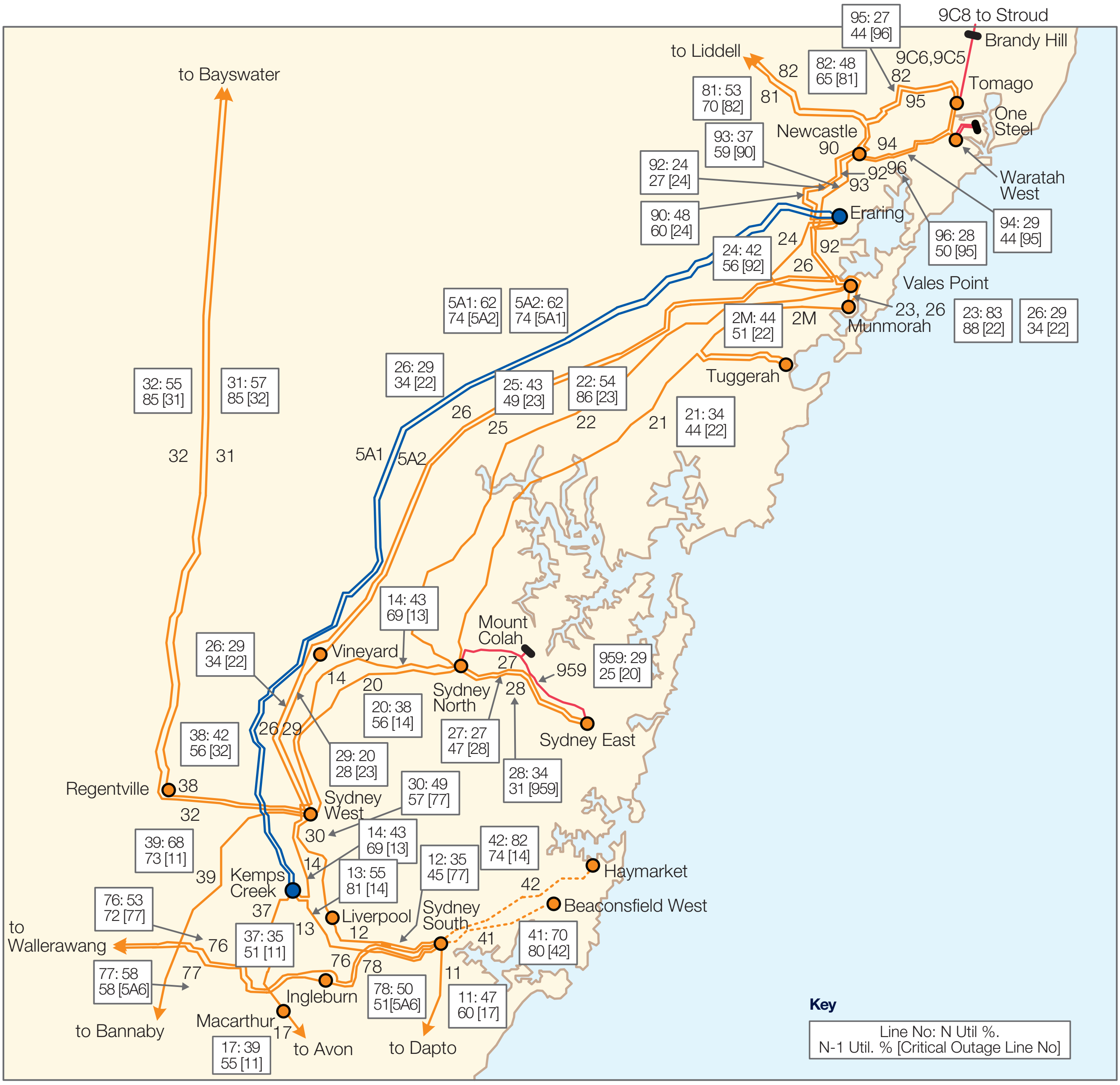


FIGURE A5. 3 – TRANSGRID N AND N–1 LINE UTILISATIONS – MAP 2 – NORTH EAST NSW

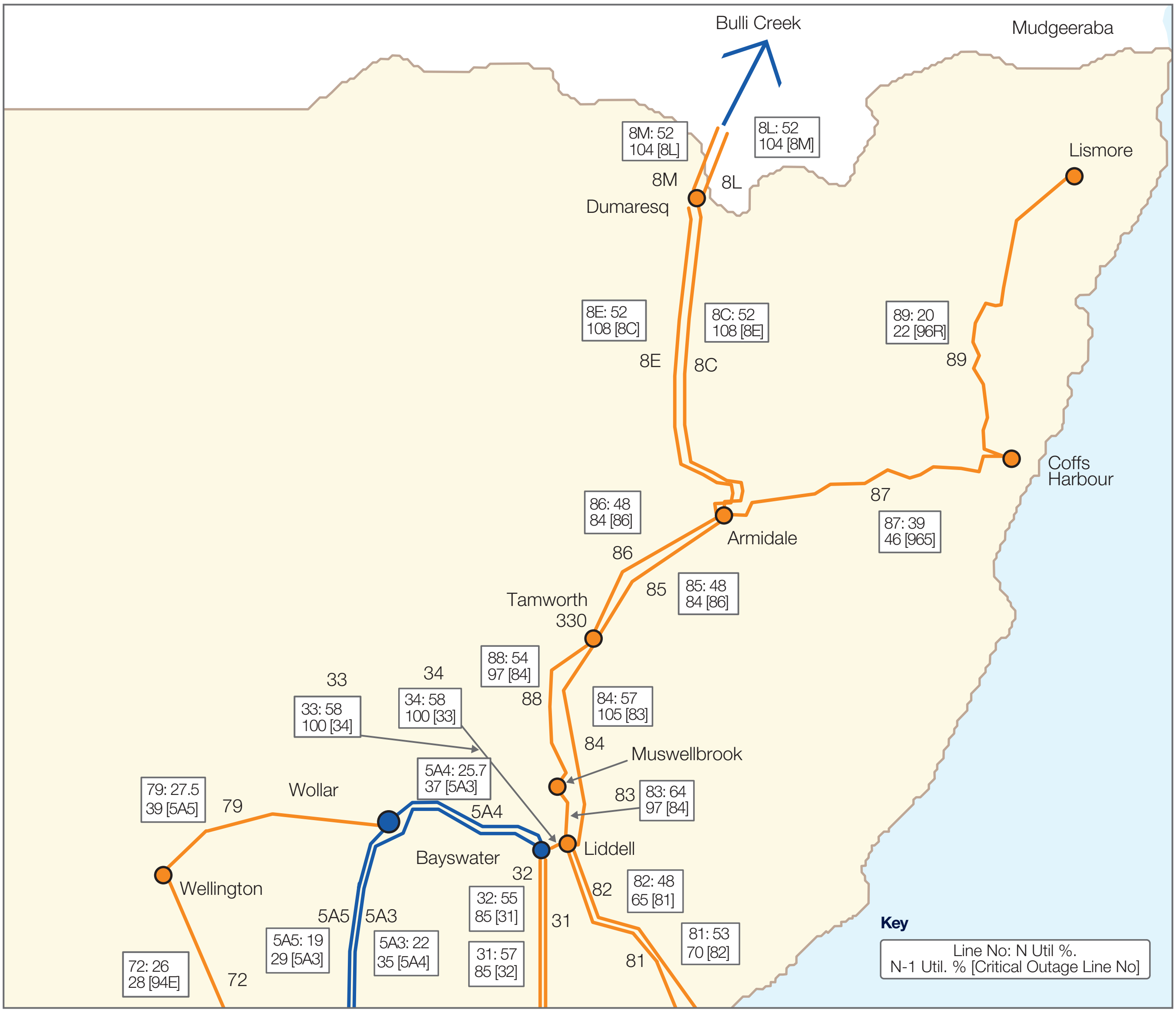


FIGURE A5. 4 – TRANSGRID N AND N–1 LINE UTILISATIONS – MAP 3 – HUNTER VALLEY

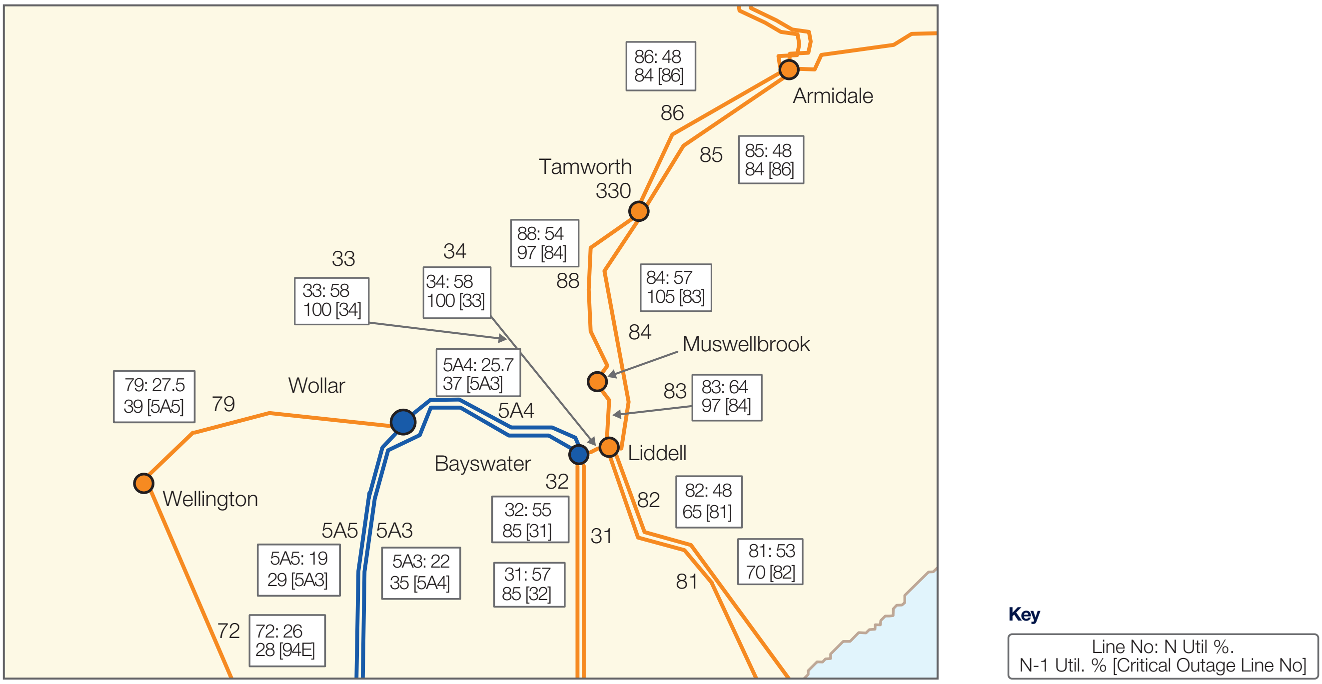


FIGURE A5. 5 – TRANSGRID N AND N–1 LINE UTILISATIONS – MAP 4 – SOUTH AND SOUTH EAST

FIGURE A5. 6 – TRANSGRID N AND N–1 LINE UTILISATIONS – MAP 5 – FAR WEST

FIGURE A5.7 – TRANSGRID N AND N–1 LINE UTILISATIONS –
MAP 6 – NORTH COAST AND NORTH WEST 132 kV SYSTEM

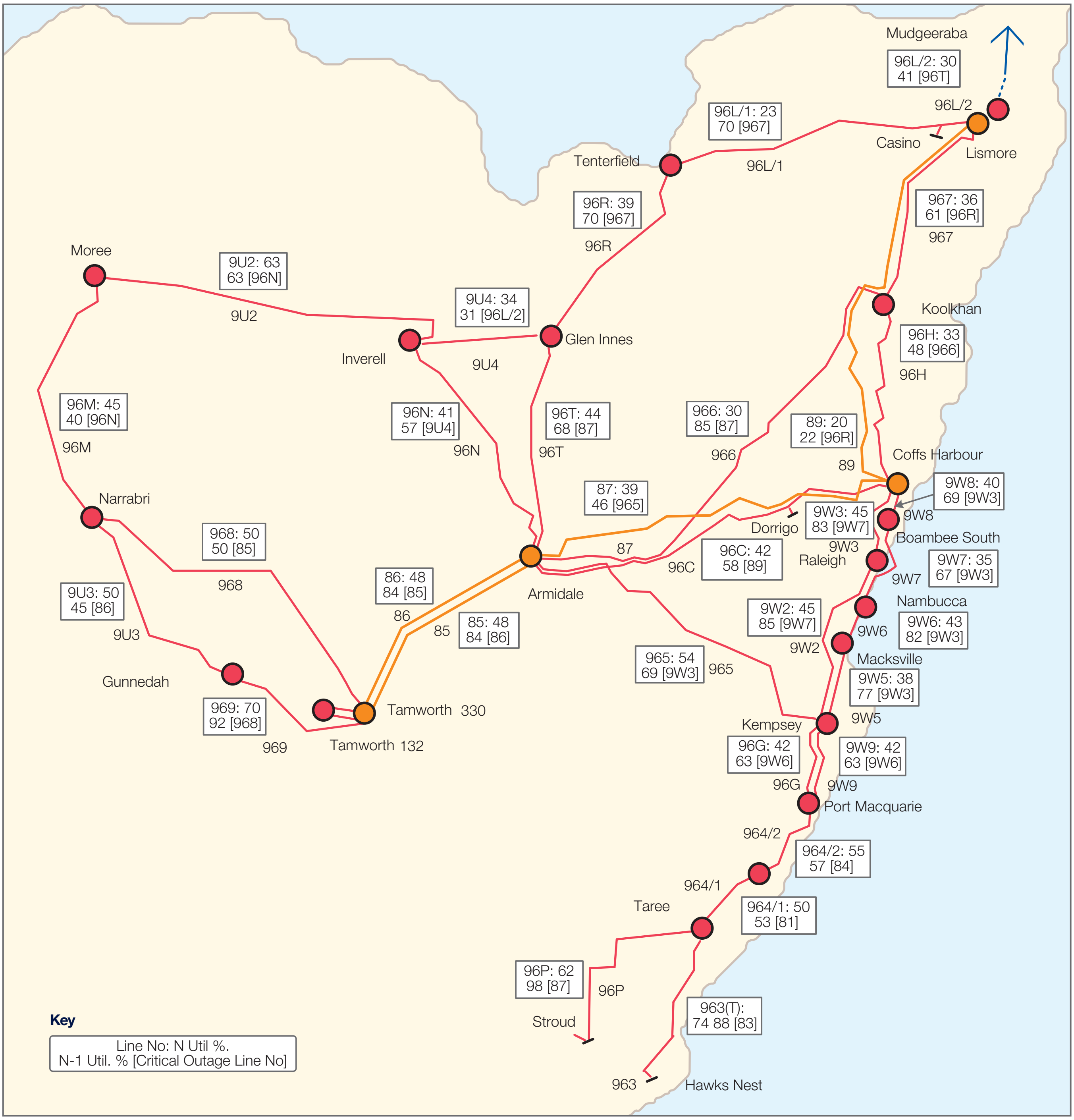


FIGURE A5. 8 – TRANSGRID N AND N–1 LINE UTILISATIONS – MAP 7 – CENTRAL WEST

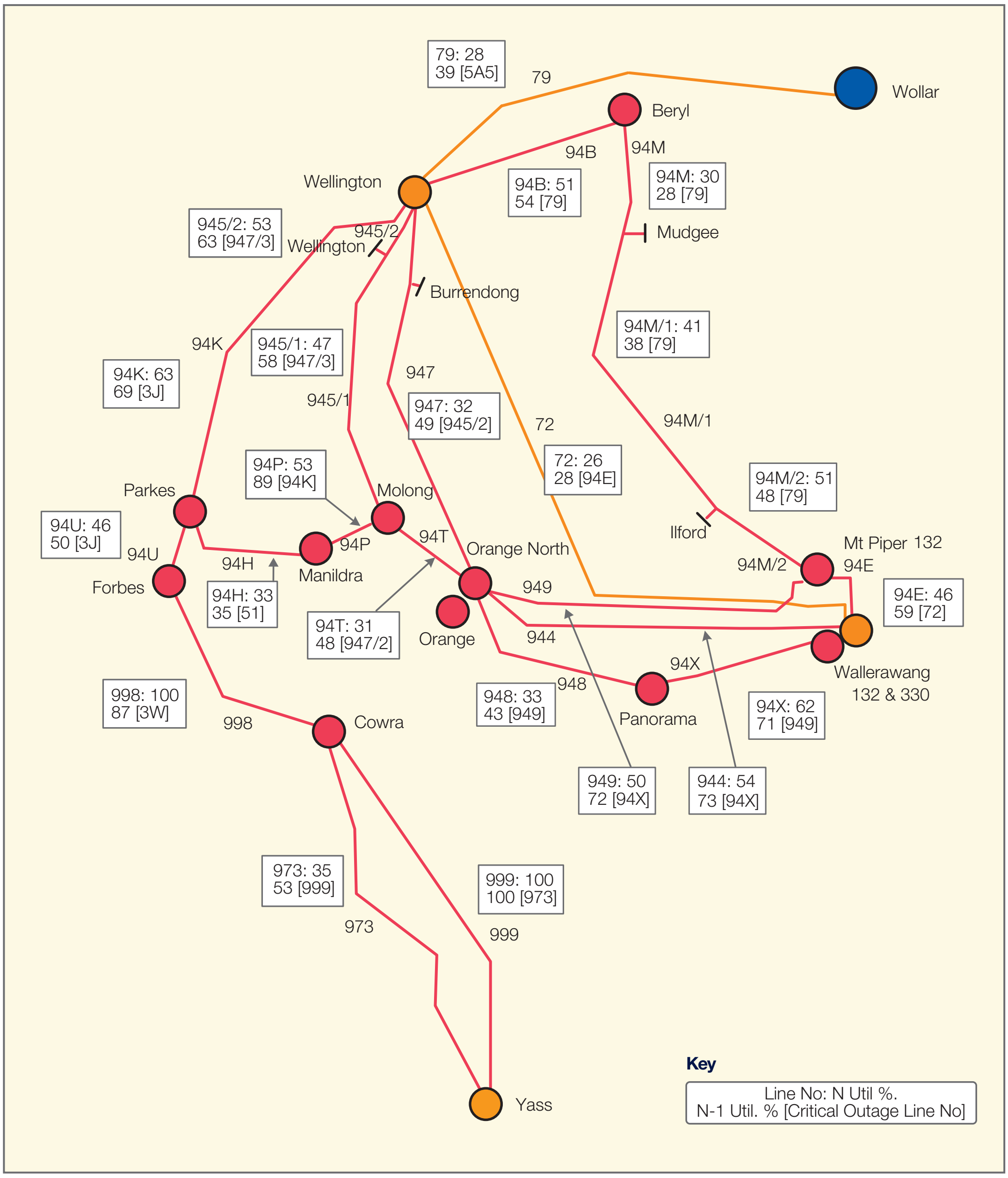


FIGURE A5. 9 – TRANSGRID N AND N–1 LINE UTILISATIONS – MAP 8 – SOUTH AND SNOWY

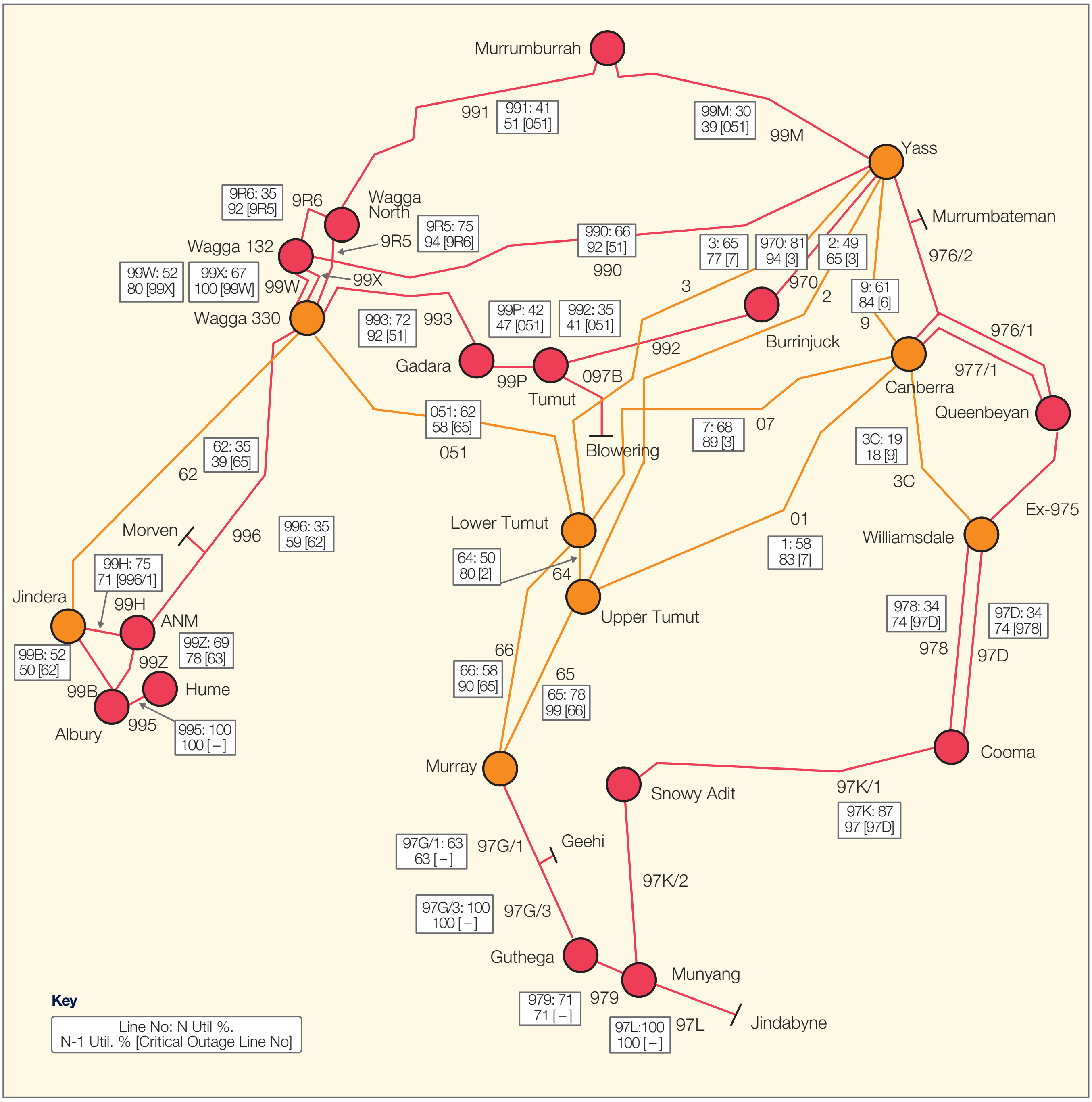
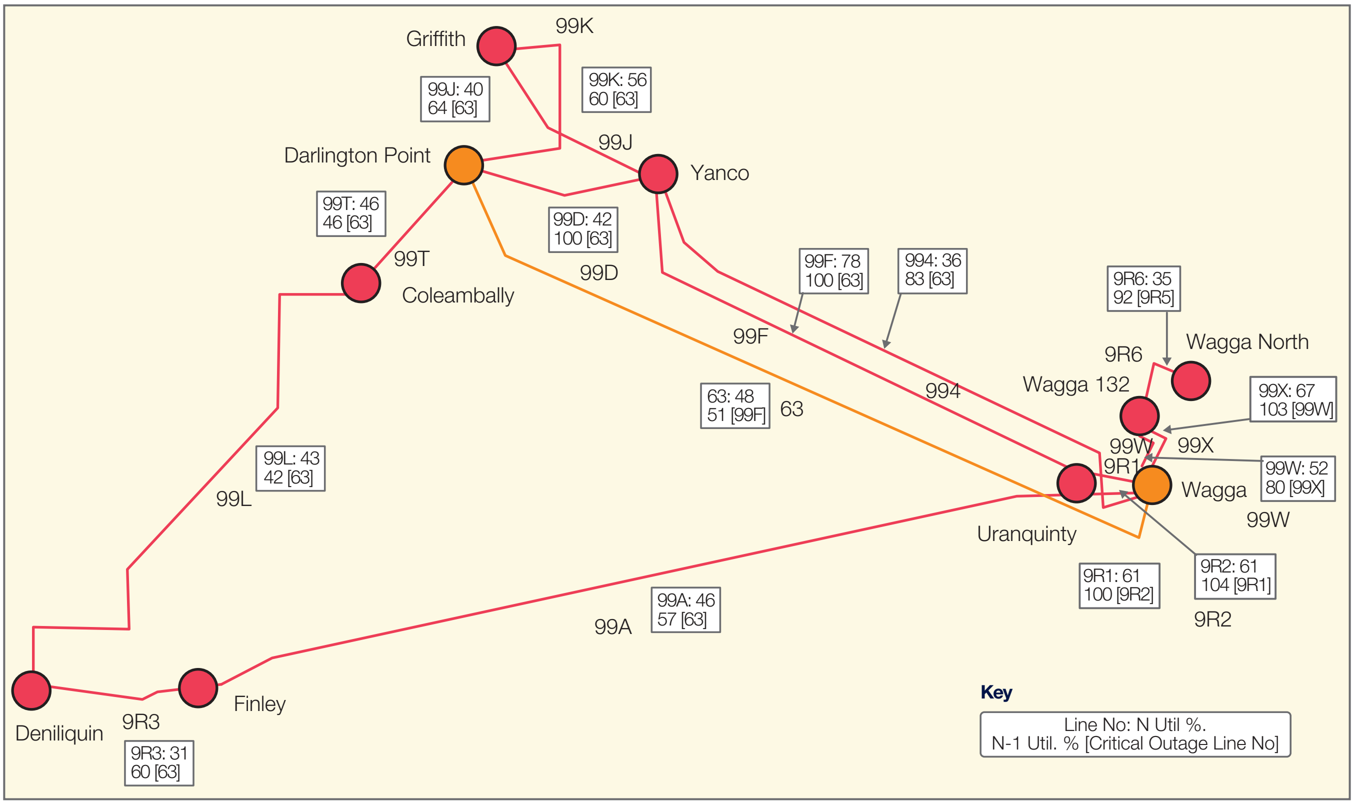
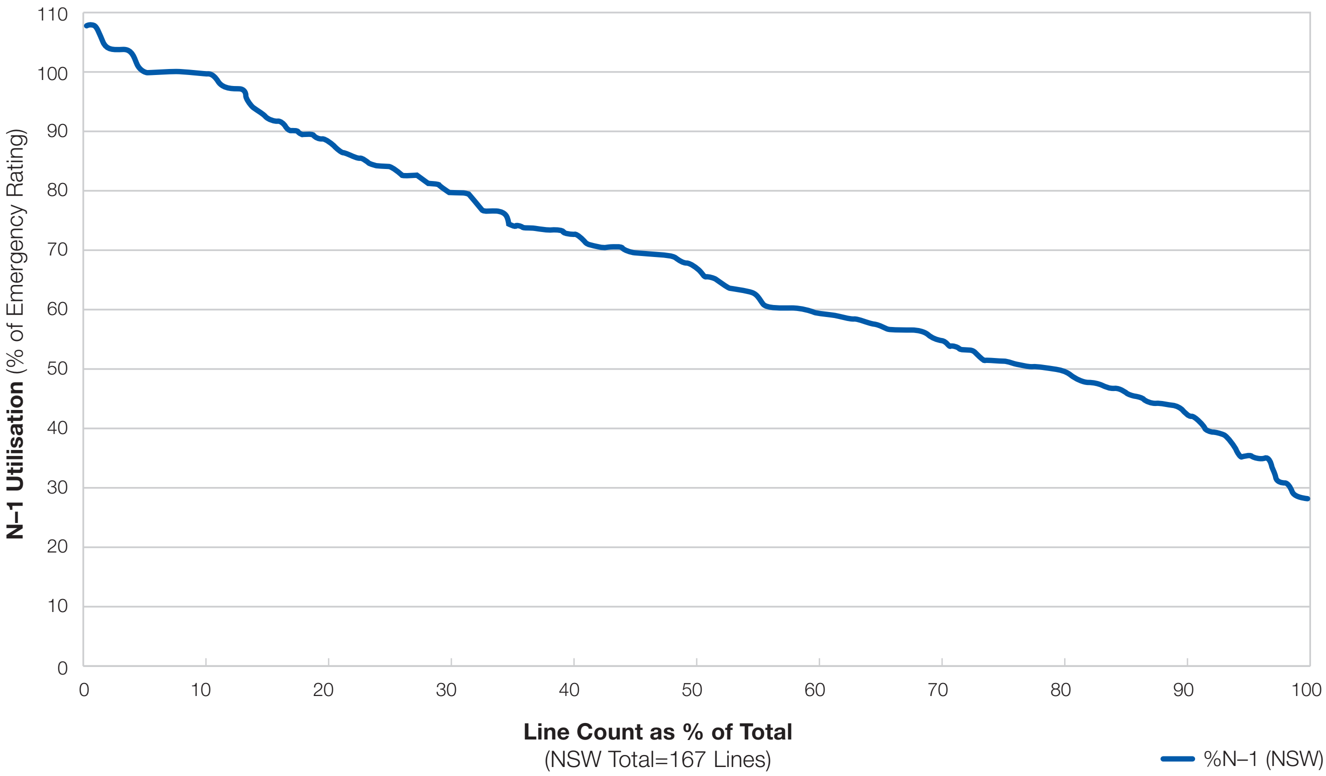


FIGURE A5. 10 – TRANSGRID N AND N–1 LINE UTILISATIONS – MAP 9 – SOUTH WEST



SUMMARY OF THE N–1 UTILISATION OF THE TRANSMISSION LINES IN THE TRANSGRID'S NETWORK

