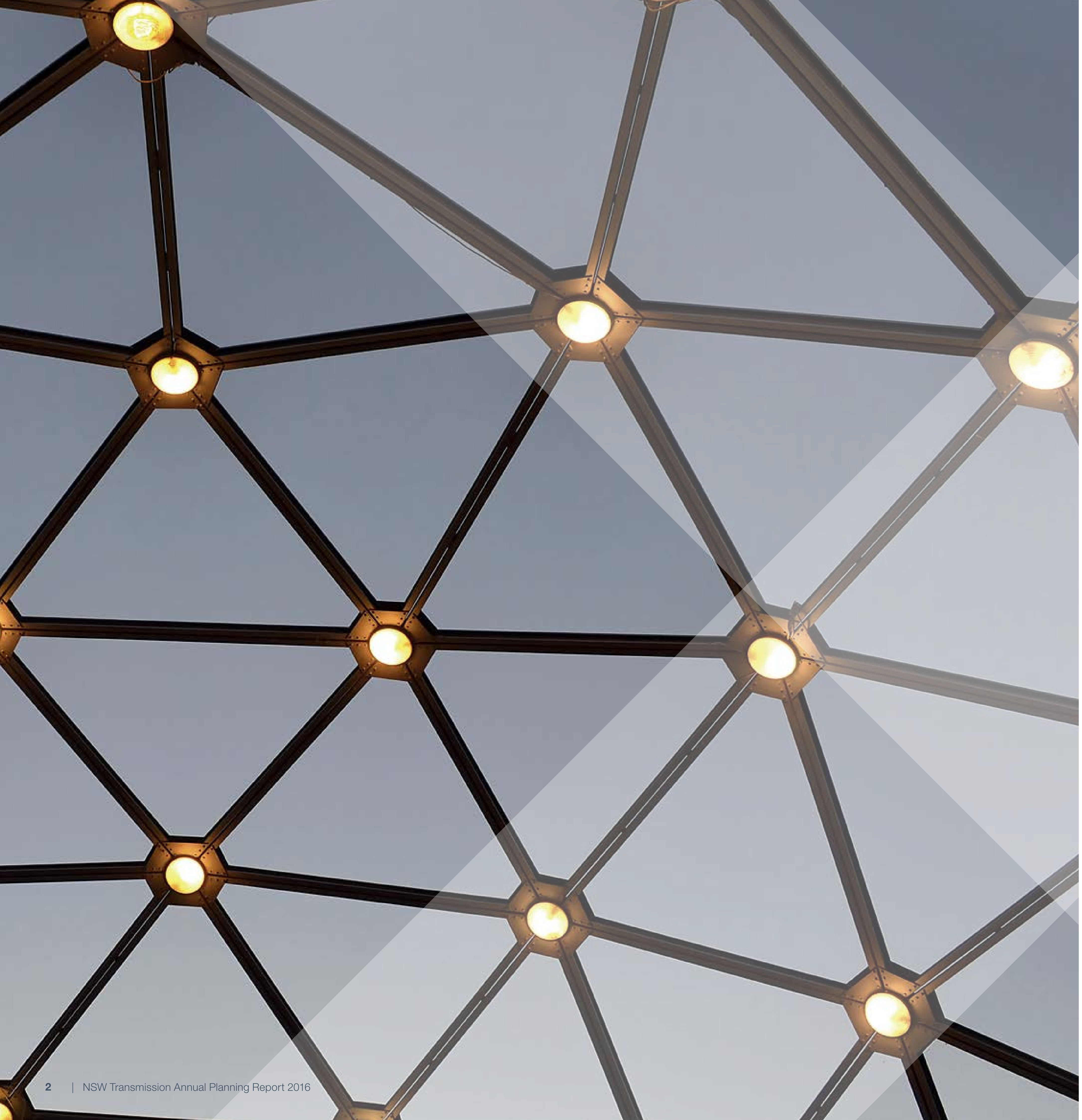
New South Wales

Transmission Annual Planning Report

2016



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Version	Date issued	Comment
0	30 June 2016	Original issue

Foreword

This Transmission Annual Planning Report (TAPR) 2016 provides an assessment of the capabilities of and constraints facing TransGrid's transmission network for the upcoming 10 year planning horizon. It outlines the process and outcomes of our annual planning review and provides advance information to our stakeholders, including market participants, on the nature and location of emerging constraints in our network together with the needs associated with our asset replacement program.

We publish a TAPR every year. When read together with similar documents published by the three NSW distributors (Ausgrid, Essential Energy and Endeavour Energy), ActewAGL and the Australian Energy Market Operator (AEMO), this report is intended to provide a meaningful picture of the network planning activities and related opportunities across NSW and the ACT.

Forecast electricity supply and use have a direct influence on how TransGrid's network will evolve into the future. We take into account AEMO and the distributors' forecasts, as well as information provided by our directly connected customers and our own analysis and modelling to understand the needs of our energy users across NSW and the ACT.

Over the next ten years, energy consumption and winter maximum demand[1] are expected to continue to grow at modest rates. Summer maximum demand is not expected to change significantly overall with different forecasts suggesting either a modest increase or a slight decline.

The changes will be driven by economic and population growth moderated by consumer responses to government energy policies and a desire to improve energy productivity. In addition, a growing number of consumers are expected to supply at least part of their energy needs using rooftop solar panels increasingly combined with energy storage. Most energy will continue to be supplied by large scale generation featuring an increasing amount of renewable plant and the ongoing retirement of the conventional fleet.

This evolving landscape presents a number of challenges and TransGrid is taking a range of actions to address them. From a planning perspective, these include:

> Further refining our understanding of our customer and end user's service level requirements — for example, we engaged in the NSW Independent Pricing and Regulatory Tribunal's (IPART's) process to develop more flexible, tailored reliability standards moving into the future

> Continuing to review all projects within the planning horizon to ensure that they will deliver value with a number of investments identified in last year's TAPR reassessed in response to moderating load growth and

> Considering options to address the implications for the security of supply issues that could arise from the change in mix from conventional to renewable generation including interstate connections to provide market stability

In addition, we continue to investigate three evolving, potentially significant needs or opportunities and their optimal solutions:

The evolving energy ecosystem brings new challenges and exciting opportunities for the power industry. Our 28 directly connected customers and more than 3 million homes and businesses across NSW and the ACT are at the centre of that system.

> Ensuring the continuing secure supply of bulk electricity to the Sydney inner metropolitan area given the approaching retirement of a number of Ausgrid's subtransmission cables and the potential need to derate TransGrid's 330 kilovolt (kV) cable 41, all of which service the CBD load

> The value of additional capacity on the Queensland to NSW interconnector and the implications for three associated renewable energy projects in the Northern part of NSW

> Increasing the interconnection capacity between NSW and South Australia as a way to help manage low reserve conditions that may emerge in South Australia due to the increasingly high penetration of renewable generation in that region.

More broadly, we continue to refine our operating and asset management processes to maximise the value to energy consumers delivered by our existing network assets. TransGrid is accredited to the global ISO55001 asset management standard and we use a comprehensive risk-based approach to asset refurbishment and replacement. We also constantly look for innovative approaches to better leverage the capacity of the network such as the recent introduction of our Asset Monitoring Centre which uses new technologies to monitor the condition of our assets in real-time.

I'd also like to highlight two other important things.

First, this document explains the implications for planning our network arising from the changes in the energy supply landscape that we expect to see over the next ten years. However, that rate of change is likely to increase further over the longer term. There is a new smart energy ecosystem developing. Customers will be at the heart of that system and the grid will play an important and evolving role in meeting their needs. TransGrid will shortly publish its Network Vision 2056 setting out how our network will connect you to that energy future over the longer term. I invite you to read and provide your feedback on that document.

Second, you may have seen that TransGrid is now under private ownership. I am excited about the fact that this will allow us to find new opportunities to deliver additional value to our customers. However, I want to emphasise that our organisation remains fully committed to safely, reliably and efficiently delivering the core transmission services required by the people of NSW and the ACT.

I look forward to ensuring that TransGrid is best placed to continue to meet your energy supply needs now and into the future.

Gerard Reiter
Executive General Manager/
Asset Management
June 2016

1 Maximum demand is demand measured at a point in time, typically in megawatts (MW) at the transmission level.

Executive summary

Chapter 1

Introduction

TransGrid owns and operates the high voltage network connecting generators, distributors and major end users in NSW and the ACT. Along with the NSW and ACT electricity distributors, we are required to conduct an annual planning review to identify future needs and possible solutions over a ten year planning horizon. We publish our findings as a Transmission Annual Planning Report (TAPR).

We plan our network to meet our customers' needs safely, reliably and at the most efficient long run cost. We explore and encourage non-network solutions to those needs wherever this is more cost efficient than a network option.

Chapter 2

Projections and other factors affecting network capacity

The forecasts that TransGrid relies upon indicate that annual electricity energy consumed from the grid in the NSW region (including the ACT) is likely to grow at an average annual rate of 0.1% over the next ten years. By contrast, the projected annual energy growth rate in last year's TAPR was higher, 1% over the next ten years. This moderation of consumption growth is due to an increasing focus on energy efficiency and strong penetration of rooftop PV (photovoltaic, or solar panels).

Under the Australian Energy Market Operator's (AEMO's) neutral economic growth scenario (50% Probability of Exceedence or POE conditions), winter maximum demand is expected to grow by around 0.4% annually over the planning horizon and summer maximum demand is forecast to decline by 0.2%. NSW is expected to remain summer peaking. Forecasts based on aggregated Bulk Supply Point data suggest slightly stronger winter and summer maximum demand growth (1.2% and 0.9% respectively).

Load growth in the Gunnedah/Narrabri area is expected to lead to network limitations within the ten year planning horizon, Western Sydney continues to experience a high growth rate compared to much of the NSW region. Recent capacity augmentations in the northern and southern parts of that area should prevent network limitations from developing in those parts during the planning horizon.

It is expected that some existing NSW coal fired generation will be retired and new renewable generation will be commissioned during the planning horizon. The renewable generation would be likely to occur in areas remote from the major load centres of Newcastle, Sydney and Wollongong. Their development would therefore be likely to increase the loading on our network in those areas and between those areas and the major load centres. The reduction in the share of large scale conventional generation and the increase in the share of renewables may have security of supply implications within the latter half of the planning horizon.

The reliability standards for operating the network in NSW are being reviewed by the Independent Pricing and Regulatory Tribunal (IPART). Broadly, the current standards are to provide a modified 'N-2' standard for the Sydney Central Business District (CBD) and 'N-1' in all other areas of NSW[2]. This means we are required to build sufficient redundancy to ensure that supply is not interrupted if two and one elements, respectively, of the network fail. The higher level of redundancy required for the Sydney CBD reflects the greater economic cost associated with supply interruption compared with other parts of the transmission network. IPART's draft recommendations regarding the future standards were published in late May 2016. Following a consultation period, final recommendations are expected to be made to the NSW Government by December 2016.

TransGrid is also subject to a reliability standard under the transmission licence it holds in the ACT. That standard includes the provision of two independent points of supply by 2020. TransGrid currently supplies the ACT load via our Williamsdale and Canberra substations. However, the Williamsdale substation is partly dependent on the Canberra substation. The requirement for a second, fully independent supply point is being met by the construction of a new substation located at Stockdill Drive.

Chapter 3

Completed, committed and planned developments

In the last financial year, twelve projects were completed that alleviated previously identified constraints. These include the replacement of Cooma substation and refurbishment of Yanco substation.

Nineteen projects are at the committed stage, including the redevelopment of the Orange substation, rehabilitation of Upper Tumut substation and condition-based works at Wagga 132 kV and Vales Point substations.

Five projects are at the planning stage including condition-based replacements at Canberra substation, connection of a subtransmission substation near Munmorah and addressing the southern supply to the ACT and supply to the Beryl/Mudgee area.

Some projects that appeared in TAPR 2015 have been reassessed. These are set out in Chapter 4 and also reported in Appendix 5 which sets out the year on year changes.

Chapter 4

Constraints and possible network developments

Possible major developments include: Powering Sydney's Future, including the condition of cable 41, the Qld – NSW interconnector and related developments and a SA – NSW interconnector (SANI).

A number of strategic asset replacement or refurbishment programs will take place. Some asset replacements, such as condition based works at Canberra substation and some remediation work on transmission lines, have progressed and are now committed projects. Others have modified scopes and timeframes due to regular review.

Other possible projects in the next five years include load related development in the Gunnedah/Narrabri area.

Other possible developments in the five to ten year period include increasing of the Snowy to Sydney network capacity and supply adequacy to the Macarthur area.

Some possible developments reported last year are now expected to arise further into the future because of moderating load forecasts and review and rescoping of the developments. These include the condition based works at Burrinjuck, Munmorah and Hume substations, and on a number of transmission lines including the 99J Yanco – Griffith 132 kV line.

Appendices

Replacement projects, load forecasts, load profiles, connection point proposals and year on year report changes

This year a number of appendices have been provided on our website rather than included in this report. This includes content setting out more detail regarding our network planning approach and system utilisation and constraint reports.

Contact details

As always we appreciate your feedback and comments in the interests of continuous improvement and ensuring this report continues to suit the requirements of our stakeholders and consumers. We have included our contact details at the back of the report for this purpose.

At TransGrid, we're shaping the grid of the future to ensure it meets your needs- safely, reliably, efficiently and sustainably.

2 Transmission Network Design and Reliability Standard for NSW, NSW Department of Industry.

Contents

Chapter 1

Introduction

> We operate and manage the NSW high voltage electricity network connecting generators, distributors and major end users in NSW and the ACT

> We plan our network to meet our customers' needs safely, securely and reliably and at the most efficient cost. We explore and encourage non-network solutions to those needs wherever this is a more cost efficient approach

> Along with the NSW and ACT electricity distributors, we are required to conduct an annual planning review to identify future needs and possible solutions over a ten year planning horizon. We publish our findings as a Transmission Annual Planning Report (TAPR).

1.1 About TransGrid

TransGrid operates and manages the NSW and ACT high voltage electricity grid, connecting you to the energy you need 24/7. Every day we enable more than 3 million homes, businesses and communities to access a reliable, efficient and safe supply of electricity.

Our electricity system transports energy from sources of power generation such as wind, coal, solar, gas and hydro power plants to large industrial customers and the distribution network, where it is then delivered to your home or business. Comprising 99 substations and nearly 13,000 kilometres of high voltage transmission lines and cables and five interconnectors to Queensland and Victoria, our grid makes energy trading possible between Australia's three largest states. Figure 1.1 sets out where TransGrid sits within the electricity supply chain. TransGrid's network is shown in Figures 1.2 and 1.3.

In December 2015, TransGrid became a private company.

FIGURE 1.1 TransGrid within the electricity supply chain

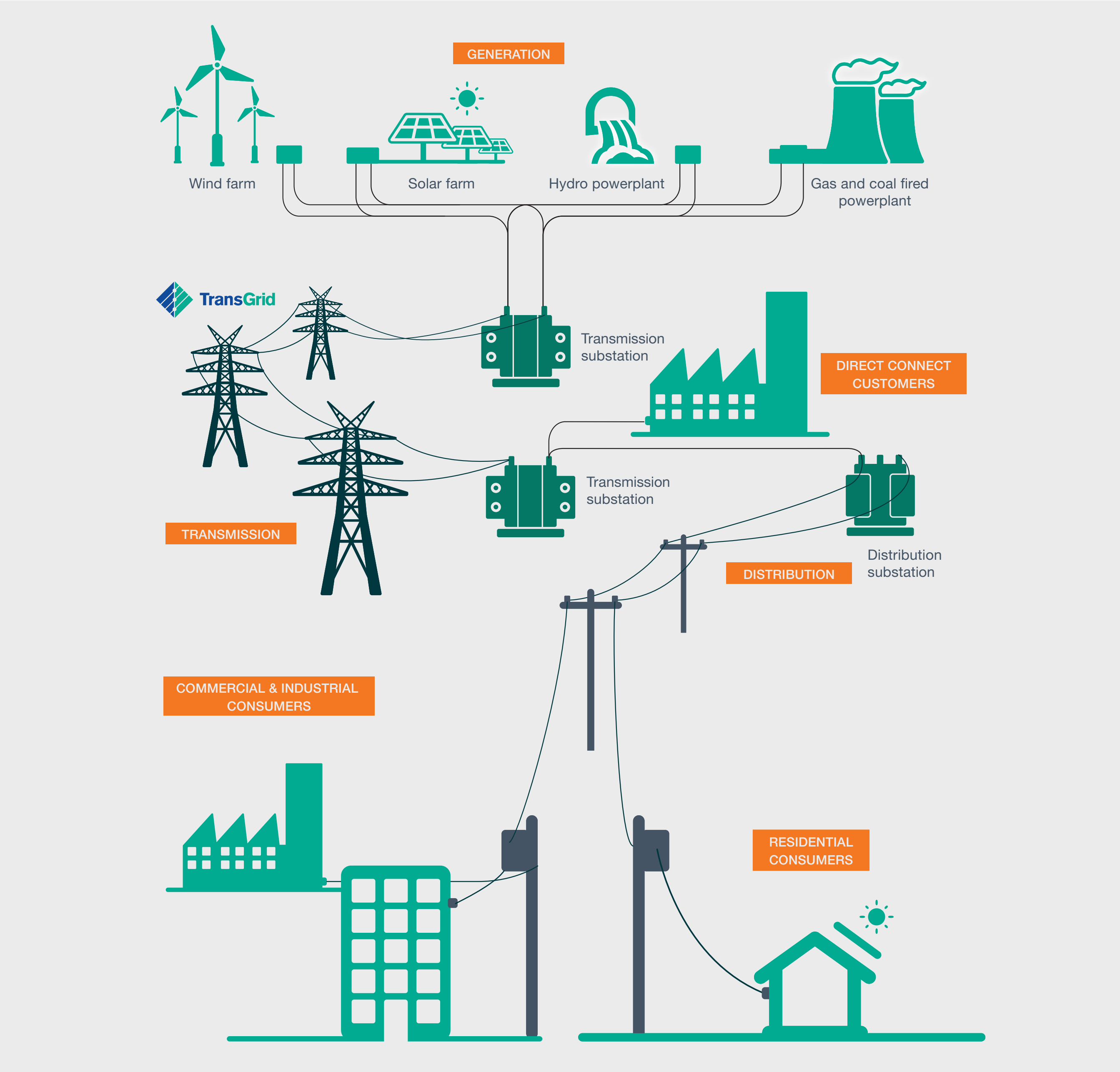


FIGURE 1.2 TransGrid's electricity network map

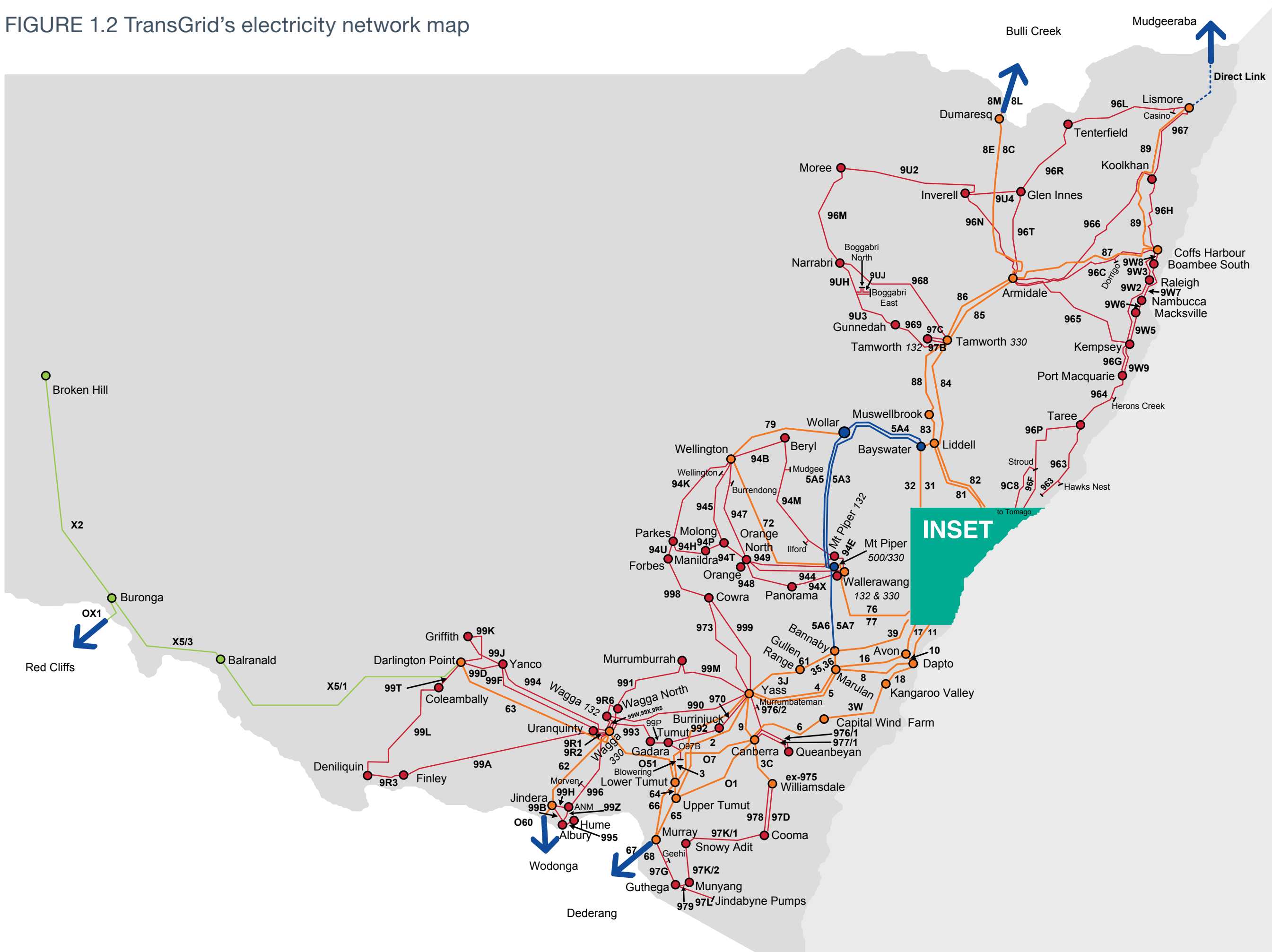
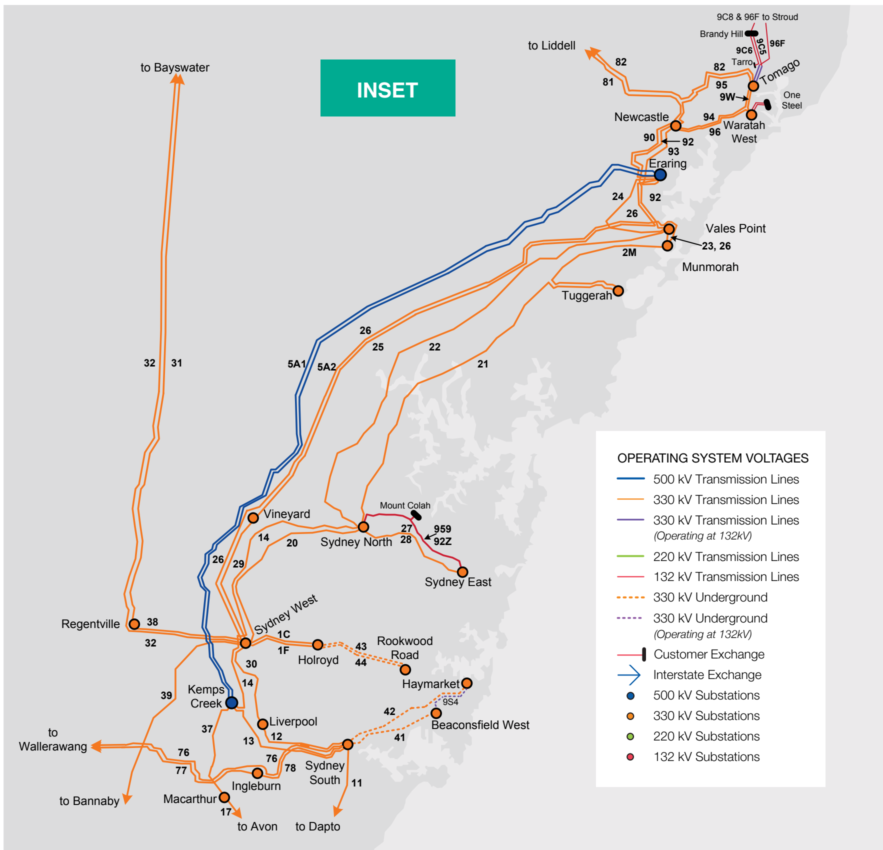


FIGURE 1.3 TransGrid's electricity network map – Inset



1.2 About this TAPR

The National Electricity Rules (NER) requires us to undertake an annual planning review and publish the results by 30 June each year. The purpose of the review is to identify an optimum level of transmission investment so that we deliver our services at efficient cost.

The review identifies the emerging constraints within the network and possible options to overcome them. It also identifies assets that are reaching the end of their serviceable lives and considers options to address this. The review is also designed to provide information to interested parties so that they may propose options to meet those needs at lower costs where feasible. This may involve components of demand management and local generation. We take a holistic approach to renewal, growth and the inclusion of non-network options in our decision processes.

Our annual planning review involves joint planning with each of the distribution network owners within NSW and the ACT (Ausgrid, Endeavour Energy, Essential Energy and ActewAGL) as well as with the Australian Energy Market Operator (AEMO), Powerlink in Queensland and Ausnet in Victoria. The objective of joint planning is to work together to develop the overall grid in the most efficient way for the benefit of the consumers.

Our planning review begins with a request by us for the distributors to provide their updated bulk supply 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 (including ACT) region of the NEM, we have updated our short term (one, three and five years) and longer term (five to ten years) analyses of present and emerging network constraints and asset renewal requirements. The results are summarised in this document.

This TAPR 2016 presents the results of our annual planning review. It:

> Identifies emerging constraints and asset renewal requirements in the nsw transmission network over the upcoming ten year planning horizon

> Provides advance information on the nature, quantification and location of the constraints and asset management requirements. 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 demand management and local generation or other options that may provide economically efficient outcomes

> Discusses options that have been identified for relieving each constraint and requirement including network, local generation, demand management and other options

> Indicates, where possible, if and when we intend to issue Request for Proposals (RfP) non-network alternatives to relieve a constraint

> Provides summary information for proposed augmentations

> Provides summary information for proposed replacement transmission network assets

> Provides a basis for annual reporting to stakeholders on the outcomes of the annual planning review.

As the Jurisdictional Planning Body for NSW appointed by the Minister, we must also provide input to AEMO's Electricity Statement of Opportunities (ESOO) and National Transmission Network Development Plan (NTNDP). Broadly the ESOO considers the adequacy of generation in the NEM. The NTNDP provides an overview of the adequacy of key parts of the interconnected transmission networks serving the NEM. Both of these reports serve as inputs into our TAPR and we must also report on any matters relevant to the TAPR arising from them.

1.3 How we plan

Our network investment process is designed to respond to the changing needs of stakeholders and deliver our capital program effectively. The process includes:

> An integrated, whole of business approach to capital program management

> Optimisation of investments to meet augmentation and asset replacement or renewal requirements including reducing capital requirements through operating and maintenance improvements

> 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

> Early engagement with stakeholders throughout the planning cycle to involve end users and impacted communities in decisions. We consider it is our responsibility to be as proactive, honest and transparent as possible in sharing information about our plans with our stakeholders.

The key processes and steps, including where and how we engage stakeholders, are set out below.

1.3.1 Design standard requirements

Reliability standards establish the level of reliability (the extent to which consumers have a continuous supply of electricity) that TransGrid is required to provide. Reliability standards are set to ensure that the number of outages resulting from transmission faults is very low. However, this has an impact on investment and the cost of electricity to consumers:

> If the reliability standard is set too high, the investment required to make sure the network meets the reliability requirement may be more than consumers are willing to pay

> If the reliability standard is too low, the reliability of the supply may fall below a level that consumers want.

TransGrid's reliability obligations are currently being reviewed by the NSW Independent Pricing and Regulatory Tribunal (IPART) with the intention of having revised obligations in place from 1 July 2018. IPART's draft recommendations were published in late May 2016 and, following a consultation period, final recommendations are expected to be made to the NSW Government by December 2016. The draft recommendations are discussed in more detail in Section 2.5.

At this stage, we anticipate that the reliability obligations may provide a greater level of flexibility for us to manage our reliability requirements more economically.

Until the revised obligations come into force, the current reliability standards will continue to apply as per our licence. A document setting out our current approach in more detail is available on our website or by using the contact details at the back of this report. (https://www.transgrid.com.au/news-views/publications).

FIGURE 1.4 – How TransGrid plans the network

		TransGrid planning process	Stakeholder involvement
STAGE 1	Identify need	Look at demand forecasts, expected generation patterns and the condition of existing assets. Will there be a shortfall in supply if we do nothing?	Sense-check forecasts with • Distributors • Directly connected customers • AEMO. 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 • Local or distributed generation • Network infrastructure optimised to expected requirements. • Improved operational and maintenance regimes	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 or renew 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.

We are also licensed to provide electricity transmission services into the ACT. One of the requirements of that licence is the provision of a second independent 330 kV supply point. The Stockdill 330 kV substation project provides the solution to that requirement and is described in Chapter 3.

1.3.2 Regulatory Investment Test for Transmission

For significant augmentation investments, we are required by the NER to also follow a Regulatory Investment Test for Transmission (RIT-T) consultation process. This is a process designed to inform stakeholders of the investment need and proposed network or non-network option to address it, test the market for more efficient solutions and advise stakeholders of the outcome of the selected solution.

The RIT-T applies to transmission network investments where the cost of the most expensive credible option is greater than $6 million. It does not apply to investments relating to maintenance, replacement or urgent and unforeseen investments. Its application to replacement projects is currently under review.

The RIT-T consultation process normally involves the issuing of three documents: the Project Specification Consultation Report (PSCR), the Project Assessment Draft Report (PADR) and the Project Assessment Conclusion Report (PACR).

Minimum consultation periods following publication of the PACR and PADR are specified and there is a requirement for the consideration of submissions received in response to these documents. The PADR can be omitted under certain circumstances provided for in the NER.

For the category of 'replacement transmission network asset' there is a requirement to disclose information in TAPRs that includes a brief project description, when they are expected to become operational, other reasonable options considered (if any) and the estimated cost. This information is provided in Section 4.2.4.

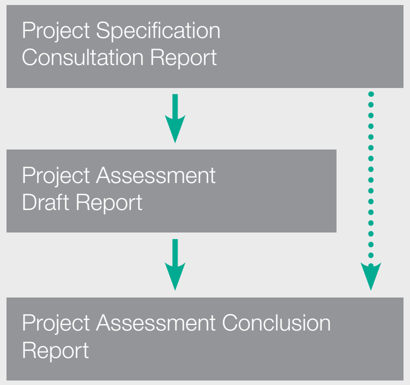
No RIT-T consultations were completed since last year's TAPR and there are none currently underway.

1.3.3 Non-network options

Where non-network options are being considered to address a network constraint, the NER requires that we indicate:

> When the constraint is expected to occur, the MegaWatt (MW) reduction at a connection point required to relieve the constraint for 12 months, and the locations at which that reduction could be made

FIGURE 1.5 – RIT-T consultation documents



> Plans and dates to issue Request for Proposal (RfP) non-network alternative.

This information is set out in Chapter 4. Additional information for one near-term augmentation need (supply to the Gunnedah/Narrabri area) is provided in Appendix 3. More general information on our approach to non-network options is included in Chapter 2.

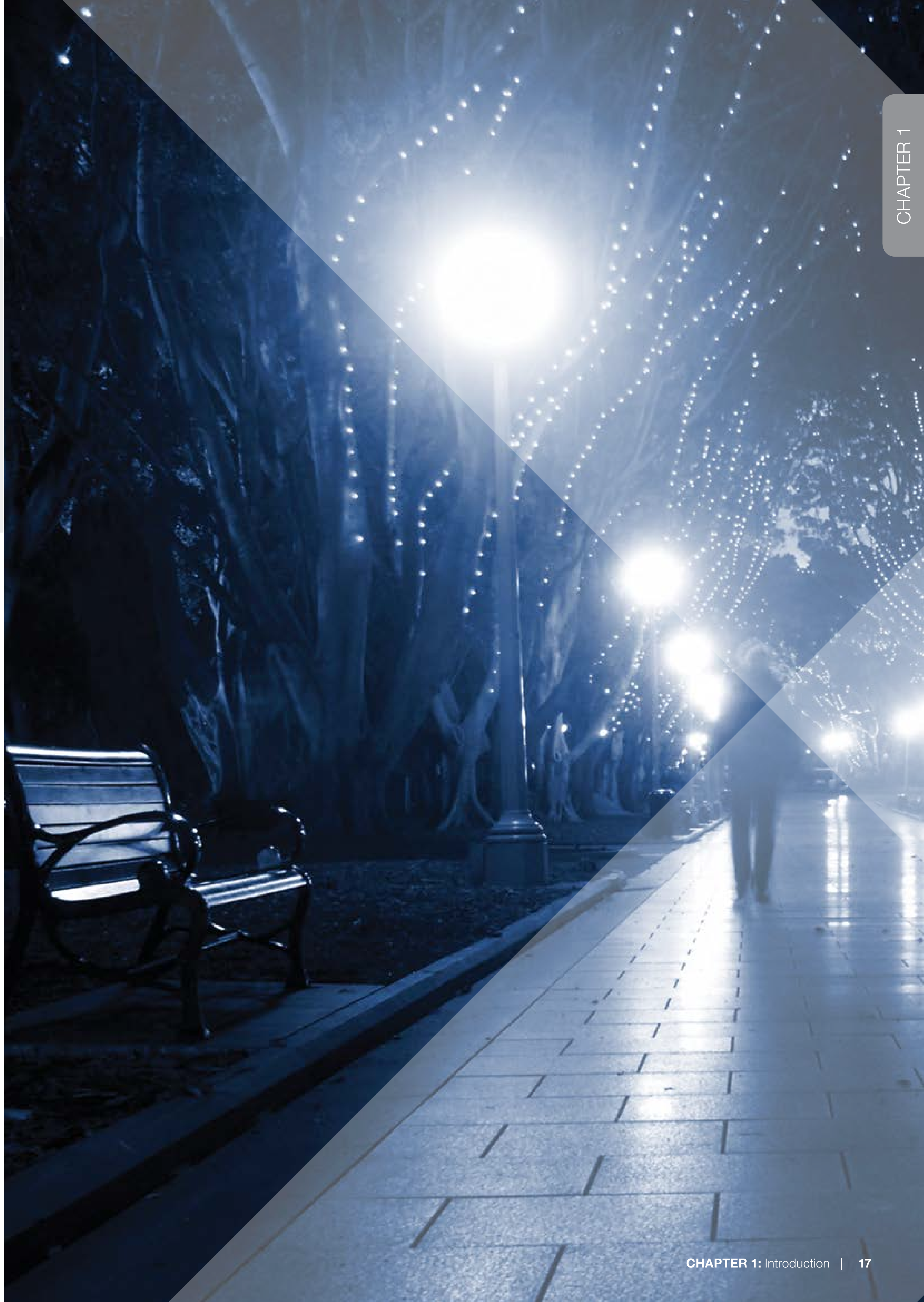
1.4 Structure of this document

The rest of this document sets out:

> Forecast load, generation and other changes that may impact on the capacity of our network over the TAPR planning horizon (chapter 2)

> Completed, committed and planned developments (chapter 3)

> Constraints and possible future developments (chapter 4).



Projections for factors affecting network capabilities

> Annual energy consumed from the grid in the NSW region (including the ACT) is forecast to grow at an average annual rate of 0.1% over the next ten years due to an increasing focus on energy efficiency and strong penetration of rooftop PV generation. This is despite a growth in population in the NSW region and strong growth in its economy. The projected annual growth rate in last year's TAPR 2015 was 1%

> Under the Australian Energy Market Operator's (AEMO's) neutral economic growth scenario (50% Probability of Exceedence or POE conditions), winter maximum demand is expected to grow by around 0.4% annually over the planning horizon and summer maximum demand is forecast to decline by 0.2%. NSW is expected to remain summer peaking. Forecasts based on aggregated Bulk Supply Point data suggest slightly stronger winter and summer maximum demand growth (1.2% and 0.9% respectively)

> Load growth is expected to lead to network limitations in the Gunnedah/Narrabri area

> It is expected that existing coal fired generation will continue to be retired and/or new renewable generation commissioned during the planning horizon. New generation would be likely to occur in areas remote from the major load centres of Newcastle, Sydney and Wollongong. Their development would therefore be likely to increase the load on our network in those areas, and between those areas and the major load centres. The reduction in the share of large conventional generation and the increase in the share of renewables may have security of supply implications within the latter half of the planning horizon

> The reliability standards and technical performance standards that we are required to operate have not changed since last year's TAPR. However IPART is currently undertaking a review of our reliability standards with final recommendations expected to be provided to the NSW Minister for Industry, Resources and Energy in December 2016. The ACT reliability standard requires two independent points of transmission supply by 2020 and this will be met by the construction of a new substation at Stockdill Drive.

2.1 Introduction

This chapter provides information regarding the likely impact of energy and demand forecasts and other factors on our transmission system over the ten year TAPR planning horizon.

Limitations on TransGrid's network, which restrict its ability to meet customer requirements, can arise from the following factors, either alone or in combination:

> Changes in loads (the magnitude of existing loads and/or geographical location of new loads)

> Changes in generation (particularly the retirement of existing generators and development of new generators, although changed bidding behaviour can also be significant)

> Changes in network capability (for example retirement of network assets once they reach the end of their serviceable lives)

> Changes in the service standards to be met.

We rely significantly on forecasting information published by AEMO and provided by the distribution businesses, and our directly connected customers, to understand changes in loads. We also take into account information published by AEMO to understand changes in generation and identify potential constraints regarding the capability of our network.

Forecasting is inherently uncertain. However, in recent years, it has become more difficult to confidently predict annual electricity consumption and maximum demand. Over this period, actual levels (not corrected for weather) for both have been below predictions. We are required to deliver a system capable of meeting the forecasts safely, securely, reliably and at efficient cost.

To help address the consequences of the uncertainty, we:

> Consider 'high loading', 'medium loading' and 'low loading' cases, which can be combinations of load patterns/magnitudes and generation patterns

> Undertake planning studies to consider the consequences of the retirement of major elements of our network

> Work with new generation proponents

> Collaborate with distribution businesses on spot load issues arising from load increases or equipment retirement.

2.2 Changes in loads

2.2.1 Introduction

Changes in how electricity is used can affect loads (the demand for electricity). While there is no clear demarcation between them, it can be useful to think of changes in loads being of two broad types. 'Organic' changes are the overall result of many small changes, either increases or decreases, across an area. 'Spot loads' are more localised, often larger changes associated with new developments or, in the case of load reductions, closure of a facility. The closure of the Kurri Kurri smelter in 2012 is a good example of a 'spot' reduction in load.

In recent years, the larger spot load increases have primarily been due to new or expanded mining activities. Two new mines in the Boggabri area, between Gunnedah and Narrabri, have recently been connected to our network. Mines in the Ulan area, which are supplied via Essential Energy's network from Beryl 132/66 kilovolt (kV) substation, are also expanding. There are also other prospective mining spot loads in the Gunnedah/Narrabri area and the Lithgow/Kandos area.

To understand the likely changes in loads, we look at forecast annual energy use for the NSW region and forecast maximum demands for the NSW region (including the ACT) and individual bulk supply points. The NSW region forecasts are provided by AEMO and those for bulk supply points, by the distributors and customers directly connected at those locations.

2.2.2 Forecast energy use

Energy use measures total energy throughput over a period of time in kilowatt hours (kWh) or, typically, described in gigawatt hours (GWh) at the transmission level. We are required to plan our network to be able to meet forecast maximum demand, not energy. However, energy forecasts can usefully reflect broader drivers that may impact the future use of the network. Those drivers include:

> Economic conditions — increasing levels of economic activity may create spot loads

> Government policies — for example, the Federal Government's Renewable Energy Target (RET) and energy efficiency programs

> Emerging technologies — for example, the ability for customers to self-generate electricity by using solar panels or store it using battery systems.

We reproduce AEMO's NSW regional energy forecast contained in its National Electricity Forecasting Report (NEFR) 2016. The NEFR considers three economic scenarios, namely, strong, neutral and weak scenarios. AEMO doesn't provide the likelihoods of its scenarios occurring. However, the neutral scenario is usually considered to be the 'central' scenario as overall, it has lesser deviations from present trends in macro-economic variables than the strong and weak scenarios. As smaller deviations from present trends are more likely than larger deviations, the neutral scenario is considered to be more likely than either the strong or weak scenarios. The strong and weak economic scenarios have been derived as sensitivities to the neutral scenario.

Table 2.1 and Figure 2.1 show the native annual energy usage projections for energy provided for the NSW region for each of AEMO's three scenarios. Details of the scenarios are given on AEMO's website[3].