FIGURE A5. 11 – DISTRIBUTION OF TRANSGRID LINE N–1 UTILISATIONS



The distribution of the utilisation of the transmission lines across TransGrid's transmission network is shown in Figure A5.11.

The distribution shows that approximately 15% of the transmission lines in the network are utilised up to their installed maximum capacity. TransGrid's plans for the most economical approach for managing the loadings on these lines are detailed in Chapters 6 and 7 of this TAPR. Approximately 30% of the lines utilise more than 80% of their installed capacity. On the other hand, approximately 20% of the transmission lines are presently only utilised between 30 and 50% of their installed capacity, representing the "step" increments in the transmission capacity as the network is augmented by building new transmission lines. The new augmentations are built with the expectation that they should provide adequate capacity over their asset lives of approximately 40 – 50 years.

The distribution of N-1 line utilisations reflects at least 40 years of planning history of the transmission network. It is considered to be typical of a well planned network where various parts of the network are well established, while there are other parts that have had recent step augmentations that will be further utilised in future years.

APPENDIX 6

Transmission Constraints

A6.1 INTRODUCTION

This Section describes an analysis of how close the flows in TransGrid's network are to its capacity limits. It identifies the transmission elements where flows have been at or close to the limits.

Capacity could be limited due to the power flows reaching:

- the maximum rating of a single transmission element such as a transmission line or a transformer;
- the combined capacity of a group of transmission elements such as several parallel transmission lines constituting inter regional links; or
- the limits set by system wide considerations such as voltage, transient or oscillatory stability limits.

TransGrid provides the capability of its transmission network to AEMO. AEMO manages the power flows in the transmission network to be within the capability of the declared limits of the individual assets or the capability of the transmission system. AEMO do so by automatically adjusting the quantity of generation dispatched, so that the transmission flows will be maintained under the prevailing operating conditions, including the flows to be expected under credible unplanned outages. The optimal generation dispatch, the dispatch which minimises total cost while ensuring the capability limits of the transmission system is not violated, is determined using the analytical tool: National Electricity Market Dispatch Engine (NEMDE). The capability limits are included within NEMDE as mathematical equations, which are known as the "Constraint Equations" (refer to Sections A6.4 and A6.5). Each constraint equation is identified by a unique identifier name, and contains information including the capability limit and the factors which describe or determine the limiting power flows such as power flow in a transmission line or generator power outputs which contribute to the limiting power flow.