The key inputs to AEMO's strong, neutral and weak economic scenarios are assumptions on economic growth, population increase, future changes in electricity prices and energy efficiency measures uptake in the NSW region. Assumptions regarding these inputs drive the differences between the three economic scenarios.

The strong economic scenario assumes high economic growth, high population growth, higher electricity prices and higher uptake of energy efficiency measures. The weak economic scenario, on the other hand, assumes lower economic growth, lower population increase, lower electricity prices and lower uptake of energy efficiency measures.

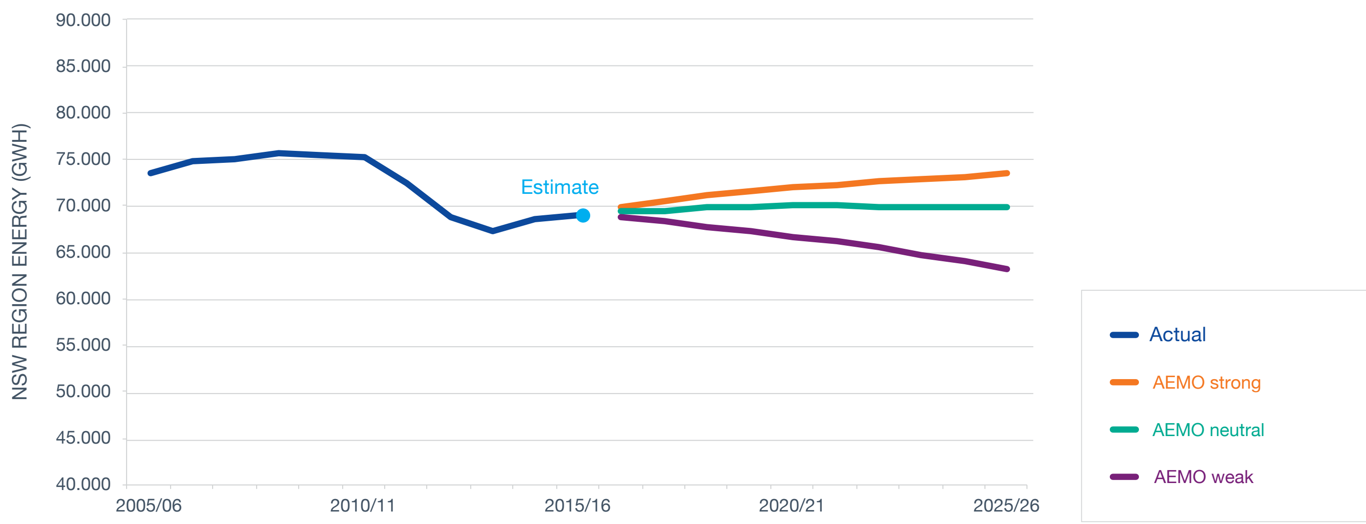
The assumption of future growth rates for the variables (economic growth, population, electricity price, energy efficiency uptake) for the neutral economic scenario lie between the strong and weak economic scenarios.

3 http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report

TABLE 2.1 – NSW region annual energy projections (GWh)

	Actual	AEMO strong	AEMO neutral	AEMO weak
2005/06	73,365			
2006/07	74,782			
2007/08	74,832			
2008/09	75,499			
2009/10	75,302			
2010/11	75,051			
2011/12	72,357			
2012/13	68,740			
2013/14	67,104			
2014/15	68,405			
2015/16 Est.	68,919			
2016/17		69,704	69,221	68,781
2017/18		70,407	69,386	68,231
2018/19		71,151	69,796	67,703
2019/20		71,524	69,838	67,084
2020/21		71,922	69,954	66,591
2021/22		72,201	69,902	65,991
2022/23		72,456	69,841	65,358
2023/24		72,739	69,791	64,633
2024/25		73,028	69,762	63,879
2025/26		73,428	69,832	63,174
Annual Average Growth Rate 2016/17 – 2025/26		**0.6%**	**0.1%**	**-0.9%**

FIGURE 2.1 – NSW region energy projections



There has been a decline in NSW region energy consumption in the last five years. However, this trend may have reversed given that the energy consumption in 2014/15 was higher than that in 2013/14 and consumption in 2015/16 is estimated to be also higher than 2014/15.

In the short term (2016/17 to 2020/21), energy consumption in NSW is forecast to increase at an annual average rate of 0.3%. In the medium to long term (2016/17 to 2025/26), energy consumption is forecast to grow at the modest annual average rate of 0.1%.

In the 2016 NEFR, AEMO has advised that the energy forecasts are on average flatter than last year. AEMO attributes this to the following.

New forecasting methods

AEMO has traditionally relied on bulk transmission data as a primary source for forecasting. However, according to AEMO, this data is highly aggregated and doesn't reveal the dynamics that originate beyond the grid. In a departure to its previous methodology, in its 2016 NEFR, AEMO has integrated new data streams such as consumer energy meter data and complementary data from other agencies and sources, including national account data from the Australian Bureau of Statistics, to support the greater understanding of structural changes in the economy. This new bottom-up approach and forecasting techniques have impacted the forecast results compared to those in NEFR 2015.

Policy assumptions

Australia has set a target to reduce carbon emissions by 26–28% below 2005 levels by 2030, which builds on the 2020 target of reducing emissions by 5% below 2000 levels.

The Council of Australian Governments (COAG) Energy Council has agreed that the contribution of the electricity sector should be consistent with national emission reduction targets, and has advised that a 28% reduction from 2005 levels by 2030 is an appropriate assumption for AEMO to use in forecasting and planning. For the 2016 NEFR, AEMO has assumed the achievement of this target will be supported by energy efficiency trends, electricity pricing trends, and coal-fired generator retirements.

AEMO's modelling has assumed a partial impact in the 2016 NEFR forecasts, with retail electricity prices assumed to increase by approximately 2.5% per annum before inflation for the 10 years from 2020. An increase in electricity prices reduces energy consumption and has contributed to the flatter trajectory of energy forecasts.

Technology and consumer behaviour

Despite assumptions of increasing population and economic growth in the NSW region, energy efficiency programs and the increasing uptake of rooftop PV and battery technology is likely to flatten the demand for electrical energy from the grid.

- Energy efficiency: In the 2015 NEFR, a small post-model adjustment was included for energy efficiency to add to an amount that was assumed to be captured in the historic data inputs to a regression-based model of consumer demand. The 2016 NEFR uses new, forward-looking economic forecasting models to model the full amount of projected energy efficiency savings. Projected savings have been separately forecast at an appliance level, and have been tuned to ensure consistency with consumer trends, as measured in recent meter data. The projections now also include a 20% rebound effect, based on observed meter data trends. Rebound refers to an increase in consumption that is enabled by the lower operating cost of energy efficient appliances.
- Price elasticity: Price elasticity of demand adjustments are now only applied for permanent increases in price, measured through the bill of a typical consumer. Estimates have been revised down to avoid overlap with energy efficiency, recognising that energy efficiency represents a structural response to price that is occurring with shorter time-lags. Temporary price changes, such as price reductions due to lower network charges, are no longer assumed to trigger a consumption response.
- Rooftop PV: For the residential sector only, the 2016 NEFR now includes an assumed increase in energy consumption made available from rooftop PV and battery storage. For the first time, the 2016 NEFR includes forecasts for the uptake and use of battery storage technologies, assuming this is implemented with an energy management system that manages charging and discharging operations.

2.2.3 Forecast maximum demand

Maximum demand is the highest total demand at a single point in time[4]. It is measured in watts, typically described in megawatts (MW) at the transmission level. The forecasts we use for planning our network are based upon:

> The NSW region summer and winter maximum demand forecasts published by AEMO in its NEFR 2016[5]

> The bulk supply point forecasts provided by the four NSW and ACT distribution businesses and our directly connected customers.

TABLE 2.2 – NSW region summer maximum demand projections (MW)

	Actual	AEMO strong			AEMO neutral			AEMO weak		
		10% POE	50% POE	90% POE	10% POE	50% POE	90% POE	10% POE	50% POE	90% POE
2005/06	12,857									
2006/07	12,375									
2007/08	12,412									
2008/09	13,648									
2009/10	13,493									
2010/11	14,399									
2011/12	11,662									
2012/13	13,392									
2013/14	11,708									
2014/15	11,714									
2015/16	13,192									
2016/17		14,349	13,004	11,511	14,299	12,908	11,453	14,229	12,888	11,314
2017/18		14,371	13,139	11,682	14,195	12,947	11,474	13,943	12,697	11,319
2018/19		14,531	13,168	11,626	14,330	12,952	11,459	13,871	12,676	11,183
2019/20		14,598	13,279	11,732	14,446	12,869	11,432	13,984	12,516	11,062
2020/21		14,701	13,384	11,836	14,237	12,914	11,480	13,875	12,502	11,018
2021/22		14,893	13,381	11,892	14,244	12,858	11,368	13,701	12,344	10,873
2022/23		14,898	13,419	11,870	14,233	12,881	11,349	13,467	12,178	10,714
2023/24		14,856	13,489	11,942	14,154	12,764	11,351	13,264	11,997	10,632
2024/25		14,928	13,470	11,961	14,124	12,665	11,276	13,224	11,867	10,434
2025/26		15,308	13,604	12,044	14,266	12,726	11,243	13,421	11,776	10,299
Annual Average Growth Rate 2016/17 – 2025/26		**0.7%**	**0.5%**	**0.5%**	**0.0%**	**-0.2%**	**-0.2%**	**-0.6%**	**-1.0%**	**-1.0%**

4 For electricity networks, maximum demand is the highest average demand over a half hour period.

5 The responsibility for NSW region electricity forecasts was transferred from us to AEMO in 2012.

2.2.3.1 AEMO region forecast

Details of AEMO's forecasts and the methodologies it uses are available from AEMO's website[6]. Note that the NEFR gives forecasts for 'operational'[7] quantities, which differ slightly from the 'native' values given here. The correlation between the two sets of values is given in the spreadsheet associated with the NEFR on the AEMO website.

AEMO's native summer and winter demand projections for the NSW region are given here on a 'sent out' basis[8]. Table 2.2 gives the historical summer peak demands (not weather-corrected) and the projections for a 10%, 50% and 90% probability of exceedance (POE) maximum demands over the next 10 years for each of the three AEMO scenarios. Table 2.3 gives the corresponding data for winter.

TABLE 2.3 – NSW region winter maximum demand projections (MW)

	Actual	AEMO strong			AEMO neutral			AEMO weak		
		10% POE	50% POE	90% POE	10% POE	50% POE	90% POE	10% POE	50% POE	90% POE
2006	12,655									
2007	13,413									
2008	13,791									
2009	12,646									
2010	13,015									
2011	12,524									
2012	11,775									
2013	11,264									
2014	11,228									
2015	11,864									
2016		12,444	12,107	11,805	12,348	12,018	11,717	12,290	11,954	11,636
2017		12,600	12,255	11,947	12,394	12,080	11,766	12,268	11,931	11,618
2018		12,772	12,413	12,108	12,432	12,125	11,818	12,209	11,873	11,569
2019		12,927	12,566	12,258	12,500	12,185	11,878	12,145	11,819	11,509
2020		13,081	12,703	12,395	12,578	12,231	11,925	12,113	11,771	11,457
2021		13,213	12,842	12,524	12,649	12,286	11,970	12,064	11,733	11,407
2022		13,355	12,988	12,649	12,683	12,322	12,000	12,029	11,690	11,353
2023		13,498	13,138	12,795	12,720	12,370	12,052	11,959	11,642	11,312
2024		13,661	13,278	12,940	12,777	12,411	12,089	11,929	11,586	11,253
2025		13,801	13,411	13,072	12,817	12,452	12,130	11,857	11,511	11,188
Annual Average Growth Rate 2016/17 – 2025/26		**1.2%**	**1.1%**	**1.1%**	**0.4%**	**0.4%**	**0.4%**	**-0.4%**	**-0.4%**	**-0.4%**

6 http://www.aemo.com.au/Electricity/Planning/Forecasting

7 'Operational' quantities: Operational consumption includes residential, commercial and large industrial consumption. It includes contributions from scheduled and semi-scheduled generation plus that from significant intermittent non-scheduled generators. It does not include contributions from small non-scheduled generation. 'Native' quantities include all of the above.

8 'Sent out' maximum demand is measured at the point of entry to the transmission network and does not include power station auxiliary loads. In 2015 AEMO's summer and winter maximum demands (as published in TAPR 2015) were on a 'as generated basis' which were measured at power stations and included power station auxiliary loads.

Figure 2.2 shows the historical electricity maximum demand in summer to 2015/16 and the AEMO 10% and 50% POE demand projections. Figure 2.3 shows the corresponding data for winter.

FIGURE 2.2 – NSW region 2016 summer maximum demand projections and actual demands

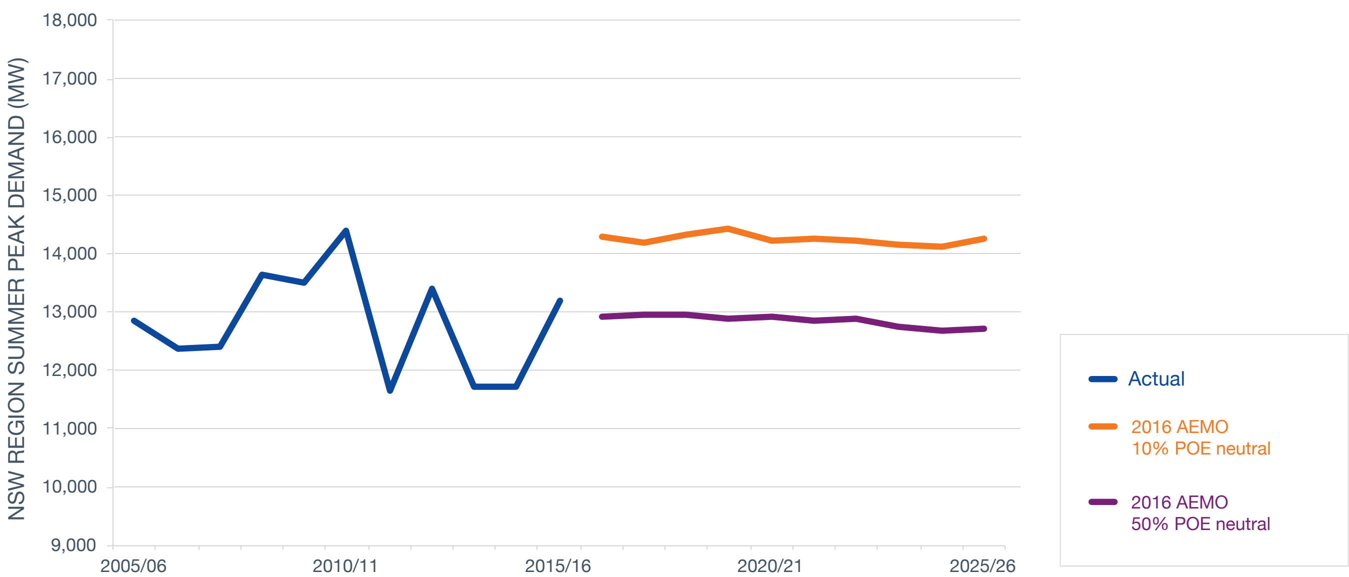


FIGURE 2.3 – NSW region 2015 winter maximum demand projections and actual demands

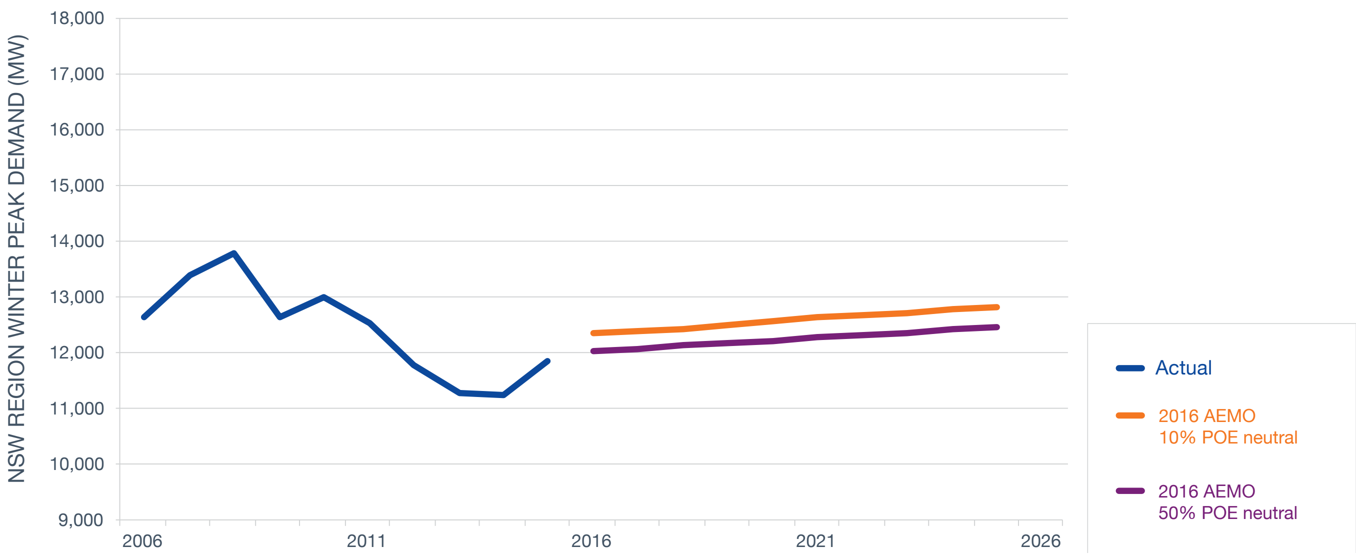


Figure 2.4 and Figure 2.5 show AEMO's forecasts produced in 2015 and 2016 for summer and winter maximum demands, respectively, together with actual (not weather and day-type corrected) maximum demands.

FIGURE 2.4 – AEMO's 2016 and 2015 summer maximum demand forecasts[9]

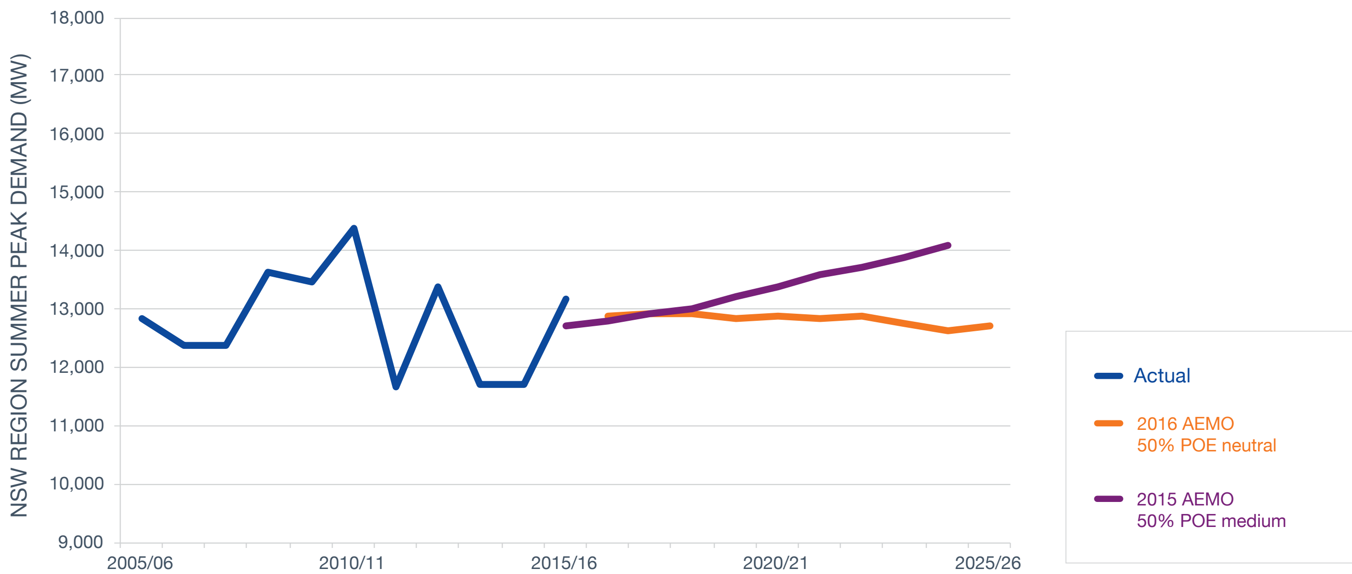
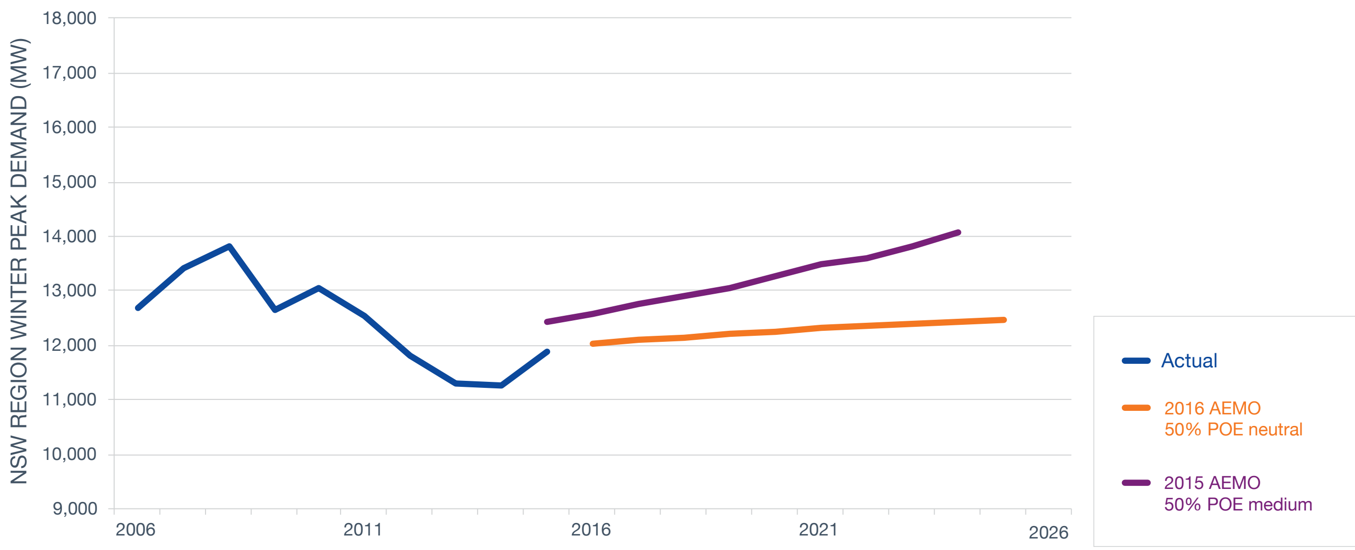


FIGURE 2.5 – AEMO's 2016 and 2015 winter maximum demand forecasts[10]



9 AEMO's 2015 summer maximum demand were prepared on an "as generated" basis i.e. as generated at power stations whereas 2016 summer maximum demands are on a "sent out" basis i.e. as entering the transmission network.

10 AEMO's 2015 winter maximum demand were prepared on an "as generated" basis i.e. as generated at power stations whereas 2016 winter maximum demands are on a "sent out" basis i.e. as entering the transmission network.

AEMO's 2016 summer forecasts are on average 4% lower than those produced in 2015. Those for winter are on average 10% lower than those it produced in 2015. The summer forecasts are flat and have a slightly negative growth for the 10 year forecast period while winter forecasts show a slightly positive growth for the 10 year horizon. In terms of network loadings, summer conditions are likely to be more onerous due to higher forecast loads, lower equipment ratings and generally worse power factors in summer.

2.2.3.2 Bulk supply point forecasts

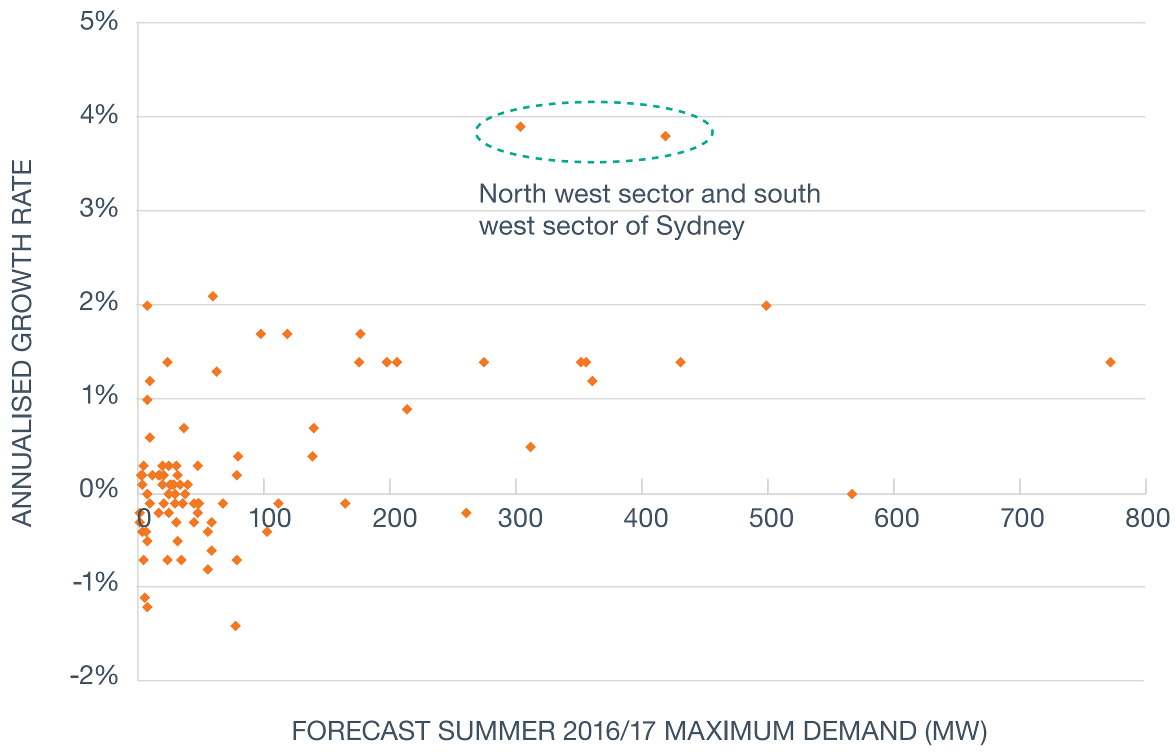
Generally, the load changes at bulk supply points (BSPs) are 'organic'. However, where there are spot loads, they will be included in the relevant forecasts. The BSP forecasts incorporate the 'local knowledge' of the distributors and directly connected customers. Macroeconomic data are generally not available at a BSP level. Consequently, it is generally not possible to develop macroeconomic models for individual BSPs and to produce forecasts for different economic scenarios. In practice, the BSP forecasts are produced in a variety of ways, reflecting the amount of data available and the nature of the loads. These issues and how we have attempted to address them are discussed in the remainder of this section.

Figure 2.6 and Figure 2.7 show the forecast growth rates, excluding the impact of spot loads, for BSPs serving the Distribution Network Service Providers (DNSPs) in summer and winter. The growth rates are annualised. The detailed year on year forecasts of summer and winter maximum demands at the individual BSP level are set out in Appendix 2. Consistent with AEMO's forecasts for the NSW region, winter growth rates are higher than those for summer.

The BSPs with the highest growth rates in summer or winter are those serving:

- > The south west sector of Sydney (primarily Macarthur with support from Ingleburn and Liverpool)
- > The north west sector of Sydney (Vineyard)
- > The Central Coast (Tuggerah, Munmorah and Vales Point)
- > The north eastern part of Sydney (Sydney East).

FIGURE 2.6 – BSP summer forecast growth rates



The primary driver of growth in these areas is residential development together with supporting infrastructure and services.

In recent years, additional transformer capacity has been installed at Liverpool, Tuggerah, Sydney East, Vales Point and Vineyard to address the relatively high growth in these areas. The benefits of that additional capacity can be seen in Figures 2.8 and 2.9 below which compare the forecast maximum demand as a proportion of the nominal firm transformer capacity (the capacity with one transformer out of service) over the planning horizon. Parts of the Central Coast and South Western Sydney also benefit from being interconnected to Ausgrid's and Endeavour Energy's networks, respectively. Macarthur substation was commissioned in 2009. Joint planning is presently underway to determine the best way to manage limitations within Endeavour's network supplied from Macarthur. The provision of an additional 330/66 kV transformer at Macarthur is an option being considered (refer to Section 4.3.2).

Overall, the only area in which load growth is expected to lead to network limitations during the TAPR forecast period is the Gunnedah/Narrabri area. Options for addressing the Gunnedah/Narrabri area limitation are discussed in detail in Section 4.2.1 and Appendix 3. A previously identified constraint in the Beryl/Mudgee area is being addressed by the installation of an extra capacitor bank (reactive support) in summer 2016/17.

Figures 2.6 and 2.7 show a number of BSPs which may have reducing loads (negative growth) over the next ten years. Reducing loads can give potential for parts of those BSPs to be retired and not replaced once they reach the end of their serviceable lives. Any such decision would be taken when the particular assets are nearer to the end of their lives.

FIGURE 2.7 – BSP winter forecast growth rates

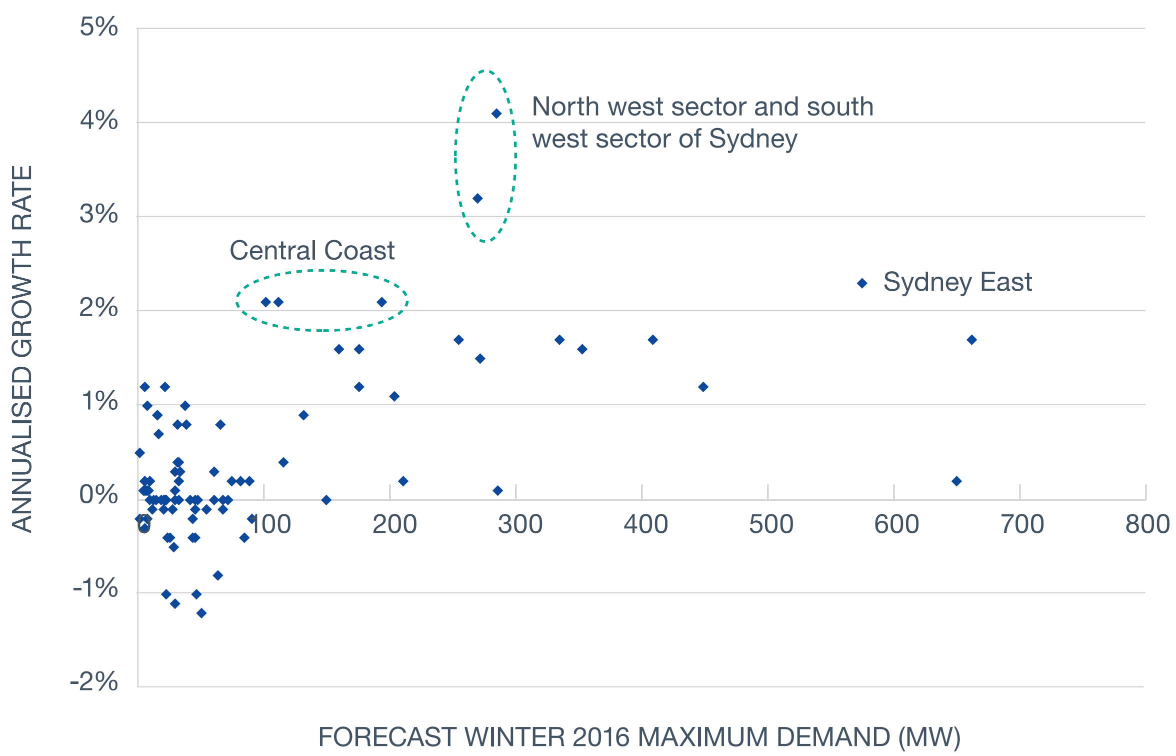
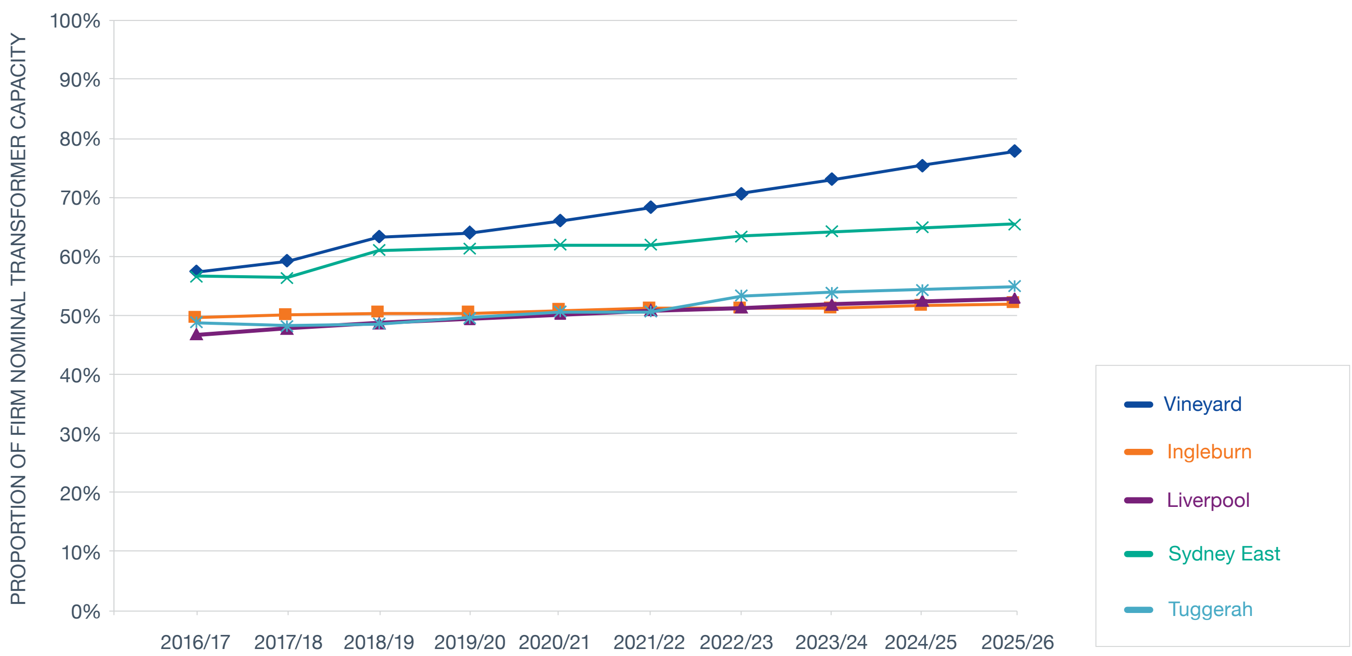


FIGURE 2.8 – Firm nominal transformer capacity vs forecast summer maximum demand



2.2.3.3 Comparing the AEMO and BSP maximum demand forecasts

The BSP forecasts are not produced on the same basis as the overall NSW projections produced by AEMO. For example:

> The underlying economic conditions may not be the same as those used by AEMO

> They may have been based on historical data with a timeframe different to that used by AEMO

> They indicate the likely maximum demand at that location, whenever it may occur, rather than the contribution to the overall NSW maximum demand

> They generally assume that only scheduled embedded generation is operating at the time of maximum demand.

Unlike the AEMO projections, none of the BSP loads, by definition, include transmission losses or power used by generator auxiliaries. Despite this difference, the individual BSP projections for each season can be aggregated to provide a useful point of comparison with the overall NSW seasonal demand projections.

We attempt to account for some of the aforementioned limitations by:

> Using 50% POE forecasts where they are available, and where they are not available, by 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 the time diversity observed between historical local seasonal maximum demand and NSW maximum demand

> Adding forecast aggregate industrial loads not included in the bulk supply point forecasts

> Incorporating loss factors, which are also derived from historical observations, into the aggregate bulk supply point projections.

FIGURE 2.9 – Firm nominal transformer capacity vs forecast winter maximum demand

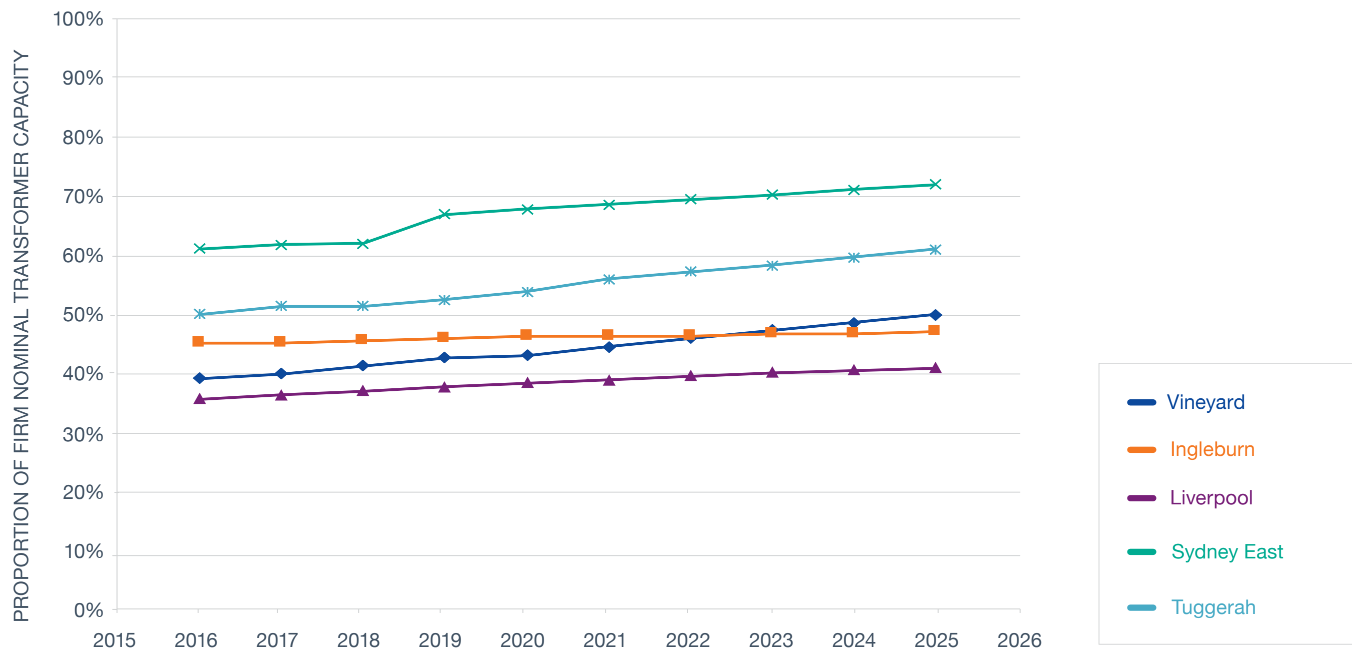


Figure 2.10 shows the comparison between the aggregated DNSP projections and AEMO's 10% POE and 50% POE neutral scenario maximum demand projections for summer. Figure 2.11 shows the equivalent data for winter.

The aggregate BSP forecasts and AEMO forecasts differ in terms of their 10 year average growth rates, as expected for forecasts developed on different bases. Although the comparisons do not indicate which forecast is more accurate, they allow a high-level comparison to be made.

There is some alignment between the winter forecasts (0.4% AEMO and 1.2% aggregate BSP) but the growth rate for the aggregate DNSP-BSP forecasts for summer is higher than AEMO's forecasts (-0.2% AEMO and 0.9% aggregate BSP).

Overall, TransGrid must plan the NSW transmission network to prudently cater for any uncertainties arising from differences in the forecasts that can't otherwise be reconciled.

2.2.3.4 Management of load growth

As part of our normal planning processes, we consider non-network options to manage network limitations. Those options aim to reduce network loadings at critical times through modification of loads and/or embedded generation.

Non-network options can be effective as the reductions in network loading which they provide can relieve limitations for longer than would have been the case in a higher growth environment.

Appendix 3 contains more detailed information on the Gunnedah/Narrabri area to assist the consideration of non-network options in that area. Information regarding the potential for non-network options for the Cable 41/Powering Sydney's Future projects is set out in Section 4.1. As required by the NER, Section 4.5.2 provides information on our intention to issue requests for proposals for non-network options.