The capability limitations of the transmission system are normally termed as "constraints" reflecting that each limitation is represented by a constraint equation in NEMDE.

The constraints reported in this Section cover the transmission system capability limitation experienced during the period from 1 May 2013 to 30 April 2014. The same information is also used to predict the potential future constraints.

A6.2 HISTORICAL TRANSMISSION SYSTEM PERFORMANCE

Following table summarises the constraints, where higher cost generation may have to be dispatched because some transmission elements or parts of the transmission network have been reached their maximum capability. The table shows the constrain identifier, its description, type of limitation addressed by the constraint equation and length of the time period where the transmission element or the part of the transmission system was operated at its maximum capability limit.

Constraint Name	Constraint description	Type of limitation	Total Duration (hh:mm)
N^^Q_NIL_B1	Constrain the northerly flow on QNI and the Terranora interconnector to avoid voltage collapse, if the Kogan Creek generator trips	Voltage stability	256:15
N^^V_NIL_1	Constrain the Southerly flow on the Victorian to New South Wales interconnector, the flow from Victoria to South Australia on Murraylink and various generators to avoid voltage collapse if the largest Victorian generator, or Basslink trips.	Voltage stability	133:10
N^^V_NIL_2	Constrain the Southerly flow on the Victorian to New South Wales interconnector, the flow from Victoria to South Australia on Murraylink and snowy generation to avoid voltage collapse if one of the Murray to Dederang 330kV transmission lines trips.	Voltage stability	9:55
N^Q_NIL_A	Constrain the northerly flow on QNI and the Terranora interconnector to avoid voltage collapse, if 83 Liddell to Muswellbrook 330kV transmission line trips.	Voltage stability	7:15
N^^Q_NIL_B4	Constrain the northerly flow on QNI and the Terranora interconnector to avoid voltage collapse, if a Tarong North generator trips.	Voltage stability	2:45
V::N_NIL_V1	Constrain the northerly flow on the Victorian to New South Wales interconnector (and other Victorian interconnectors and generation) to prevent transient instability if one of the HWTS to SMTS 500kV transmission lines trips.	Transient stability	06:50
Q:N_NIL_BCK2L-G	Constrain the southerly flow on QNI to prevent transient instability if one of the 330kV transmission lines between Armidale and Dumaresq or Dumaresq and Bulli Creek trips.	Transient stability	01:55
V::N_NIL_V2	Constrain the northerly flow on the Victorian to New South Walers interconnector (and other Victorian interconnectors and generation) to prevent transient instability if one of the HWTS to SMTS 500kV transmission lines trips.	Transient stability	00:50
N>>V-NIL_O	Constrain the southerly flow on the Victorian to New South Wales interconnector to avoid the overload of 65 Murray to Upper Tumut 330kV transmission line if O51 Lower Tumut to Wagga 330kV transmission line trips.	Thermal	02:10
N>N-NIL__4_15M	Constrain northerly flow on QNI and the Terranora interconnector to avoid the overload of 88 Muswellbrook to Tamworth 330kV transmission line if 84 Liddell to Tamworth 330kV transmission line trips.	Thermal	02:05
N>>N-NIL__2_OPENED	Constrain northerly flow on QNI and the Terranora interconnector to avoid the overload of 84 Liddell to Tamworth 330kV transmission line if 83 Liddell to Muswellbrook 330kV transmission line trips.	Thermal	00:30
N>>N-NIL_1A_OPENED	Constrain northerly flow on QNI, northerly flow on the Terranora interconnector, other interconnectors and NSW generation to avoid the overload of 33 or 34 Liddell to Bayswater 330kV transmission line if either line trips.	Thermal	00:30
N>>N-NIL__3_15M	Constrain northerly flow on QNI and the Terranora interconnector to avoid the overload of 83 Liddell to Muswellbrook 330kV transmission line if 84 Liddell to Tamworth 330kV transmission line trips.	Thermal	00:20

A6.3 POSSIBLE FUTURE TRANSMISSION SYSTEM PERFORMANCE

Based on the performance[1] of the transmission system over the period 1 May 2013 to 30 April 2014, it is expected that the following transmission elements or parts of the transmission system may be operated approaching their maximum limits as described in the following table.

Constraint Name	Constraint description
V>>N-NIL_HA	Constrain the northerly flow on the Victorian to New South Wales interconnector, the westerly flow on Murraylink and some NSW generation to avoid the overloading of 65 Murray to Upper Tumut 330kV transmission line if 66 Murray to Lower Tumut 330kV transmission line trips.
V>>N-NIL_HB	Constrain the northerly flow on the Victorian to New South Wales interconnector, the westerly flow on Murraylink and some NSW generation to avoid the overloading of 66 Murray to lower Tumut 330kV transmission line if 65 Murray to Upper Tumut 330kV transmission line trips.
V>>N-NIL_HG	Constrain the northerly flow on the Victorian to New South Wales interconnector, the westerly flow on Murraylink and some NSW generation to avoid the overloading of 65 Murray to Upper Tumut 330kV transmission line.
N>>V-NIL_O	Constrain the southerly flow on the Victorian to New South Wales interconnector and constrain on some NSW generation to avoid the overloading of 65 Murray to Upper Tumut 330kV transmission line if O51 Lower Tumut to Wagga 330kV transmission line trips.
N>>N-NIL__3_15M	Constrain the northwards flow on QNI and the Terranora interconnector to avoid overloading 83 Liddell to Muswellbrook 330kV Transmission line if the 84 Liddell l to Tamworth 330kV Transmission Line trips. (Can also constrain Redbank on).
N>>N-NIL__2_15M	Constrain the northwards flow on QNI and the Terranora interconnector to avoid overloading 84 Liddell to Tamworth 330kV Transmission line if the 83 Liddell to Muswellbrook 330kV Transmission Line trips. (Can also constrain Redbank on).
N>>N-NIL_DPTX	Constrains the southerly flow on the Victorian to New South Wales interconnector, the westerly flow on Murraylink and the output of some generators in order to restrict the flow on the remaining Darlington Point Transformer one of the two transformers trip.
N>>N-NIL__3_CLOSED	Constrain the northwards flow on QNI and the Terranora interconnector to avoid overloading 83 Liddell to Muswellbrook 330kV Transmission line if the 84 Liddell to Tamworth 330kV Transmission Line trips. (Can also constrain Redbank on).
N>>N-NIL__3_OPENED	Constrain the northwards flow on QNI and the Terranora interconnector to avoid overloading 83 Liddell to Muswellbrook 330kV Transmission line if the 84 Liddell to Tamworth 330kV Transmission Line trips. (Can also constrain Redbank on).

The constraints listed in the tables above are being reviewed by TransGrid to fully understand their nature, and to provide possible solutions to reduce the market impact of the transmission constraints.

TransGrid intends to continue with its analysis of network constraints. It is expected that this will involve:

- Analysing additional data as it becomes available;
- Investigation of the distribution(s) of marginality values and, if possible, refinement of likelihood estimates; and
- Identification and analysis of trends (which may be a leading indicator of the onset of constraints).

1. These constraints had average value for the period from 1 May 2013 to 30 April 2014 that was the closest to binding in terms of direct value, or number of standard deviation.

A6.4 BACKGROUND TO CONSTRAINT EQUATIONS

This appendix describes an analysis of how close constraints relating to TransGrid's network have come to binding. It identifies the most onerous constraints using three different criteria and provides the historical outcomes as well as broad estimates of future constraints.

TransGrid provides the capability of its transmission network to AEMO, which AEMO then translates into constraint equations. AEMO use the constraint equations in the National Electricity Market Dispatch Engine (NEMDE), to control the transmission network to be within its physical capability.

The NEMDE uses linear programming (LP) methods to dispatch the NEM, and the constraint equations use the jargon of LP, which gives special meaning to the left and right hand sides of the equations.