FIGURE 2.10 – AEMO and aggregate DNSP projections of NSW summer maximum demand[11]

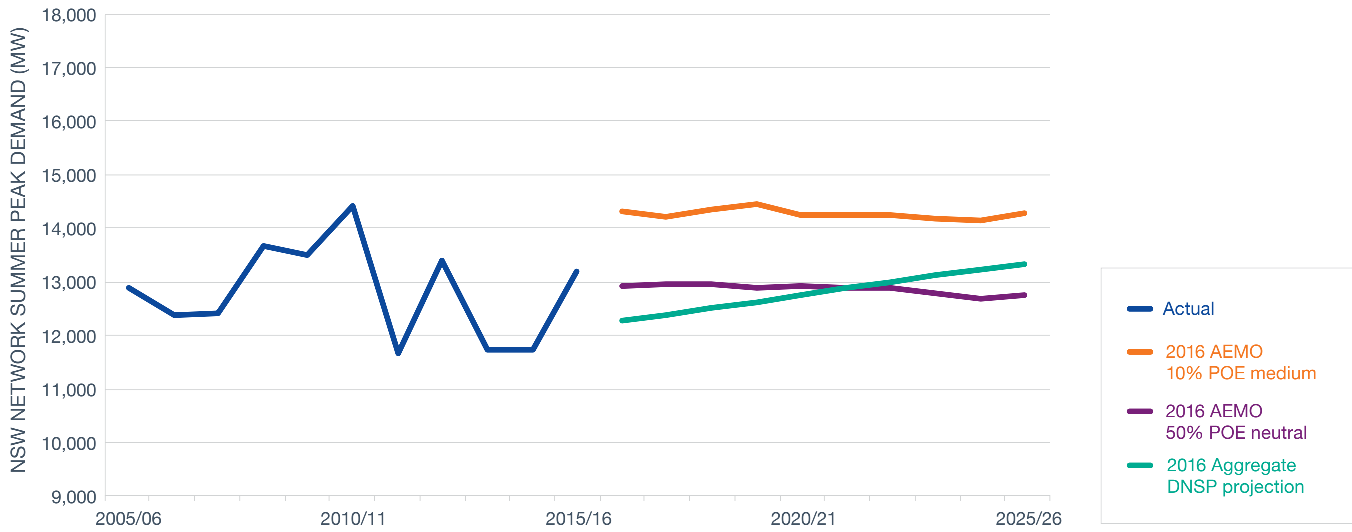
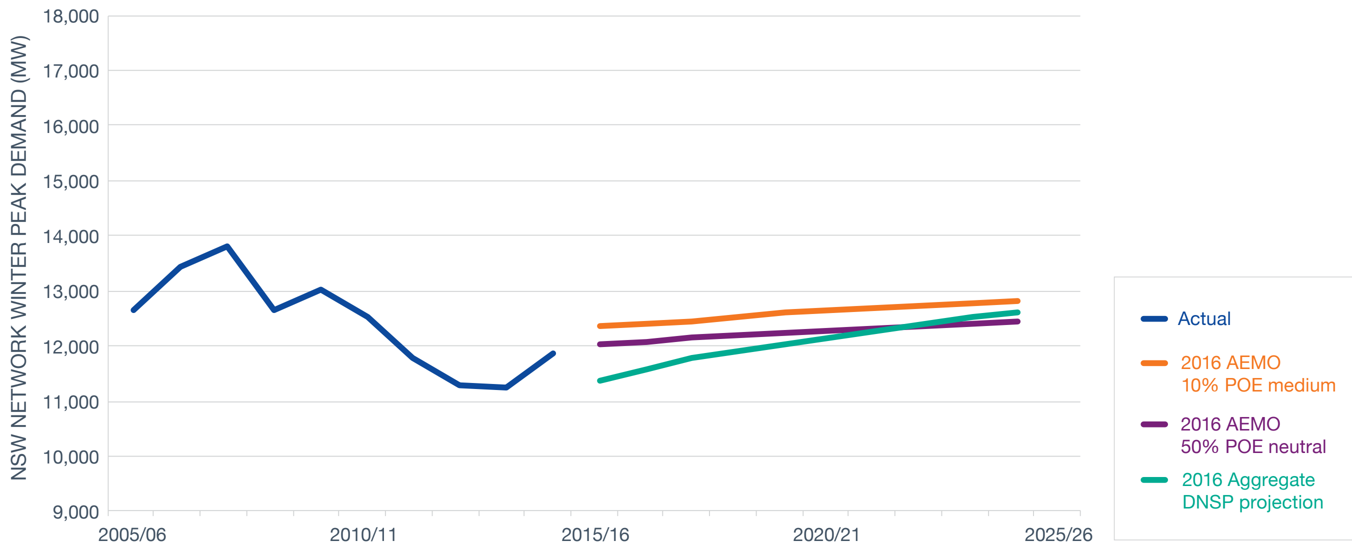


FIGURE 2.11 – AEMO and aggregate DNSP projections of NSW winter maximum demand[11]



11 Actuals and AEMO forecasts are on a 'sent out' basis. DNSP projections are on an 'as delivered' basis adjusted for transmission network losses and other factors.

2.3 Changes in generation

2.3.1 AEMO ESOO and NTNDP

To understand the changes in generation that have the potential to impact on our network's ability to meet our customers' needs, we take into account AEMO's 2015 Electricity Statement of Opportunities (ESOO) and National Transmission Network Development Plan (NTNDP).

The 2015 ESOO notes that five coal fired generators have been retired in recent years. These were at Munmorah (late 2014), Wallerawang (early 2014) and Redbank (July 2014). The Smithfield Energy Facility (171 MW) and Liddell Power Station (2000 MW) are expected to be retired in 2017 and 2022 respectively. The ESOO also noted that within NSW there were 'publicly announced' new generation proposals totalling just under 7,900 MW of which wind projects comprised over half. Assuming both the retirements and new capacity occur, under the medium scenario, Unserved Energy (USE) in New South Wales could exceed the current Reliability Standard from 2022/23, bringing the Low Reserve Condition (LRC) point forward by at least two years compared to the 2014 ESOO.

The key findings of NTNDP 2015 were that:

> Renewable generation, mostly wind and PV generation, will dominate large scale generation additions to 2020

> Rooftop PV provides the highest contribution to additional generation capacity under all scenarios considered.

In relation to network developments, the NTNDP 2015 noted that:

> Minimal new transmission infrastructure expenditure is expected to be required over the next 20 years so long as new generation is located efficiently to balance the quality and availability of the fuel source and network costs

> There is a risk that concentration of generation in the same location will cause local transmission congestion.

2.3.2 Forecast generation developments in NSW

Table 2.4 shows the magnitudes of renewable generation enquiries that TransGrid has recently received.

TABLE 2.4 - Indicative NSW generation investment interests

Technology	Connection enquiry stage	
	Preliminary (MW)	Advanced (MW)
Solar	1659	180
Wind	2395	860

The most prospective wind resources tend to be along the Great Dividing Range in the Yass/Bungendore/ Taralga area in the south of the State and the Glen Innes/Inverell/ Tenterfield area in the north. These areas are remote from the major load centres of Newcastle, Sydney and Wollongong. Other possible areas such as Broken Hill are even more remote. The development of generation at these locations would be likely to increase the loading on our network in those areas and between those areas and the major load centres.

Additional information on connection opportunities is available on our website at: https://www.transgrid.com.au/what-we-do/our-network/NSWConnectionOpportunities/Pages/default.aspx

Future renewable generation connection inquiries are likely to be influenced by government policy. Since January 2011, the Renewable Energy Target has operated in two parts – the Small-scale Renewable Energy Scheme (SRES) and the Large-scale Renewable Energy Target (LRET). The LRET creates a financial incentive for the establishment or expansion of renewable energy power stations, such as wind and solar farms or hydro-electric power stations. In June 2015, the Federal Government revised the current LRET down from 41,000 GWh to 33,000 GWh by 2020, but the solar credits scheme continued unchanged.

Australia's Paris[12] 2015 commitment is to reduce greenhouse gas emissions by between 26% and 28% below 2005 levels by 2030. State governments are targeting increasing levels of renewable generation but the instruments to achieve these targets are yet to be determined, although the ACT government is presently using a tender approach. At this point, it is unclear the extent to which this policy change will impact on the future renewable energy generation projects.

Ernst & Young (EY) has provided TransGrid with additional advice on generation expansion scenarios. EY identified key influencing factors likely to impact on generator developments over the period from 2015/16 to 2029/30. These factors are:

> Demand growth

> Renewables penetration and emission response

> Interconnector augmentation

> Small-scale, distributed energy resource (DER) uptake, including consideration of storage.

Combining these factors leads to a range of different plausible future planting scenarios. Generation developments under the 'most likely' scenarios corresponding to three different demand growth levels are shown in Table 2.5.

12 21st Conference of the Parties for the United Nations Framework Convention to Climate Change

TABLE 2.5 – Forecasts of NSW generator expansion by 2029/30[13]

	Northern NSW	Central NSW	Canberra	South West NSW
Medium demand growth scenario	Wind: +753 MW Solar: +270 MW	Wind: +725 MW Solar: +103 MW OCGT: +615 MW Biomass: +158 MW Coal: -2170 MW	Wind: +1077 MW Solar: +233 MW OCGT: +500 MW	Wind: +655 MW Solar: +53 MW
Low demand growth scenario	Wind: +588 MW Solar: +140 MW	Wind: +1149 MW Solar: +50 MW OCGT: +15 MW Biomass: +158 MW Coal: -2170 MW	Wind: +1165 MW Solar: +73 MW	Wind: +330 MW Solar: +53 MW
High demand growth scenario	Wind: +588 MW Solar: +270 MW	Wind: +695 MW Solar: +50 MW OCGT: +15 MW Biomass: +158 MW	Wind: +1243 MW Solar: +333 MW	Wind: +655 MW Solar: +53 MW

In the low and medium scenarios, there is a net reduction in generation in central NSW, closest to the major load centres, and increased generation in remote areas. Consequently, the possibility of requiring major transmission works is greatest under these scenarios. In the high scenario, the Liddell power station is not retired (or is replaced with an equivalent base load plant) and so less transmission investment would be expected to be needed.

2.3.3 Two potential issues

There are two issues that may arise from the above.

The first concerns the ability of a power system with a significant amount of intermittent generation to be able to reliably meet peak demand.

Until relatively recently, there has not been a significant amount of large scale wind generation within NSW. Consequently there is only limited data that can be used to estimate the amount of wind generation which may be able to be relied upon in such circumstances. Figure 2.12 shows the total wind generation in NSW and the corresponding demand in each half hour trading interval over summer 2015/16. There is no discernible relationship between them. The assessments for summer 2013/14 and summer 2014/15 show similar results and indicate that there is no consistent relationship at times of high demands.

Consequently, at present it is not possible to estimate the amount of generation which may be able to be relied upon at times of high demand. In the future, with higher levels of wind generation, which is likely to be geographically more diverse, it may be possible to make an estimate[14].

If only small proportions of wind and solar generation can be relied upon to be operating at times of high demand, there may be sufficient generation to (notionally) meet the state's annual energy requirements, but insufficient to meet maximum demands.

We therefore agree with AEMO's 2015 ESOO assessment that, under the medium scenario, NSW USE could exceed the current Reliability Standard from 2022/23, bringing the LRC point forward. The results of our analysis, based on NSW existing local generation with full interconnector support and the retirement of Liddell in 2022, appear in Figure 2.13.

One way to address this would involve increasing transmission capacity to NSW from its neighbouring states, potentially by:

> Upgrading the Qld - NSW Interconnector (QNI, see Section 4.1.2)

> Enhancement of the Snowy to Sydney network (see Section 4.3.1)

> Interconnection between SA and NSW (SANI, see Section 4.1.3). Investigations will be pursued through joint planning with ElectraNet.

A second potential issue from the above concerns AEMO's assumption that future generation will be located efficiently. If this proves to be incorrect, generation developments may be constrained by lack of transmission capacity. Should this impact on the ability to meet maximum demands in the state, due either to there being insufficient generation or insufficient network capacity to transmit generation to the major load centres, additional transmission capacity would be required. The provision of additional transmission capacity could be complicated by the long lead-times for major transmission works relative to those to establish generation once it becomes committed[15].

FIGURE 2.12 – Wind generation vs NSW regional demand in summer 2015/16

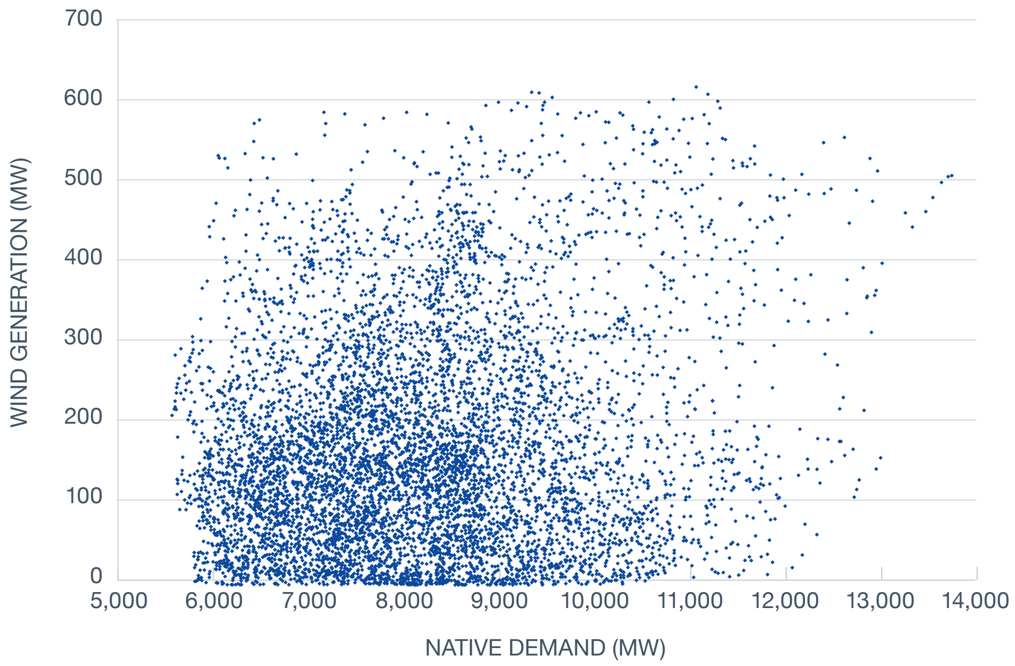
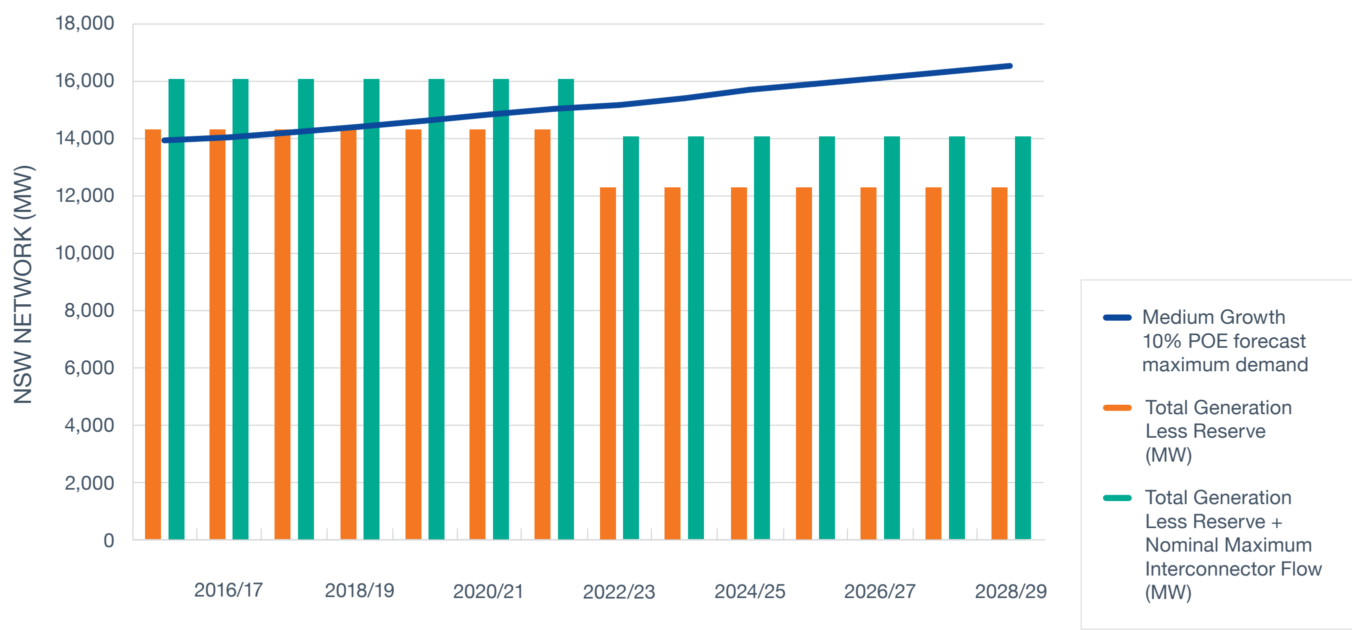


FIGURE 2.13 – Forecast maximum demand and supply capacity



13 2015 AEMO National Transmission Network Development Plan. Based on current LRET, AEMO modelled between 4,200 MW and 6,700 MW of forecast additional large-scale renewable generation installed across the NEM by 2020.

14 AEMO NSW Generation Information on 15th April 2016. AEMO assumed that the NEM wind contribution to summer peak demand is 7% of the maximum firm generation capacity and NSW wind contribution to summer peak demand is 1.2%.

15 The difficulty is that where there are generation proposals which have the potential to avoid "problems" such as a generation shortfall or an inability to transmit sufficient power to the major load centres, those problems do not become certain until the generation does not proceed in sufficient time. By that time, the longer lead-times for major transmission developments mean that they cannot manage the problem either.

2.4 Changes in network capability

This section discusses three further matters related to potential limitations on the existing network:

> Constraints — either reliability or market benefits types and how they have been/may be alleviated

> Network system control and ancillary services (NSCAS) needs

> Asset management — how we manage our assets can have an impact on network capability.

2.4.1 Constraints

Constraints are of two types: those where relieving them can bring benefits to customers by providing for greater wholesale market competition, and those where the ability to meet reliability or power quality requirements may be at risk.

Regarding the former, we monitor network limitations which have bound or have been close to binding in the past. That analysis appears in our 'Transmission Constraints' report[16].

The NTNDP 2015 identified two potential market benefits constraints under the most likely development scenarios. These are the transmission network capacities between Liddell/Muswellbrook and Tamworth (constraint E-N2) and between Yass/Canberra and the Sydney Area (constraint E-N3 concerning the Snowy-Sydney transmission system). These possible constraints are discussed in Sections 4.1.2 and 4.3.1, respectively.

The NTNDP 2015 identified one transmission reliability constraint occurring within five years. This is an overload of the Sydney South – Beaconsfield West 330 kV cable for an outage of the Sydney South – Haymarket 330 kV cable (constraint L-N1). We are addressing the constraint for supplying the Sydney metropolitan area (L–N1). Details are given in Section 4.1.1.

Line loading can provide a leading indicator of future constraints. While loads within NSW have moderated in recent years, parts of our network remain heavily loaded. Our 'Transmission Utilisation' report[17] which is on our website shows the utilisation of our transmission lines relative to their contingency ratings during the period from 1 March 2015 to 29 February 2016. During that period, approximately 21% of the transmission lines in our network would have been loaded at or above 90% of their capacity, should a critical outage have occurred (see our 'Transmission Constraints' report). This is broadly consistent with a similar analysis reported in the TAPR 2015, for the period from 1 May 2014 to 31 March 2015 which showed approximately 16% of our lines in this category.

2.4.2 NSCAS needs

NSCAS are ancillary services procured in order to prevent adverse security of the power system or negatively affect reliability. Under the NER, AEMO identifies NSCAS needs in NSW and TransGrid is required to procure NSCAS services to address them. AEMO effectively has a backup role in terms of procuring NSCAS, where we are unable to do so.

Voltages at Kangaroo Valley are presently managed under an NSCAS agreement which terminates in June 2018. TransGrid's assessment shows that the reactors presently installed and available in the NSW transmission network are sufficient to meet the identified NSCAS gap beyond 2018. AEMO and TransGrid will continue to monitor this situation.

The NSCAS assessment in NTNDP 2015 did not identify any further means of maximising market benefits for maintaining or improving power transmission capability.

2.4.3 Asset management

One potential constraint on the network supplying the Sydney CBD and surrounding suburbs concerns whether the condition of cable 41 will result in a derating of the cable. Cable 41 is one of two major 330 kV cables that, together with numerous Ausgrid 132 kV cables, supply that critical load. Recent investigations found that the cable backfill has degraded, reducing its ability to dissipate heat, and that soil samples along the cable route show ground temperatures exceeding those assumed in the original cable design. These findings resulted in cable 41 being derated from 663 MVA to 575 MVA. A more detailed assessment may further reduce the cable rating to 426 MVA. The implications of this issue on the capacity of TransGrid's supply to the Sydney inner metropolitan area are discussed in Section 4.1.

More generally, as our assets approach the end of their serviceable lives, it is important to plan for their orderly retirement. We review a number of options, as part of our assessment of the ongoing need for an asset, including:

> Doing nothing

> Whether there are any viable non-network options, to defer the need for replacement

> Like for like replacement

> Replacement with an asset of different capacity based on forecast demand

> Reconfigure the network.

Our regular review of our asset renewal program has led to some changes in replacement work this year.

A number of asset replacement projects have progressed this year, sometimes with a reduced scope. For example the replacement of equipment at Vales Point substation was reviewed and the scope of work reduced to replace only essential items at this time and the changes at Canberra substation optimised with the new Stockdill Drive substation. The condition of the remaining equipment will be continually monitored so that replacement can be planned as appropriate.

Our review has also led to targeted remediation of low clearances on specific individual transmission line spans rather than whole lines in the northern, central and southern regions of NSW. This takes into account the Dynamic Line Rating (DLR) equipment we have recently been installing. Some other transmission line remediation work has been rescoped to carry out specific work on specific structures, rather than carrying out a broad based program. For example, the condition of 944 Wallerawang – Orange North 132 kV line will be addressed by targeted replacement of individual poles, rather than rebuilding the entire line.

Some other replacement works have been deferred further into the future than originally planned, as load growth has moderated and risk has reduced. These are listed in Section 4.4, and include replacement of secondary systems at Hume and ANM substations, replacement of equipment at Newcastle, Burrinjuck and Munmorah substations and remediation work on 959/92Z Sydney North – Sydney East 132 kV line and 01 and 02 Snowy – Yass/Canberra 330 kV lines.

Overall, the retirement of individual assets at the end of their lives is not expected to materially affect the capability of our network.

2.4.4 Non-network options

Non-network solutions can provide value to customers for both load and asset replacement driven needs. This reflects the fact that investment in transmission networks is typically 'lumpy', and non-network solutions can be tailored to smaller increments and better match the service requirements. This is particularly the case where load growth is low or modest, and the long-term future service requirements are less certain.

There are three broad kinds of non-network solutions:

> Load curtailment where the consumer agrees to reduce demand during times of high demand

> On-site or local generation and storage where consumers generate their own electricity to offset their impact on the network or provide an injection back into the network.

> Enter into a large scale contract to manage load requirements at an aggregated level, for example, by procuring grid-level storage.

Chapter 4 of this document identifies a number of emerging needs where non-network solutions could potentially provide a cost-effective solution.

2.5 Changes in service standards

Changes in service standards can arise from changes in technical standards or in reliability criteria. At this stage, we are not aware of any changes to the technical standards which may change the service standards we are required to meet.

Reliability criteria can be thought of as a description of the consequences that a society is prepared to insure against. The reliability standards that we are required to operate to in NSW are being reviewed by the IPART. Broadly, the current standards are to provide a modified 'N-2' standard for the Sydney CBD and 'N-1' in all other areas of NSW[18]. This means we are required to build sufficient redundancy to ensure that supply is not interrupted if two and one elements, respectively, of the network fail. The higher level of redundancy required for the Sydney CBD reflects the greater economic cost associated with supply interruption compared with other parts of the transmission network.

IPART published its draft recommendations regarding the future standards in late May 2016. The proposals include retaining the current level of redundancy for each bulk supply point in the network while introducing flexibility around how the specified level of redundancy is met by including an allowance for TransGrid to plan for a positive value of unserved energy. The draft standards also provide for non-network solutions to be part of the arrangements to meet the redundancy criteria.

After a period of public consultation, closing in late June 2016, the final recommendations are expected to be provided to the NSW Government by December 2016.

Until the new criteria come into force TransGrid's network planning approach will remain as it is for NSW as per TransGrid's licence. That approach is available on our website[19].

TransGrid is also subject to a reliability standard under the transmission licence it holds in the ACT. That standard includes the provision of two independent points of supply by 2020. TransGrid currently supplies the ACT load via our Williamsdale and Canberra substations. However, the Williamsdale substation is dependent on the Canberra substation. The requirement for a second, fully independent supply point is being met by the construction of a new substation located at Stockdill Drive.

16 https://www.transgrid.com.au/news-views/publications/Documents/TAPR%202016%20Transmission%20constraints%20report.PDF
17 https://www.transgrid.com.au/news-views/publications/Documents/TAPR%202016%20Line%20utilisation%20report.PDF
18 Transmission Network Design and Reliability Standard for NSW, NSW Department of Industry.
19 https://www.transgrid.com.au/news-views/publications/Documents/TAPR%202016%20TransGrids%20network%20planning%20approach.pdf

2.6 Summary of factors affecting network capability

Loads within NSW have generally moderated over the past several years. This has resulted in the times at which network limitations are expected to arise being further into the future. Apart from some locations with spot loads, such as the Gunnedah/Narrabri area, load growth is presently not a major factor in the onset of network limitations. Should the reliability standards our network must meet be relaxed, load growth would be a less important factor for longer.

At present, the main contributor to known future network limitations is the retirement of major conventional generation and its replacement with intermittent renewable generation. The impact would depend on how much generation is retired and its location. For smaller amounts the impacts may be just on generation dispatch. For larger amounts, supply reliability could be impacted.

The historical minimum demand in NSW has been slightly increasing over 2012 – 2015. The level of minimum demand is not expected to significantly reduce in the near future. TransGrid's assessment has confirmed that the quantity of reactors presently installed in the transmission grid is adequate for managing the transmission voltages to be within the operational limits.

Changes in service standards can arise from changes in technical standards or in reliability criteria. At this stage, we are not aware of any changes to the technical standards which mat change the service standards we are required to meet.

3 Chapter

Completed, committed and planned developments

- In the last financial year, 12 projects that have alleviated previously identified needs were completed. These include replacement of Cooma substation and the refurbishment of Yanco substation
- 19 projects progressed to, or are at, the committed stage including Orange substation redevelopment, rehabilitation of Upper Tumut switching station and condition-based works at Wagga 132 kV and Vales Point substations
- Five projects are planned including condition-based replacements at Canberra substation, connection of a sub transmission substation near Munmorah and addressing the southern supply to the ACT and supply to the Beryl/Mudgee area.
- The timing and scope of a number of projects identified in last year's TAPR have been reassessed. These are addressed in Chapter 4.

3.1 Introduction

This chapter is structured around the following project classifications:

> 'Completed' projects are those that have alleviated constraints that were identified in previous TAPRs

> 'Committed' developments are those where we have made a financial and contractual commitment to undertake them and they are under development

> 'Planned' developments have completed the regulatory process but do not (yet) meet the criteria above for committed developments.

Within each classification, projects are broadly divided into major developments (typically entire lines, cables or substations) and minor developments.

MAP – Completed developments

3.2 Completed developments

3.2.1 Major developments

Replacement of the Cooma substation

The original Cooma 132/66/11 kV substation, which supplied the Cooma area, the NSW alpine region and the NSW far south coast, was commissioned in 1954. The substation required replacement due to the majority of its equipment nearing the end of its serviceable life, to ensure supply reliability.

A new Cooma 132/66 kV substation was established close to the existing substation, and the existing Cooma substation was transferred to Essential Energy to allow the sites to be converted to a 66/11 kV substation.

The new Cooma 132/66 kV substation was completed in November 2015.

Refurbishment of the Yanco substation

The 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 was nearing the end of its serviceable life and needed to be replaced to maintain reliability of supply.

The refurbishment of Yanco substation was completed in September 2015.

Strategic land acquisition at Riley Street

TransGrid completed the acquisition of a parcel of land in Riley Street, Surry Hills in September 2015. The land is suitable for building a replacement for the Haymarket 330 kV substation. The latter plays a critical role in maintaining reliable supply in the Sydney inner city and CBD areas and will need to be replaced around the mid 2040s.

3.2.2 Minor developments

TABLE 3.1 – Completed line switchbays for customer requirements

Location	Installation	Completion	Comments
Beryl 132 kV substation	One 66 kV line switchbay	September 2015	Required by Essential Energy to reinforce the network supplying Dunedoo and Coonabarabran
Vineyard 330 kV substation	One 132 kV switchbay	February 2016	Endeavour Energy requested a 132 kV line switchbay to connect a new 132 kV line supplying the new Marsden Park zone substation
Molong 132 kV substation	One 66 kV switchbay	March 2016	Essential Energy required a second 66/11 kV transformer at Molong

TABLE 3.2 – Completed substation fault rating upgrades

Location	Installation	Completion	Comments
Sydney West 330/132 kV substation	Equipment replacements to ensure the 132 kV fault rating is adequate	February 2016	To maintain system security

TABLE 3.3 – Completed transformer and reactor replacements and upgrades

Location	Installation	Completion	Comments
Buronga 220 kV switching station	Reactor X2 replacement	July 2015	Condition-based replacement
Broken Hill 220/22 kV substation	No 1 and 2 reactor replacement	Winter 2016	Condition-based replacement

TABLE 3.4 – Other completed works

Location	Installation	Completion	Comments
Armidale 330/132 kV substation	Replacement of the SVC[20] control system	September 2015	Condition-based replacement
Kangaroo Valley 330 kV substation	Replacement of the secondary systems	February 2016	Condition-based replacement
Sydney South 330 kV substation	Replacement of the 415-VAC system and LV cables	February 2016	Condition-based replacement

3.3 Committed developments

3.3.1 Major works

Redevelopment of Orange 132/66 kV substation

Commissioned in 1954, the Orange 132/66 kV substation and the 66 kV equipment and secondary systems, are nearing the end of their serviceable lives. Following the completion of the Orange North 132 kV switching station, most of the 132 kV equipment at the Orange substation will be removed and the 66 kV equipment and secondary systems will be replaced. While removing and replacing the necessary parts at this substation, we will install an additional 66 kV capacitor required as part of our reliability commitment.

Due to supply issues, the project is now expected to be completed in 2019.

Rehabilitation of Upper Tumut switching station

Most of the rehabilitation work at the Upper Tumut switching station has been completed, including replacement of the high-voltage equipment.

Replacement of the secondary systems is scheduled to be completed progressively until July 2016.

Condition of Wagga 132/66 kV substation

Commissioned in 1955, the Wagga 132 kV substation supplies most of the load in Wagga and the surrounding area. The balance of the load is supplied from Wagga North and Morven substations.

An assessment of the condition of the Wagga 132 kV substation and its assets revealed that many components are nearing the end of their serviceable lives. The assessment also revealed some substation problems with the No 2 and No 3 132/66/11 kV transformers that need to be addressed.

The substation will be re-built in situ, including:

> Replacement of the existing No 1 and 3 132/66 kV 60 MVA transformers with 132/66 kV 120 MVA transformers

> Removal of the existing No 2 transformer

> Installation of secondary systems buildings and associated cable trenches

> Replacement of equipment that is identified as nearing the end of its serviceable life

> A new oil containment system.

This work is expected to be completed in mid 2019.

Condition of Vales Point 330/132 kV substation

Vales Point substation forms an integral part of the 330 kV transmission system on the Central Coast. It provides a connection for Vales Point power station and supplies Ausgrid's 132 kV network through two 200 MVA transformers. An assessment of the condition of Vales Point substation and its assets revealed that many components are reaching the end of their service life. The assessment also revealed a number of other problems that need to be addressed, including the condition of the steelwork and buildings.

The replacement of equipment at Vales Point is expected to be completed in 2018.

Dynamic line ratings

Our current line ratings consider the probabilistic nature of weather and line loading conditions. The weather information used for determining the line ratings does not necessarily refer to the weather conditions on critical constraint spans of a transmission line, where conductor sagging is the constraining issue.

Real-time line ratings have the dual benefit of allowing maximum power transfer capability of the system (where thermal ratings are the determining factor) to be available and de-rating lines in order to protect the assets and the system during adverse conditions. Twenty two transmission lines have been identified where constraints were seen to impact future power flows, and dynamic line rating (DLR) will be implemented on these.

Installation on lines 01, 02, 03 and 07 was completed in November 2015.

Further installations on lines in the Yass, Marulan, Canberra, Bannaby area and in the Liddell, Muswellbrook, Tamworth, Armidale area are expected to be completed by spring 2016.

Quality of supply monitoring

Quality of Supply (QoS) monitors will be installed at 13 strategic customer connection points, so that we can measure, record and analyse aspects of the quality of supply at these customer connection points.

The installations are expected to be completed by June 2017.

Point-on-wave switching control

Our 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 point on wave (POW) closing controls, energising a shunt capacitor bank can produce high levels of transient distortion. These distorted voltage waveforms are applied to customer loads and can cause the customer equipment to malfunction or fail.

Since 2005, new capacitor banks have included capacitor circuit breakers fitted with POW closing controls. Replacement capacitor circuit breakers also have included POW closing controls.

There are still some shunt capacitor banks remaining where the circuit breakers need to be replaced with those fitted with POW closing controls. These replacements are expected to be completed by early 2018.

Installation of fibre networks

As technology evolves, increasing volumes of useful data is available from smart devices located at remote sites. This data can be transported back to a centralised location for monitoring, detection, diagnosis and trending purposes. At the same time, staff attending these remote sites are relying more heavily on access to TransGrid's corporate data systems to ensure work is completely safely, accurately and efficiently.

Installing optical fibre to replace the existing microwave networks has been identified as the most efficient way of increasing data capacity. This is typically achieved by replacing an earthwire of a transmission line with an optical fibre cable encased in aluminium conductor, referred to as OPGW.

TransGrid has developed a 15 year strategy for rolling out OPGW across the transmission network, beginning with the formation of three new communications rings over the next 2 years. Works on the southern ring between Yass and Wagga, as well as the central west ring (Mt Piper to Orange, Wellington, Parkes and Forbes), will be substantially complete by Mid 2017. Works on the north coast ring between Newcastle and Lismore will be complete by Mid 2018.

MAP – Committed developments

20 Static var compensator (SVC)

3.3.2 Minor works

There are no committed line switchbays or substation fault rating upgrades since the publication of TAPR 2015.

TABLE 3.5 – Committed transformer and reactor replacements and upgrades

Location	Installation	Completion	Comments
Beaconsfield West 330 kV substation	No 1 and 2 transformer replacement with a single transformer	2018	Condition-based replacement of one transformer. The other will be retired and not replaced

TABLE 3.6 – Committed capacitor bank installations

Location	Installation	Completion	Comments
Orange 132/66 kV substation	Additional 66 kV capacitor bank	2019	To be provided as part of condition-based replacement. See Section 3.3.1

TABLE 3.7 – Other committed works

Location	Installation	Completion	Comments
Tamworth 132/66 kV substation	Substation rebuild	Early 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
Sydney West 330/132 kV substation	Replacement of the secondary systems	Mid 2016	Condition-based replacement
Sydney North 330 kV substation	Replacement of the secondary systems	Late 2018	Condition-based replacement
Haymarket 330 kV substation	Removal of SICAM (control and monitoring system) from GIS	Mid 2017	Condition-based removal
Albury 132 kV substation	Replacement of the secondary systems	Late 2016	Condition-based replacement
970 Burrinjuck – Yass 132 kV line	Pole replacements (including installation of OPGW)	2017	Condition-based replacement
Northern region pole lines	Remediation of low spans (including installation of OPGW)	Late 2017	Remediation of high priority low spans
Taree 132 kV substation	Secondary systems replacement and 33 kV switchyard condition	Late 2017	Condition-based replacement
96H Coffs Harbour – Koolkhan 132 kV line	Pole replacement	2018	Condition-based replacement

3.4 Planned developments

3.4.1 Major works

Condition of Canberra 330/132 kV substation

Canberra 330/132 kV substation was commissioned in 1967 and supplies Queanbeyan substation and the ActewAGL 132 kV sub-transmission network. It forms an integral part of the transmission interconnection between the Victorian region, Snowy Mountains generation and the rest of NSW. An assessment of the condition of Canberra substation and its assets found the numerous items of equipment are reaching the end of their serviceable life and that other substation issues need to be addressed.

A number of options were considered to address the Canberra substation condition, including:

> Replacing the Canberra substation in-situ or in a piecemeal fashion

> Rebuilding the Canberra substation across two interconnected sites, on an adjacent site, or at a location remote from the existing substation.

Non-network options are not feasible because of the ACT's reliability requirements and the fact that the number of connections will not be changed.

The initial piecemeal replacement program has been optimised to take into account the development of a second independent supply to the ACT at Stockdill Drive. The works are expected to be completed in 2019.

Connection of Ausgrid's new sub-transmission substation in the Munmorah area

Munmorah power station has been retired. However, the two 330/33 kV transformers which provide supply to Ausgrid have been retained. Those transformers are nearing the end of their serviceable lives and are to be retired in 2017.

Ausgrid will establish a new Munmorah 132/33 kV sub-transmission substation (STS) adjacent to TransGrid's Munmorah 330/132 kV substation. The Munmorah STS will provide a 132 kV busbar near Munmorah for the connection of Ausgrid's 132/33 kV transformers as well as Ausgrid's 132 kV lines to Charmhaven and Lake Munmorah. This STS would also provide for any future 132 kV feeder connections.

TransGrid needs to provide for the connection of a 132 kV supply for the new Munmorah STS by adjusting secondary system functionality to suit the new arrangement.

Development of southern supply to the ACT

TransGrid was granted a licence in early 2015 to provide electricity transmission services in the ACT. A condition of the licence was that TransGrid provide two independent, geographically separate 330 kV supplies to the ACT, the first of which is the existing Canberra 330/132 kV substation.

Williamsdale 330/132 kV substation (commissioned in 2013) provides a second supply point to the ACT. However, Williamsdale substation is currently supplied from the Canberra 330/132 kV substation via line 3C and is therefore dependent on Canberra 330/132 kV substation being in service. Williamsdale is therefore not considered to be a geographically separate supply point.

The feasible option identified that complies with the licence conditions is the establishment of a switching station at a suitable site together with associated 330 kV line connections. After review by the ACT Government, a site near Stockdill Drive is preferred with lines 01 and 3C diverted and connected to the switching station and a transformer connected to ActewAGL's Woden line.

Supply to Beryl/Mudgee area

Beryl 132/66 kV substation is supplied by two 132 kV transmission lines, the 53 km line 94B from Wellington 330/132 kV substation, and the 125 km line 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-connections.

In recent years, mines in the area have been developed or expanded, and further expansions are forecast.

An additional 66 kV capacitor will be installed at Beryl substation, to provide additional reactive support. The work is expected to be completed in summer 2016/17.

3.4.2 Minor works

Other then the Avon 330 kV secondary systems replacement noted in Table 3.8 below, since the publication of the TAPR 2015 there have been no:

> New minor developments that have completed the regulatory process

> Substation fault rating upgrades in this category

> Transformer or reactor replacements in this category

> Projects for the provision of line switchbays to meet NSW Distributor's requirements in this category

> System reactive plant requirements in this category.

TABLE 3.8 – Other planned minor works

Location	Installation	Completion	Comments
Avon 330 kV switching station	Replacement of the secondary systems	End 2017	Condition-based replacement

3.5 Replacement transmission network assets previously reported

Table 3.9 summarises replacement transmission network assets previously reported.

TABLE 3.9 – Replacement transmission network assets previously reported

Location	Installation	Completion	Comments
97K Cooma – Munyang 132 kV line	Line rehabilitation	2018	Remediation of low spans
Central region tower lines	Remediation of low spans	Late 2017	Remediation of low spans
99F Uranquinty – Yanco 132 kV line	Pole replacements (including installation of OPGW)	Early 2017	Condition-based replacement

MAP – Planned and replacement developments

CHAPTER 3

Chapter 4

Constraints and possible network developments

> Possible major developments include: Powering Sydney's Future, including the condition of cable 41, the Queensland – NSW interconnector and three related developments and a SA – NSW interconnector (SANI)

> A number of strategic asset replacment or refurbishment programs will take place. Some asset replacements, such as condition based works at Canberra substation and some remediation work on transmission lines, have progressed and are now committed projects. Others have modified scopes and timeframes due to regular review.