The Left Hand Side (LHS) of the equations contain variables that are controllable by the NEMDE, and contains terms like the MW generated at a power station. The Right Hand Side (RHS) of the equation generally contains the variables that are not controlled by dispatch such as line ratings and the size of loads at various locations. A simple example of a constraint equation follows:

LHS	≤	RHS
a_1 x Generation at power station 1		$+b_1$ x Network Limit1
$+a_2$ x Generation at power station 2	≤	$+b_2$ x Network Limit2
$+a_3$ x generation at power station 3		$+b_3$ x Load1

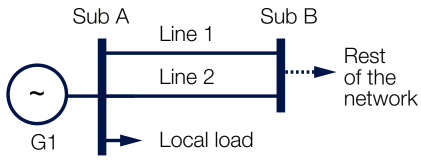
Subtracting the RHS from the LHS (LHS – RHS) of the equation gives an indication of "how close" the constraint is to binding. If both sides of the equation are equal, then (LHS – RHS) equals zero, the constraint is binding, and the transmission network is operating at its limit.

The (LHS – RHS) value is referred to as the marginality of the constraint.

A6.5 INDICATIVE EXAMPLE OF A CONSTRAINT EQUATION

Figure A6.1 illustrates a network which consists of a generator (G1) and a "Local load" connected to "Sub A". Two transmission lines ("Line 1" and "Line 2") are connected from "Sub A" to "Sub B", which in turn is connected to the rest of the network.

FIGURE A6.1 – A TWO TRANSMISSION LINE EXAMPLE OF A TRANSFER LIMIT



The limit of generation from G1 will be the local load plus the power that can be securely transferred from "Sub A" to "Sub B" to the rest of the network via "Line 1" and "Line 2". In this example, that will be the minimum Sustained Emergency Ratings (SER) of the two lines. For example, if "Line 1" has a SER of 100 MVA and "Line 2" has an SER of 90 MVA, then the maximum power that can be transferred securely will be 90 MVA. We assume the generation cannot be reduced sufficiently quickly on the loss of one of the lines. If "Line 1" trips, then "Line 2" will be at its limit, if 90 MVA is being transferred.

The constraint equation for the network illustrated in Figure 1 would be:

LHS	≤	RHS
Generation at power station (G1)	≤	Local load + Rating of "Line 2"

If the local load is 10 MVA, and the lowest rating of the lines is 90 MVA, then:

- If the generation output is 100 MVA then the marginality of the equation is zero; the constraint is binding, that is, the system is operating at its very limit of power transfer. The constraint equation would be:

LHS	≤	RHS
100	≤	10 + 90

- If we consider the same load and rating, but reduce the generation to 90 MVA, then the marginality is -10, hence, the maximum additional power transfer capacity is 10 MVA. The constraint equation would be:

LHS	≤	RHS
90	≤	10 + 90

- If the generation is increased to 110 MVA, the marginality would be +10. In addition, in the event of a contingency trip of "Line 1", "Line 2" would be overloaded. The constraint equation would be:

LHS	≤	RHS
110	≤	10 + 90

If the marginality is greater than zero the network is operating in an insecure state and the constraint has been violated.

APPENDIX 7

Planning Proposals for Future Connection Points

The NER requires the TAPR to set out planning proposals for future connection points. These can be initiated by generators or customers or arise as the result of joint planning with a Distributor.

The term "planning proposal" is not defined in the NER. In its previous TAPRs TransGrid has taken a very broad interpretation covering developments up to five years in the future relating to:

- Provision of new bulk supply points;
- Provision of additional switchbays for new connections at existing bulk supply points; or
- Developments which may increase the capability of a bulk supply point, such as installation of new transformers or capacitors.

For consistency, that approach has been maintained for the TAPR 2014 even though it includes developments which are not considered to be proposed under TransGrid's network investment process and/or don't relate to *connection points* as defined in the NER and/or involve existing bulk supply points.

The following table covers developments which meet TransGrid's broad interpretation.

TABLE A7.1 – CONNECTION POINT

Bulk Supply Point	Development	Proposed Service Date	TAPR 2014 Section
Orange 132/66 kV Substation	Replacement of 66 kV substation equipment and additional 66 kV capacitor	Mid 2017	6.2.1.1
Rookwood Road 330/132 kV Substations	New 132 kV connection points	Late 2014	6.2.1.2
Cooma 132/66/11 kV Substation	Condition based substation replacement	Late 2015	6.2.2.3
Yanco 132/33 kV Substation	Condition based substation replacement	Late 2015	6.2.2.4
Wagga North 132/66 kV Substation	New 132 kV switchbay connection	Mid 2015	6.2.3
Yanco 132/33 kV Substation	Condition based transformer replacement	Mid 2014	6.2.5
Griffith 132/33 kV Substation	Condition based transformer replacement	Late 2014	6.2.5
Newcastle 330/132 kV Substation	Condition based transformer replacement	Late 2014	6.2.5
Canberra 330/132 kV Substation	Expansion of a capacitor bank Additional capacitor bank	Late 2014 Mid 2014	6.2.6 6.2.6
Yass 330/132/66 kV Substation	Additional capacitor bank	Summer 2014/15	6.2.6
Orange 132/66 kV Substation	Additional capacitor (in lieu of 944 line)	Mid 2017	6.2.6
Tamworth 132/66 kV Substation	Condition based substation replacement	2017	6.2.7
Sydney West 330/132 kV Substation	Two 132 kV switchbay connections	2016 to 2020	6.3.8
Williamsdale 330/132 kV Substation	New 132 kV switchbay connection	2018	6.3.8
Tamworth 330/132 kV Substation	Condition based transformer replacement	2018	7.2.1.2
Beryl 132/66 kV Substation	Additional or expanded capacitor	2015	7.2.2.4

The timely identification of emerging constraints also allows the market to identify potential non-network alternatives and TransGrid to develop and implement appropriate and timely measures

Bulk Supply Point	Development	Proposed Service Date	TAPR 2014 Section
Munmorah 330/132 kV Substation	Condition based substation replacement	2017	7.2.2.6
Vales Point 330/132 kV Substation	Condition based substation replacement	2018	7.2.2.7
Panorama 132/66 kV Substation	Additional capacitor (in lieu of 944 line)	2017	7.2.2.8
Orange North 132 kV Switching Station	Additional capacitor (in lieu of 944 line)	2017	7.2.2.8
Beryl 132/66 kV Substation	New 66 kV switchbay	2015	7.2.2.9
Molong 132/66 kV Substation	New 66 kV switchbay	2015	7.2.2.10
Vineyard 330/132 kV Substation	New 132 kV switchbay	2018	7.2.2.11
Canberra 330/132 kV Substation	Condition based substation replacement	2019	7.2.3.3
Burrinjuck 132 kV Substation	Condition based 132 kV switchyard replacement	2019	7.2.3.4
Taree 132/66/33 kV Substation	Condition based 33 kV switchyard replacement	2018	7.2.5
Forbes 132/66 kV Substation	Condition based transformer replacements	2018	7.2.5
Beaconsfield 330/132 kV Substation	Condition based transformer replacements	2018	7.2.5

APPENDIX 8

Progress of Developments Reported in the TAPR 2013

Changes to this TAPR in regard to the organisation of the Chapters are detailed in Chapter 2.

The following table lists the developments reported in TransGrid's TAPR 2013, and the Section in this current TAPR where the progress/current status of that development is reported.

Development	TAPR 2013	TAPR 2014	Comment
Committed Developments reported in TAPR 2013:			
Armidale SVC: Power Oscillation Damping Control	5.2.1	6.1.1.3	Completed
Western Sydney Supply Project	5.2.2	6.2.1.2	Completion expected September 2014
Upper Tumut Switching Station Rehabilitation	5.2.3	6.2.2.1	Completion expected progressively through to January 2015
Supply to the Lower Mid North Coast	5.2.4	6.1.1.1	Completed Jan 2014
Reinforcement of Supply within the Sydney Inner Metropolitan Area	5.2.5	6.1.2.2	Completed July 2013
Voltage Control in the Snowy Area	5.2.6	6.1.3.1	Completed May 2014
41 Cable Capacity, Sydney South works	5.2.7	7.2.2.2	Possible development within five years
Planned Augmentations that have completed the Regulatory Process, reported in TAPR 2013:			
Redevelopment of Orange 132/66 kV Substation	5.3.1	6.2.1.1	Completion expected April 2017
Development of southern supply to the ACT	5.3.2	6.3.2.1	
Supply to the Forster/Tuncurry Area	5.3.3	7.3.1.4	Possible development within five to ten years.
Dynamic line ratings	5.3.4	6.3.3.1	Completion expected progressively from 2014/15 through to 2018/19
Supply to the Kew/Laurieton Area	5.3.5	6.1.1.2	Completed Nov 2013
Reinforcement of voltage control in northern NSW	5.3.6	7.3.1.3	Possible development within five to ten years
Transposition works on the 76/77 Wallerawang – Sydney South/Ingleburn double circuit 330 kV lines	5.3.7	6.3.1.1	Completion expected October 2014
Multiple contingency protection scheme	5.3.7	6.3.3.2	Completion expected Summer 2016/17
Newcastle 330 kV Substation: provision of 330 kV bus coupler circuit breaker	5.3.7	6.1.8	Completed May 2014
Sydney South 330 kV Substation: provision of 330 kV bus coupler circuit breaker	5.3.7	6.1.8	Completed 2014
Quality of supply monitoring	5.3.8	6.3.3.3	Completion expected 2019
Orange 132/66 kV Substation: provision of additional 66 kV capacitor bank	5.3.13	6.2.1.1	Completion expected April 2017