> Other possible projects in the next five years include load related development in the Gunnedah/Narrabri area

> Other possible developments in the five to ten year period include development of the Snowy to Sydney network capacity and supply adequacy to the Macarthur area

> Some possible developments reported last year are now expected to arise further into the future because of moderating load forecasts and review and rescoping of the developments. These include the condition based works at Burrinjuck, Munmorah and Hume substations, and on a number of transmission lines including the 99J Yanco – Griffith 132 kV line

This chapter:

> Describes three possible major projects that may arise over the ten year planning horizon (Section 4.1)

> Provides an overview of a number of strategic asset replacement and refurbishment programs expected to be undertaken over the planning horizon (Section 4.2)

> Describes constraints expected to emerge within a five year planning horizon, where there is at present no firm proposal. One or more options for removing each constraint are described. Non-strategic replacement projects in the same timeframe are also identified (Section 4.3)

> Summarises constraints expected to arise within the five to ten year planning horizon. One or more indicative developments to mitigate the constraints are given (Section 4.4)

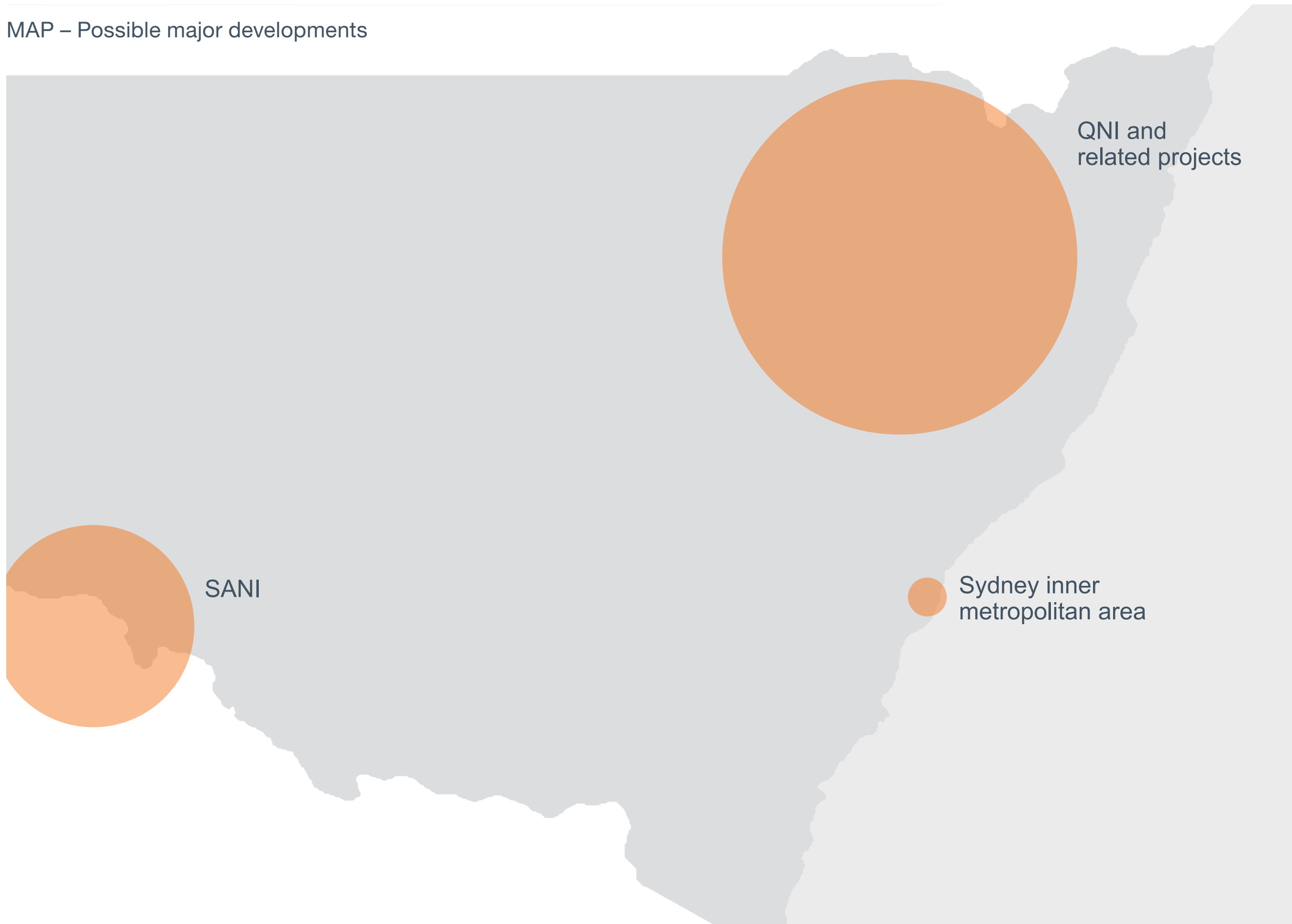
> Outlines potential constraints beyond the TAPR ten year planning horizon (Section 4.5) and

> Identifies those constraints expected to arise in one, three and five years in respect of which we intend to issue Requests for Proposals (RfPs) (Section 4.6).

At the time of publication of this TAPR, no RIT-T consultations were being undertaken.

4.1 Possible major developments

MAP – Possible major developments



4.1.1 Powering Sydney's Future and the condition of Cable 41

The Sydney inner metropolitan area, including the CBD, is supplied by an integrated network consisting of two 330 kV cables and a number of Ausgrid 132 kV cables. The network capacity in this area is impacted by:

> The retirement program for the Ausgrid 132 kV cables

> The recent and potential further de-rating of one of the 330 kV cables: cable 41, between Sydney South and Beaconsfield

Over the coming years, some of Ausgrid's 132 kV oil-filled cables will near the end of their serviceable lives and may need to be retired, because of increasing costs to maintain them in service as well as potentially increased cable failure rates and environmental impacts. In TAPR 2015, we reported this constraint as arising in the five to ten year horizon. However, recent joint planning has identified the potential need to retire some of Ausgrid's cables earlier.

At the same time, investigations into the condition of cable 41 have found that the cable backfill has degraded, reducing its ability to dissipate heat. In addition, field measurements have identified ground temperatures exceeding those assumed in the original cable design. This problem resulted in an interim de-rating of the cable's continuous cyclic capacity (its rating) from 663 MVA to 575 MVA. A further derating to 426 MVA may be required.

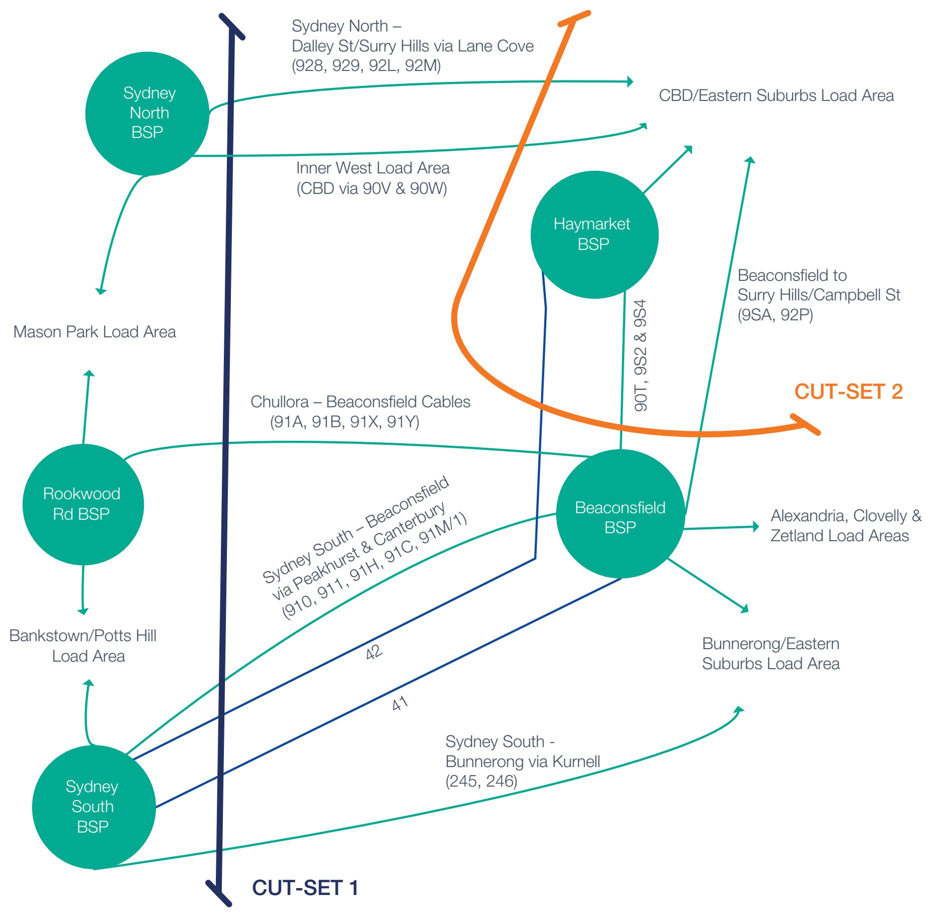
A detailed assessment of the cable installation is currently being conducted by testing soil samples at a large number of points along the entire cable route. A sample of the cable will also be removed for testing to determine the cable condition, which is expected to be completed by December 2016. These assessments will be used to determine what economic remedial solutions are available for cable 41 including the long-term economic life of the cable.

In last year's TAPR, we reported that the constraint on the Sydney inner metropolitan area network was expected to arise in the five to ten year timeframe due to moderating load growth. However, should Ausgrid's cables need to be retired earlier than planned or should cable 41 be further derated, the network constraint would arise within five years.

We are working with Ausgrid on a joint strategy to manage these issues. Our objective is to determine a strategy which best balances the costs and risks associated with keeping Ausgrid's cables in service against the costs and risks of other options, such as non-network options or installing new cables.

There are two critical parts of the network. The first, described as cut-set 1, relates to the ability to transmit power into the inner metropolitan area, from TransGrid's Sydney North, Sydney South and Rookwood Road substations. The second, described as cut-set 2, relates to the ability to transmit power within the inner metropolitan area, essentially to the CBD and eastern suburbs area. Those cut-sets are shown in Figure 4.1.

FIGURE 4.1 – Sydney inner metropolitan supply network constraint cut-sets 1 and 2



The following figures show the reduction in network capacity that occur with different cable retirement arrangements for each of the cut-sets, against the forecast load across those cut-sets. It is important to note that the studies on which these diagrams are based use the 'interim' 575 MVA rating for cable 41. Consequently the years in which capacity shortfalls would arise may not be correct, but the concept of large changes in capacity as cables are retired or derated makes the need for action within the next five years likely. This will be confirmed as Ausgrid's retirement strategy and TransGrid's cable 41 strategy are settled.

FIGURE 4.2 – Cut-set 1 network capacity and forecast load

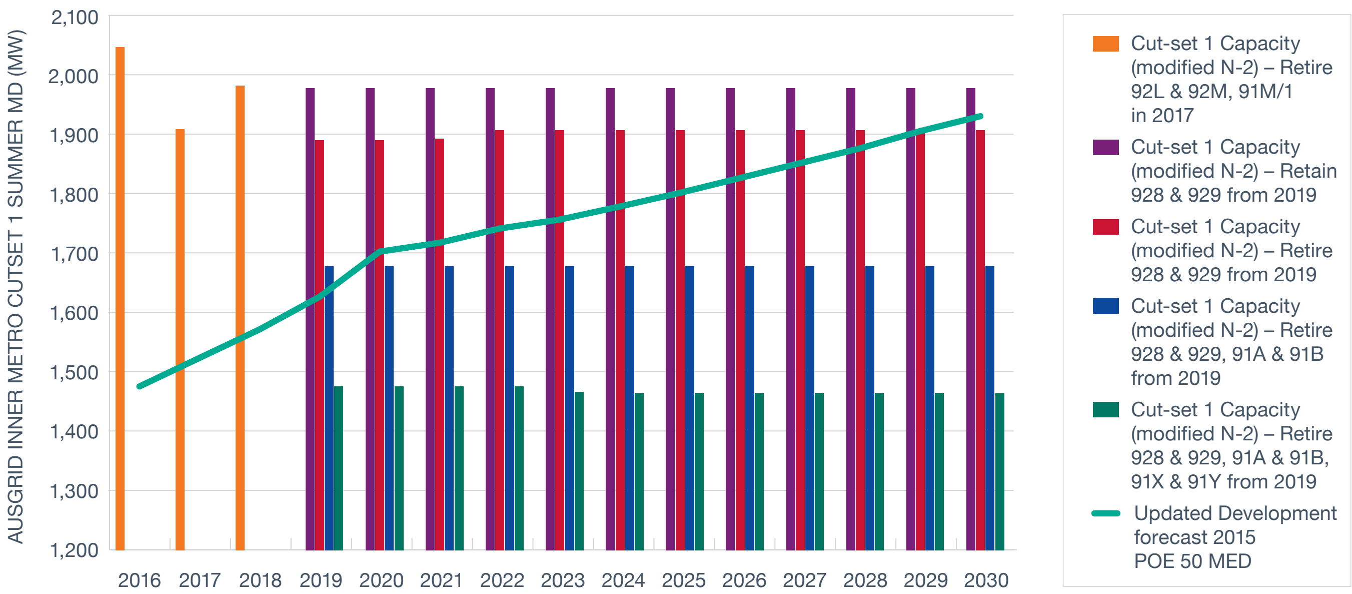
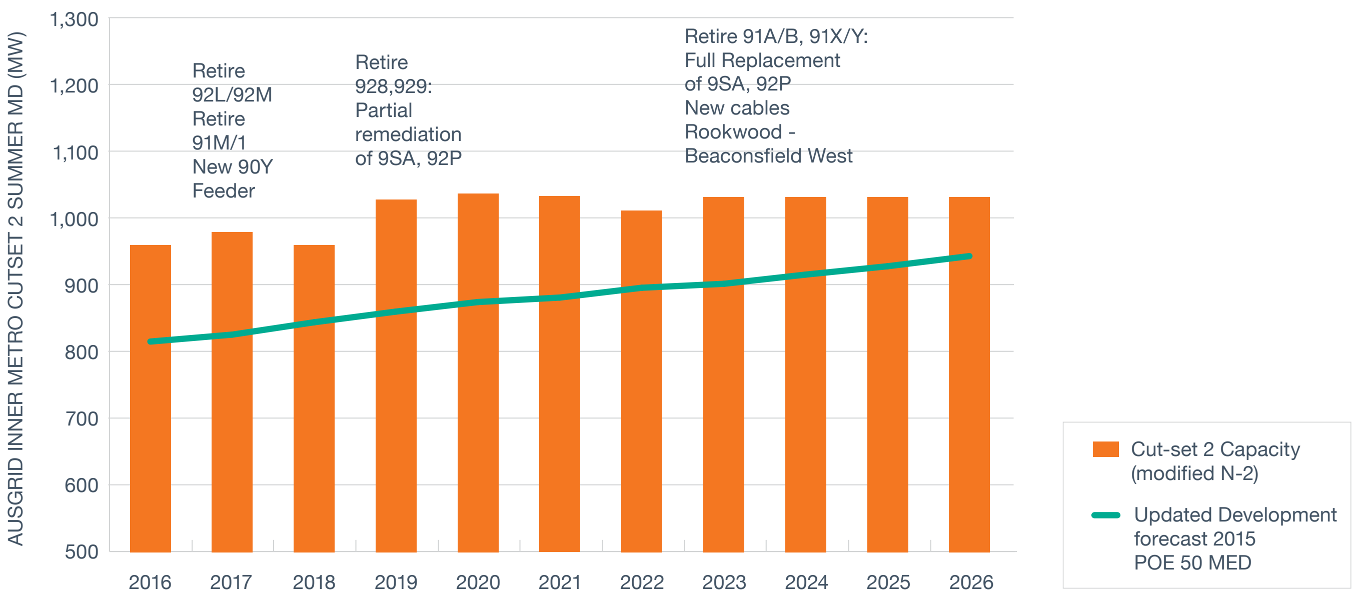


FIGURE 4.3 – Cut-set 2 network capacity and forecast load



The following options to address the constraint have been identified:

- Establishing two new 330 kV cables to be initially operated at 132 kV between Rookwood Road and Beaconsfield substations
- Establishing one new 330 kV cable between Rookwood Road and Beaconsfield, with provision for a second cable in the same route, and one new 330 kV cable between Beaconsfield and Haymarket. Part of the latter cable is presently in service at 132 kV. This would require the installation of additional 330 kV GIS switchbays at each of these substations
- Establishing two new 330 kV cables between Rookwood Road and Beaconsfield and one new 330 kV cable between Beaconsfield and Haymarket. Part of the latter cable is presently in service at 132 kV. This would require the installation of additional 330 kV GIS switchbays at each of these substations.
- Non-network options to defer or avoid network investment to address the need
- Combinations of network and non-network options.

In terms of non-network option requirements, until the joint strategy with Ausgrid is finalised, it is currently not possible to define exactly when a capacity shortfall may arise or the magnitude of that shortfall.

At this stage, and subject to completion of the joint strategy, our preferred option is to establish two new 330 kV cables between Rookwood Road and Beaconsfield initially operated at 132 kV. The exact timing of such a development would depend on the cost and availability of non-network options, such as demand management. If potential non-network options can be identified that are practical and cost effective, they would be used to defer or possibly avoid one or both of these cables.

4.1.2 Qld – NSW Interconnector (QNI) upgrade and related projects

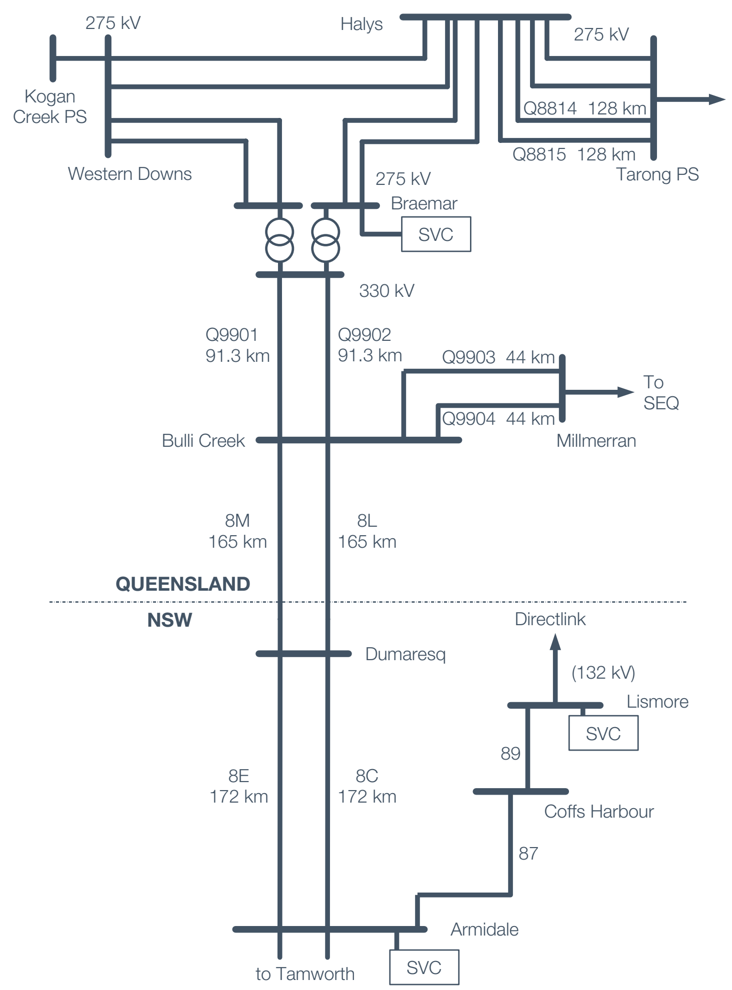
QNI upgrade

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

The transfer capacity of QNI is frequently fully utilised, leading to network constraints between NSW and Queensland. Currently, the transfer capability across QNI is limited by voltage control, transient stability, oscillatory stability and line thermal rating considerations. The capability of the network at any time is dependent on a number of power system conditions, including the loads and generation patterns.

Whilst the 330 kV interconnecting lines may have a relatively high thermal rating, the power transfer capability of QNI is governed by the capability of the supporting transmission systems in NSW and Queensland, as well as power system conditions across the whole interconnected NEM grid. These supporting systems, in particular the transmission lines from Liddell to Armidale, can, and do at times limit the capability for power transfer from NSW to Queensland.

FIGURE 4.4 – QNI system diagram



Since it was commissioned in 2001, a number of studies have been undertaken, jointly with Powerlink, to assess the technical and economic viability of increasing the power transfer capability in both directions.

Upgrading the power transfer capability across QNI has the potential to provide market benefits. The primary source of potential market benefits is related to reductions in the cost of supply from generators. Increasing QNI capability allows generating plant with a relatively high cost of fuel to be displaced with lower cost sources. Other sources of market benefits include reduction in forecast levels of unserved energy by facilitating increased sharing of generation reserves between regions, and competition benefits.

A study in 2008 found that, in the absence of any large changes in forecast load growth and generation developments, an augmentation to the interconnector capacity of up to nominally 300-400 MW would not have a positive net market benefit until around 2015/16, and therefore, the report concluded that it would be premature to recommend any augmentation option at that time.

The most recent of study was the RIT-T assessment, commenced in June 2012 and completed in late 2014, which was prompted by network, generation and load developments:

> Some generation and large load developments in NSW and Queensland, particularly renewable wind generation and Liquefied Natural Gas (LNG) and coal developments, as well as NEM-wide reductions in forecast load and energy consumption

> Routine revision of the limit equations defining the transfer capability across the Queensland to NSW interconnector.