TransGrid's asset management system provides a framework for managing its transmission network assets over their life cycle

Development	TAPR 2013	TAPR 2014	Comment
Proposed Network Developments within Five Years, reported in TAPR 2013:			
Capacity of the Snowy to Yass/Canberra 330 kV System	6.1.1	7.2.3.1	Possible development within five years
Kangaroo Valley Voltage Levels	6.1.2	6.1.3.2	Completed March 2014
Supply to the Gunnedah/ Narrabri/Moree area	6.1.3	7.2.1.1	Possible development within five years
Murraylink runback control scheme	6.1.4	7.2.3.2	Possible development within five years
Smart grid application	6.1.5		Completed
Supply to the Sydney Inner Metropolitan Area ("Powering Sydney")	6.1.6	7.2.2.1	Possible development within five years
Supply to the Beryl/Mudgee area	6.1.7	7.2.2.4	Possible development within five years
Newcastle 330/132 kV Substation: increase 960 and 961 line switchbay ratings	6.1.8		Limitation is not expected to arise within ten years
Point on wave capacitor circuit breakers	6.1.8	6.3.3.4	Completion expected progressively from 2015 to 2018
Other Constraints Emerging within Five Years, reported in TAPR 2013:			
Supply to Tumut/Gadara	6.2.1	7.4.3.5	Limitation not expected to arise within ten years
NSW to Queensland transmission capacity	6.2.2	7.1.1	Regulatory Consultation underway
Yass – Bannaby and Yass – Marulan 330 kV lines	6.2.3	7.2.3.1	Possible development within five years
Tamworth and Armidale 330 kV switchyards	6.2.4	7.3.1.1	Possible development within five to ten years
Supply to the Darlington Point area	6.2.5	7.4.3.1	Limitation not expected to arise within ten years
Supply to the Tomerong/Nowra area	6.2.6	7.4.2.8	Limitation not expected to arise within ten years
Longer Term Constraints and Indicative Developments, in TAPR 2013			
Hunter Valley – Tamworth – Armidale 330 kV system	6.3.1	7.3.1.2	Possible development within five to ten years
Kemps Creek 500/330 kV transformers	6.3.2	7.4.2.4	Limitation not expected to arise within ten years
Further development of supply to the Newcastle/Sydney/ Wollongong area	6.3.3	7.4.2.5	Need is not expected to arise within ten years

Development	TAPR 2013	TAPR 2014	Comment
Capacity of the Marulan – Avon, Marulan – Dapto and Kangaroo Valley – Dapto 330 kV lines	6.3.4	7.3.3.1	Possible development within five to ten years
Loading on the Wallerawang – Sydney South/Ingleburn 330 kV lines	6.3.5	7.4.2.3	Limitation not expected to arise within ten years
Supply to Sydney East	6.3.6	7.4.2.1	Limitation not expected to arise within ten years
NSW – South Australia interconnection	6.3.7	7.4.3.2	Limitation not expected to arise within ten years
NSW – Victoria interconnection	6.3.8	7.4.3.3	Limitation not expected to arise within ten years
Capacity of connections between Central Coast power stations	6.3.9	7.2.2.7	Need can be addressed with Vales Point Substation condition, refer 7.2.2.7
Supply to the Albury area	6.3.10	7.4.3.4	Limitation not expected to arise within ten years
Supply to southern Sydney	6.3.11	7.4.2.2	Limitation not expected to arise within ten years
Supply to far north NSW	6.3.12	7.4.1.1	Limitation not expected to arise within ten years
Supply to Mudgee	6.3.13	7.4.2.7	Limitation not expected to arise within ten years
Committed Transformer Replacements and Upgrades (Table 5.5, TAPR 2013):			
Wallerawang 330/132 kV Substation: Replacement of No 1 and 2 330/132 kV transformers	5.2.10	6.1.6	Completed May 2014
Sydney East 330/132 kV Substation: Installation of 375 MVA 330/132 kV transformer to replace an existing transformer	5.2.10	6.1.6	Completed Jan 2014
Yanco 132/33 kV Substation: Replacement of two 45 MVA 132/33 kV units with new 60 MVA units	5.2.10	6.2.5	Completion expected Aug 2014
Griffith 132/33 kV Substation: Replacement of three 45 MVA 132/33 kV transformers by three new 60 MVA units	5.2.10	6.2.5	Completion expected Nov 2014
Narrabri 132/66 kV Substation: Replacement of three 30 MVA 132/66 kV transformers by two 60 MVA units released from Coffs Harbour	5.2.10	6.1.6	Completed July 2013
Newcastle 330/132 kV Substation: Replacement of two banks of single phase 330/132 kV transformers with new 375 MVA three phase units	5.2.10	6.2.5	Completion expected late 2014
Yass 132/66 kV Substation: Replacement of No 3 132/66 kV transformer	5.2.10	6.1.6	Completed Dec 2013
Committed Capacitor Bank Installations (Table 5.6, TAPR 2013):			
Sydney South 330/132 kV Substation: New 200 MVAr 330 kV capacitor bank	5.2.11	6.1.7	Completed Dec 2013
Canberra 330/132 kV Substation: Expansion of existing 80 MVAr bank to a 120 MVAr 132 kV capacitor bank	5.2.11	6.2.6	Completion expected Nov 2014
Yass 330/132 kV Substation: New 80 MVAr 132 kV capacitor bank	5.2.11	6.2.6	Completion expected Summer 2014/15
Other Committed Works (Table 5.7, TAPR 2013):			
Sydney West 330 kV Substation: Provide a 330 kV bus coupler circuit breaker	5.2.12	6.1.8	Completed Sept 2013

Development	TAPR 2013	TAPR 2014	Comment
Various 330 kV Substations: Install surge arrestors on 330 kV line entries to substations	5.2.12	6.2.7	Progressive completion expected through to early 2015
Vineyard/Cattai area: Acquisition of a site to enable a future 500/330 kV substation to be developed.	5.2.12	6.2.7	Completion expected 2016
Dapto 330/132 kV Substation: secondary systems replacement	5.2.12	6.2.7	Completion expected mid 2014
Broken Hill 220/22 kV Substation: SVC control system replacement	5.2.12	6.2.7	Completion expected Summer 2014/15
Armidale 330/132 kV Substation: SVC control system replacement	5.2.12	6.2.7	Completion expected late 2015
Sydney West 330/132 kV Substation: Secondary systems replacement	5.2.12	6.2.7	Completion expected late 2015
Griffith 132/33 kV Substation: Secondary systems replacement	5.2.12	6.2.7	Completion expected Nov 2014
Tumut 132/66 kV Substation: Secondary systems replacement	5.2.12	6.1.8	Completed Jun 2014
Armidale 330/132 kV Substation: No 1 Reactor replacement	5.2.12	6.1.6	Completed Apr 2014
97G Murray-Guthega 132 kV transmission line: remedial work	5.2.12	6.2.2.2	Completion expected Nov 2014
94B Wellington-Beryl 132 kV transmission line: wood pole replacement	5.2.12	6.2.7	Completion expected Summer 2014/15
"Proposed" Network Asset Replacements and Upgrades (Tables 5.10 and 5.11, TAPR 2013):			
Sydney West 330 kV Substation: 132 kV fault rating	5.3.9	7.2.2.12	Possible development within five years
Beaconsfield West 330/132 kV Substation: No 1 transformer replacement	5.3.10	7.2.5	Possible development within five years
Buronga 220 kV Switching Station: X2 shunt reactor replacement	5.3.10	6.3.9	Completion expected Summer 2015/16
Broken Hill 220/22 kV: No 1 and No 2 shunt reactor replacement	5.3.10	7.2.5	Possible development within five years
Sydney West: 330/132 kV Substation: two 132 kV line switchbays	5.3.11	6.3.8	Possible development within five years
Newcastle 330 kV Substation: one 132 kV line switchbay	5.3.11	6.3.8	Beyond ten years
Tamworth 132/66 kV Substation: one 66 kV line switchbay	5.3.11	7.3.4	Possible development within five to ten years
Williamsdale 330/132 kV Substation: one 132 kV line switchbay	5.3.11	7.2.3.6	Possible development within five years
Replacement Transmission Network Assets Previously Reported (Table 5.13, TAPR 2013):			
999 Yass to Cowra 132 kV transmission line: line rating restoration	5.3.12	7.4.2.6	Limitation not expected to arise within ten years
Sydney North 330/132 kV Substation: secondary systems replacement	5.3.12	7.2.5	Possible development within five years
Orange 132/66 kV Substation: 66 kV and secondary systems replacement	5.3.12	6.2.1.1	Completion expected April 2017
Tamworth 132/66 kV Substation: substation rebuild	5.3.12	6.2.7	Completion expected 2017
Cooma 132/66 kV Substation: substation rebuild	5.3.12	6.2.2.3	Completion expected Nov 2015
Albury 132/22 kV Substation: secondary systems replacement	5.3.12	7.2.5	Possible development within five years
Vales Point 330/132 kV Substation: substation rebuild	5.3.12	7.2.2.7	Possible development within five years
944 Wallerawang to Orange North 132 kV transmission line: reconstruction	5.3.12	7.2.2.8	2016/17
Possible Replacement Transmission Network Assets within five years (Table 6.2, TAPR 2013):			
97K Cooma to Munyang 132 kV line rehabilitation	6.1.9	7.2.5	Possible development within five years
959/92Z Sydney North to Sydney East 132 kV transmission line: tower life extension	6.1.9	7.2.5	Possible development within five years

Development	TAPR 2013	TAPR 2014	Comment
96F Tomago to Stroud 132 kV transmission line pole replacements	6.1.9	7.2.5	Now part of Low Spans – northern regions pole lines project
96H Coffs Harbour to Koolkhan 132 kV transmission line pole replacements	6.1.9	7.2.5	Possible development within five years
992 Burrinjuck to Tumut 132 kV transmission line: low spans remediation	6.1.9	7.2.3.4	
99F Uranquinty to Yanco 132 kV transmission line: pole replacements	6.1.9	7.2.5	Possible development within five years
01 and 2 Canberra to Upper Tumut and Upper Tumut to Yass 330 kV transmission lines remediation	6.1.9	7.2.3.1	Possible development within five years
4 and 5 Yass – Marulan 330 kV transmission lines remediation	6.1.9	7.2.3.1	
ANM 132 kV Substation: secondary systems replacement	6.1.9	7.2.5	Possible development within five years
Armidale 330/132 kV Substation: No 2 330 kV reactor replacement	6.1.9		Not expected to be required in the near future
Beryl 132/66 kV Substation: secondary systems replacement	6.1.9	7.3.5	Possible development within five to ten years
Buronga 220 kV Substation: secondary systems replacement	6.1.9		Possible development within five to ten years
Burrinjuck 132 kV Substation: substation condition	6.1.9	7.2.3.4	Possible development within five years
Canberra 330/132 kV Substation: No 2 transformer replacement	6.1.9	7.2.3.3	
Canberra 330/132 kV Substation: substation condition	6.1.9	7.2.3.3	Possible development within five years
Deniliquin 132/66 kV Substation: secondary system replacement	6.1.9	7.2.5	Possible development within five years
Forbes 132/66 kV Substation: substation condition	6.1.9		Timing of this need is being assessed
Forbes 132/66 kV Substation: No 1 and No 2 132/66 kV transformer replacement	6.1.9	7.2.5	Possible development within five years
Haymarket 330/132 kV Substation: secondary system replacement	6.1.9	7.2.5	Possible development within five years
Kangaroo Valley 330 kV Substation: secondary system replacement	6.1.9	7.2.5	Possible development within five years
Munmorah 330 kV Substation: substation condition	6.1.9	7.2.2.6	Possible development within five years
Murrumburrah 132/66 kV Substation: secondary system replacement	6.1.9	7.2.5	Possible development within five years
Tamworth 330/132 kV Substation: No 2 transformer replacement	6.1.9	7.2.1.2	Possible development within five years
Taree 132/66/33 kV Substation: secondary system replacement	6.1.9	7.2.5	Possible development within five years
Possible Line Switchbays within five years (Table 6.3, TAPR 2013):			
Tumut 132/66 kV Substation: one 66 kV switchbay	6.2.7	7.3.4	Possible development within five to ten years
Wellington 330/132 kV Substation: one 132 kV switchbay	6.2.7	6.1.4	Completed Jun 2014
Lismore 330/132 kV Substation: two 132 kV switchbays	6.2.7	7.3.4	Possible development within five to ten years
Vineyard 330/132 kV Substation: one 132 kV switchbay	6.2.7	7.2.2.11	Possible development within five years
Wagga North 132/66 kV Substation: one 132 kV switchbay	6.2.7	6.2.3	Completion expected Summer 2014/15

Glossary

Term	Explanation/Comments
AEMO	The Australian Energy Market Operator. Responsible for management of the NEM and has the role of Victorian JPB.
AER	The Australian Energy Regulator.
AEMC	The Australian Energy Market Commission.
Annual Planning Review	The annual planning process covering transmission networks in New South Wales.
Annual Planning Report (APR 20XX)	Please see Transmission Annual Planning Report.
CBD	Central Business District.
Clean Energy Bill, 2011	An emissions reduction scheme consisting of a fixed price carbon tax proceeding to a floating price emissions trading scheme. The legislation was approved in November 2011 and is set to take effect from July 2012.
Constraint	An inability of a transmission system or distribution system to supply a required amount of electricity to a required standard.
DNSP (Distributor)	Distribution Network Service Provider. A body which owns controls or operates a distribution system in the NEM.
DM	Demand management. A set of initiatives which are put in place at the point of end-use to reduce the total and/or peak consumption of electricity.
Electricity Statement of Opportunities (ESOO) or Statement of Opportunities (SOO)	A document produced by AEMO that focuses on electricity supply demand balance in the NEM.
GWh	Gigawatt hour. A unit of energy consumption equal to 1,000 MWh or 1,000,000 kWh. One Megawatt hour is the amount of energy consumed in one hour at a rate of one Megawatt.
IPART	Independent Pricing and Regulatory Tribunal of NSW.
Jurisdictional Planning Body (JPB)	The organisation nominated by a relevant minister as having transmission system planning responsibility in a jurisdiction of the NEM.
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.
MVAr	A unit of reactive power. One "Mega-VAr" is equal to 1,000,000 VAr.
National Electricity Rules (NER or “the 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.
Native energy (demand)	Energy (demand) that is inclusive of Scheduled, Semi-Scheduled and Non-Scheduled generation.
NEM	The National Electricity Market.
NTFP	National Transmission Flow Path.
NTNDP	National Transmission Network Development Plan
Registered Participant	A person registered with AEMO as an NER participant.
RET	Renewable Energy Target.
RIT-D	Regulatory Investment Test for Distribution, effective date from 31 August 2013. To replace the current Regulatory Test for distribution projects.
RIT-T	Regulatory Investment Test for Transmission, introduced from 1 August 2010.
SVC	Static VAr Compensator. A device that provides for control of reactive power.
the Minister	The New South Wales Minister for Resources and Energy.
TNSP	Transmission Network Service Provider. A body that owns controls and operates a transmission system in the NEM.
Transmission Annual Planning Report (TAPR 20XX)	A document that sets out issues and provides information to the market that is relevant to transmission planning in New South Wales. This document is the NSW TAPR 2014.

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