The RIT-T assessment identified four important factors that influence the market benefit of credible options:

> Future gas prices in Queensland

> The possible retirement of Redbank Power Station

> The development of wind farms in Northern NSW

> Load growth.

We assessed the following credible options in the RIT-T:

> Uprating of the Northern NSW 330 kV transmission lines

> Series compensation of the interconnecting 330 kV lines between Armidale, Dumaresq and Bulli Creek, looking at various combinations of series compensation with and without SVC

> New SVCs at Armidale, Dumaresq and Tamworth, and switched shunt capacitors at Dumaresq, Armidale and Tamworth substations.

A number of other options were considered, including protection system upgrade, installation of a second HVAC interconnector at 330 kV and at 500 kV, and installation of a braking resistor, but these all had negative market benefits.

We also tested the robustness of the net market benefits and ranking of options against a number of other factors, including:

> The exclusion of competition benefits

> A reduction in QNI capacity provided by the option

> An increase and decrease in the cost of the credible options

> Differences in the discount rate used in the net present value (NPV) assessment.

Our analyses reveal 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, as such, rank below the 'do nothing' option. Therefore, with Powerlink, it is our view that there is too much uncertainty concerning these factors and that it is prudent to not recommend a preferred option. At this stage, any development is expected to be beyond five years. Instead, we will continue to monitor market developments regularly to determine if any material changes could warrant reassessment of an upgrade to QNI.

None of the submissions received during the RIT-T identified any potential non-network options. We will continue to investigate the feasibility of any non-network option otherwise identified. Any new information obtained on non-network options which may arise through early stakeholder engagement processes will be taken into account as part of any later RIT-T assessment undertaken for QNI.

While there is no current regulatory consultation process underway, we still encourage expressions of interest for potential non-network solutions which may be capable of increasing the transfer capability across the interconnector and hence deliver market benefits. This is part of a broader strategy we are implementing, based on enhanced collaboration with stakeholders, to further develop, expand and capture economically and technically feasible non-network solutions.

Further detail and discussion of these issues is in our RIT-T documents, available on our and Powerlink's websites[21].

Since the RIT-T was undertaken, Redbank Power Station has been retired. Since its retirement there has been an increase in thermal constraints on the Liddell – Muswellbrook – Tamworth section of the network. This is likely to reflect longer periods of high northward flows on QNI and retirement of Redbank.

If, in the future, an upgrade of QNI were to proceed, a number of other developments may need to be carried out on parts of the NSW transmission system that are part of the interconnection with Queensland or may be impacted by increased power flows to and from Queensland. These possible developments, which are described below, are:

> Upgrading the Tamworth and Armidale 330 kV switchyards, for managing higher power transfers between NSW and Queensland and accommodating possible new generation in the area

> Upgrading the capacity of the Hunter Valley – Tamworth – Armidale 330 kV system, to mitigate thermal constraints on several lines

> The management of voltage control in northern NSW, to maintain adequate voltage levels and transient stability constraints.

We expect to revisit the assessment of the market benefits of upgrading QNI within five to ten years, and at that time, we will review these contingent developments if necessary.

Tamworth and Armidale 330 kV switchyards

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. Instead of serving local loads, they became 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 possibly gas fired generation developments in the area, and higher power transfers between NSW and Queensland.

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

> Expanding only the Tamworth substation by installing an additional bus section circuit breaker on the existing single busbar

> Rebuilding both Armidale and Tamworth substations in a breaker-and-a-half configuration to improve reliability to the desired level

> Rebuilding both Armidale and Tamworth substations in a breaker-and-a-half configuration in the future, when the existing assets reach the end of their serviceable lives

> At both Armidale and Tamworth substations, undertaking the staged development of a second switchyard in a breaker-and-a-half configuration adjacent to the existing switchyard.

Should any development be warranted, the preferred option 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 reconstructing the switchyards within the existing site boundaries. We are also identifying potential sites for the new switchyards in the event that an in situ development is not feasible.

Hunter Valley – Tamworth – Armidale 330 kV system capacity

Capacity constraints may arise in the northern NSW supply system due to increased power flows to and from Queensland. The constraints may also arise due to increased generation developments from gas, solar and wind power in northern NSW. The de-rating of lines 83 and 84 has imposed further thermal constraints on the capability of NSW export to Queensland at times of high load in the northern NSW system.

The northern NSW supply system, shown in the following figure, comprises four 330 kV lines:

> Liddell – Tamworth line 84

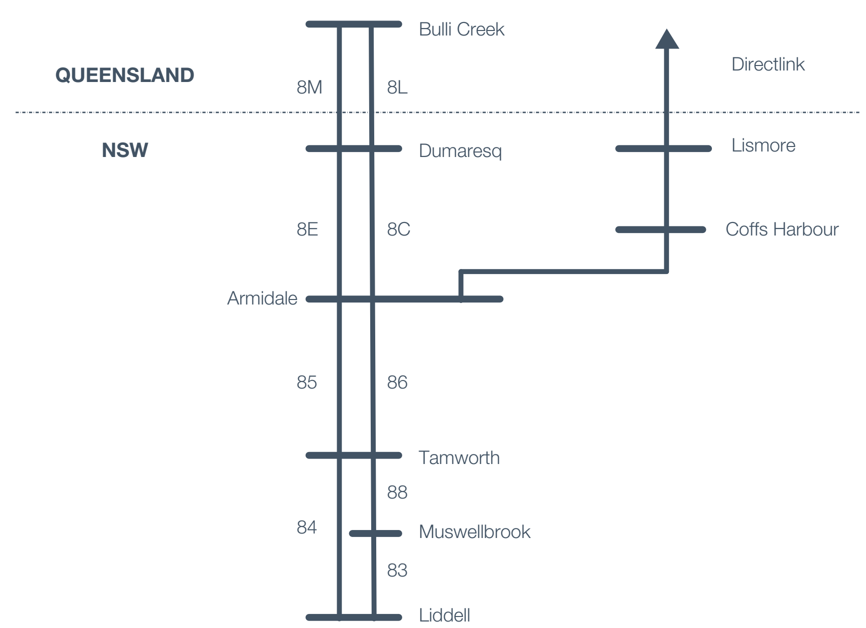
> Liddell – Tamworth via Muswellbrook lines 83 and 88

> Tamworth – Armidale line 85

> Tamworth – Armidale line 86.

The 330 kV system extends north from Liddell to Armidale via Muswellbrook and Tamworth. The 330 kV lines are conventional steel tower design, except for the Tamworth – Armidale line 86, which is a wooden pole line with relatively small conductors.

FIGURE 4.5 – Northern NSW system diagram



21 TransGrid and Powerlink websites for the QNI RIT-T documents

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

- > Uprating the lines 83, 84, 85 and 88 from an operating temperature of 85°C to 120°C
- > Installing a new single circuit 330 kV line from Liddell to Tamworth
- > Installing a new double circuit 330 kV line on a new route from Liddell to Tamworth.

Voltage control in northern NSW

The 330 kV system extends north beyond Armidale to Dumaresq and forms part of the interconnection with Queensland over QNI. The power transfer capability north from Liddell, to supply the northern NSW loads and to export power to Queensland, is partly governed by line thermal ratings, the ability to maintain adequate voltage levels and transient stability constraints.

The power transfer capability of the system is dependent on load levels and the dispatch of generators across the NEM.

The ability to maintain adequate voltage levels is currently the main constraint 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.

Subject to the amount of new generation in northern NSW and the magnitude of the increase in QNI capacity, the most cost effective way of managing the voltage stability constraints would be to install additional capacitors or an SVC in the area.

4.1.3 Interconnection between SA and NSW (SANI)

In South Australia, generation capacity reserves are reducing, with withdrawals of over 1000 MW announced to occur over the next ten years[22]. At the same time, AEMO reports there are 15 project proposals for wind generation in the state, and installation of rooftop PV continues.

Taking all these factors into account with forecasts for the state, AEMO's 2015 ESOO anticipates low reserve conditions, where the reserve generation margin does not meet the reliability standard, in South Australia from the end of this decade under the medium and high growth scenarios. Under the low growth scenario low reserve conditions are expected in the mid-2020s.

In addition AEMO's 2015 NTNDP uses South Australia as a case study of the consequences of high penetration of renewable generation, especially rooftop PV.Specifically the NTNDP considers:

- > Reductions in dispatchable generation associated with high levels of PV and battery storage
- > Frequency stability of low inertia systems and the importance of interconnection
- > Low fault level impacts on protection schemes and voltage stability during disturbances.

An option which could help to manage low reserve conditions as well as the difficulties associated with the high penetration of renewable generation is to improve system diversity by increasing the capacity of interconnections to an adjacent state such as NSW.

TransGrid and ElectraNet have recently commenced a joint investigation of options to increase the interconnection capacity between South Australia and NSW. At this stage the network options are expected to include:

- > Works to better utilise the capacity available in the existing NSW – Northern Victoria - South Australia network
- > Incremental upgrades of the existing NSW – Northern Victoria – South Australia network
- > Development of new transmission lines which may traverse solar and wind resource rich areas in NSW and South Australia.

As the investigations proceed, updates will be provided in future TAPRs and possibly also in regulatory consultation documents should net market benefits be likely.

22 AEMO 2015 Electricity Statement of Opportunities, Aug 2015

4.2 Strategic asset programs

The following strategic asset replacement and refurbishment programs are expected to be undertaken between 2016 and 2026.

4.2.1 Transmission lines

A refurbishedment program will be undertaken to address steel corrosion issues on coastal tower transmission lines in the Newcastle, Central Coast, Sydney and Illawarra regions. The program includes refurbishment of rusted steel towers and the replacement of conductor fittings, earth wires and insulators at risk of failure.

Asbestos impregnated paint has been identified on steel tower transmission lines in the greater Sydney and Illawarra regions. The paint has been assessed as currently presenting a low risk to health. However it is expected to deteriorate with time and will require removal.

In aggressive soil conditions the buried steelwork of grillage foundations are expect to degrade over time and require reinforcement. In non-aggressive soil conditions, installation or replacement of depleted cathodic protection systems is required to prevent any further steel loss.

4.2.2 Wood poles

A program will be undertaken to replace wood pole structures in poor condition on transmission lines that have exceeded their expected life. Defect rates from the past 5 years has been analysed to forecast the replacements required on the following lines:

- > 94X Wallerawang – Panorama 132 kV line
- > 948 Panorama – Orange 132 kV line
- > 966 Armidale – Koolkhan 132 kV line
- > 993 Gadara 132 kV – WAGGA 330 kV line
- > 995 Hume PS – Albury 132 kV line
- > 9U3 Gunnedah – Boggabri East 132 kV line
- > 976/2 Yass – Spring Flat 330 kV line
- > 97B Tamworth 330 kV – Tamworth 132 kV line
- > 97A Tamworth 330 kV – Tamworth 132 kV line
- > 99P Tumut – Gadara 132 kV line
- > 97L Guthega – Jindabyne pumps
- > 97G/3 Geehi – Guthega 132 kV line
- > 96L Tenterfield 132 kV – Lismore 330 kV line

4.2.3 Substation plant and steelwork

TransGrid continuously monitors the condition of its substation plant to ensure its safe and reliable operation. Replacement is planned when those obligations are not able to be met or where doing so is otherwise economically justified. Programs have been established to cover the replacement of circuit breakers, instrument transformers and disconnectors where doing so is more efficient than including them in a larger site based project.

TransGrid has a number of sites that have been in service for longer than the design life of the steelwork. Some sites built in the 1960s and in a coastal environment are the worst affected. To prevent major deterioration, a program to replace the steelwork is planned.

4.2.4 Secondary systems

Secondary systems

TransGrid is proposing to perform Secondary Systems Replacements (SSRs) across a number of sites as a means of establishing a single generation of technology at those sites. The program comprises projects to replace the protection, control and metering devices at each site. The program targets locations that have a high concentration of assets identified for replacement and provides a holistic approach to updating the sites to modern automation standards that couldn't be achieved via piecemeal replacements.

SSRs also provide the opportunity to remediate 415V distribution systems in poor condition and in specific cases replace cabling and control buildings that are no longer fit for purpose.

SSRs are being proposed for Wagga 330, Murrumburrah, Deniliquin, Lower Tumut, Broken Hill, Tenterfield, Coleambally, Tamworth 330, Wallerawang 330, Panorama, Muswellbrook, Darlington Point, Ingleburn, Regentville, Tuggerah, Marulan and Molong substations.

415V distribution

In recent years, TransGrid has experienced an increase in the number of safety incidents related to the 415V distribution systems at substation sites. The poor condition of these assets was identified as a major contributor to the increase in incidents. A number of sites have systems approaching 40 to 50 years of age and, while corrective maintenance is being undertaken to address high priority defects, better safety outcomes can be achieved by bringing these systems up to current standards.

The sites with the largest number of defects on the 415V systems have been targeted for replacement. This includes Newcastle, Armidale, Sydney East, Vineyard, Liverpool, Lismore, Kempsey and Koolkhan substations.

SVC control system

TransGrid has recently completed projects to update the control and protection systems associated with the Static Var Compensators (SVCs) at Broken Hill and Armidale Substations. This involved replacing obsolete, bespoke systems that could not be maintained with a modern system fully supported by the manufacturer and in the case of Armidale, providing greater functionality and potential market benefits.

The control and protections systems at TransGrid's two more recently constructed SVCs at Lismore and Sydney West are approaching their end of life and will require addressing within the planning horizon. The works for the Lismore SVC will be more extensive as replacement of the thyristor valves and cooling plant as well as the control system will be required.

Operational technology systems

Two key systems TransGrid utilises to monitor and operate the transmission network will require replacement within the ten year planning horizon. These are the SCADA Energy Management System (EMS) and the SDH telecommunications network.

The SCADA EMS is used by network operators to monitor and operate TransGrid's network from a centralised control centre. The SDH telecommunications network provides the communications links from the substations to the control centre. Both systems feature hardware that is no longer supported by their manufacturer and, due to the high interdependency of these systems, will require a co-ordinated approach to replacing them in parallel.

Protection assets

Protection asset replacement programs are targeted at assets that present substantial risk to the network, either due to high failure rates or inability to be effectively maintained. TransGrid has been systematically replacing obsolete protection assets based on electromechanical and discrete component technology. Their completion will allow the start of replacement programs for early microprocessor based assets. Microprocessor assets provide greater functionality and security but have a significantly shorter economic life.

Batteries and chargers

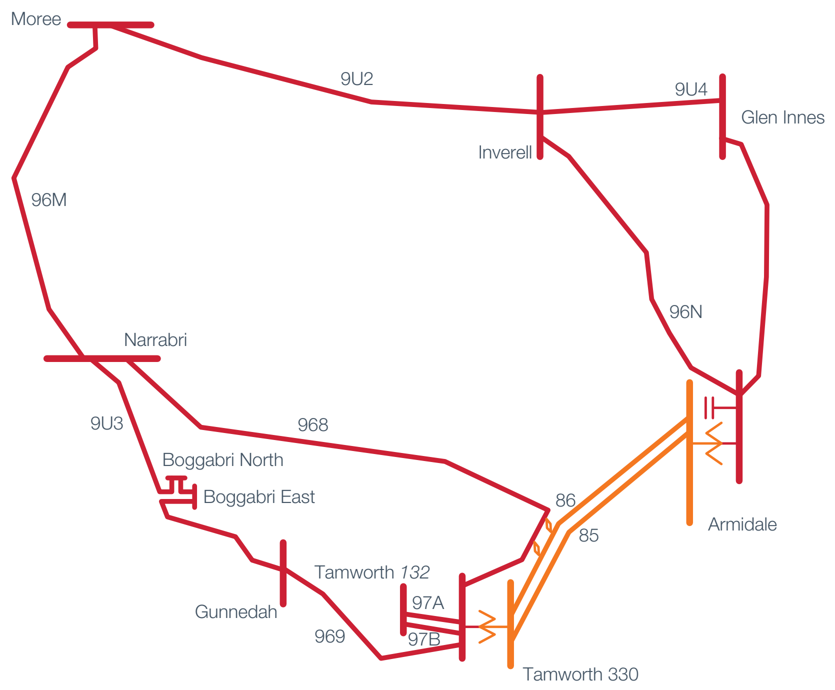
Batteries and chargers are installed at remote substation sites so that they can be operated safely for a time upon loss of auxiliary power. TransGrid undertakes the regular replacement of its Nickel Cadmium station batteries, associated chargers and Rack Power Supply units to ensure the integrity of these systems. These replacements are predicated on age, condition, testing performance, obsolescence and manufacturer support. TransGrid is proposing to replace over 200 battery, charger and rack power systems over the ten year planning horizon.

4.3 Other possible network developments within five years

MAP – Other possible network developments within five years

4.3.1 Supply to the Gunnedah/Narrabri area

Background	The transmission system supplying the Gunnedah, Narrabri and Moree areas, shown in the figure below, is about 300 km long. An outage in the 968 Tamworth – Narrabri 132 kV line, at times of high summer load, will cause the 969 Tamworth – Gunnedah 132 kV line to reach its thermal capacity. The power flows on QNI and Directlink also influence the thermal constraint. A northerly flow would exacerbate the constraint while a southerly flow would relieve the constraint. The thermal constraint is present and being managed by load shedding schemes at two mines in the area. There is potential for the existing mines to be expanded, which would further exacerbate the thermal limitation and, depending on their magnitude, introduce a second limitation. That second limitation is unacceptably low voltages at Gunnedah should the 969 Tamworth – Gunnedah 132 kV line be out of service at times of high summer load.



Transmission system supplying Gunnedah and Narrabri.

Nature of the constraint	A thermal constraint on line 969 in the event of an outage on line 968
Expected date	2019
Possible network options	Options available to address the thermal constraint include: > Constructing a 132 kV line from Tamworth to Gunnedah, possibly on the route of the recently dismantled 875 Tamworth – Gunnedah 66 kV line ($34 to $42m in 2014) > Installing a phase shifting transformer in line 969 ($15m) > Relocating the phase shifting transformer which is presently connected to 965 line at Armidale ($5.8m) (not favoured as it serves a useful purpose at Armidale) > Reconductoring line 969 and the 9U3 lines with higher capacity conductors ($15m) > Reconductoring line 969 with higher capacity conductors ($7.5m).
Load reduction to delay constraint and non-network option requirements	**Feasibility:** We continue to work closely with our customers to plan, develop and manage the network to ensure it meets their service expectations now and into the future. In September 2014, we wrote to two major electricity consumers in the constrained area to gauge their interest in providing a non-network solution, and discussed the requirements for a non-network solution in person in February 2014. A non-network solution will not be progressed further until we have consulted publicly on the need via the RIT-T consultation process. **N–1:** 968 **Shortfall:** Approximately 8 MW summer and 2 MW winter **Location:** Gunnedah, Narrabri and Boggabri area **Deferral value:** $7.5m **Speed:** Any demand management would need to be dispatched within 5 – 10 minutes. This includes the notification process following the contingency.
Preferred network option	At this stage the preferred network option is the reconductoring line 969 with higher capacity conductors. As mentioned in section 2.5, TransGrid's reliability obligations are presently being reviewed. Should these obligations be relaxed, it is possible that no network or non-network development will be required.

4.3.2 Line switchbays for distributor requirements within five years

The following table summarises possible projects occurring within five years to provide line switchbays to meet NSW distributors' requirements.

TABLE 4.1 – Possible line switchbays for distributor requirements within five years

Location	Installation	Indicative date	Distributor
Williamsdale 330/132 kV substation	One 132 kV switchbay	2018	Essential Energy
Macarthur 330/132 kV substation	Two 66 kV switchbays	2018 – 2020	Endeavour Energy

4.3.3 Other possible network asset replacements within five years

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

TABLE 4.2 – Other possible network asset replacements within five years

Project	Location	Scope of works	Possible commissioning date	Indicative cost
Low spans northern tower lines	Central Coast, Hunter Valley, Northern NSW	Remediation of high priority low spans	2018	$2m
Low spans central pole lines	Central West NSW	Remediation of high priority low spans	2019	$3m
Low spans southern tower lines	Southern NSW	Remediation of high priority low spans	2019	$0.5m
Low spans southern pole lines	Southern NSW	Remediation of high priority low spans	2019	$1m
Sydney East 330/132 kV substation	Sydney	No.1 transformer replacement	2020	$16m
Condition of 944 Wallerawang – Orange North 132 kV transmission line	Central west NSW	The program of work has been rescoped. Based on their condition, a small number of poles have been identified for replacement.	2019 – 2026	$0.5m

4.4 Other possible network developments within five to ten years

This section describes possible network developments within a five to ten year timeframe. The possible constraints arising in this timeframe include the capacity of the Snowy to Sydney network (Section 4.4.1) and supply adequacy to the Macarthur area (Section 4.4.2)

MAP – Other possible network developments within five to ten years

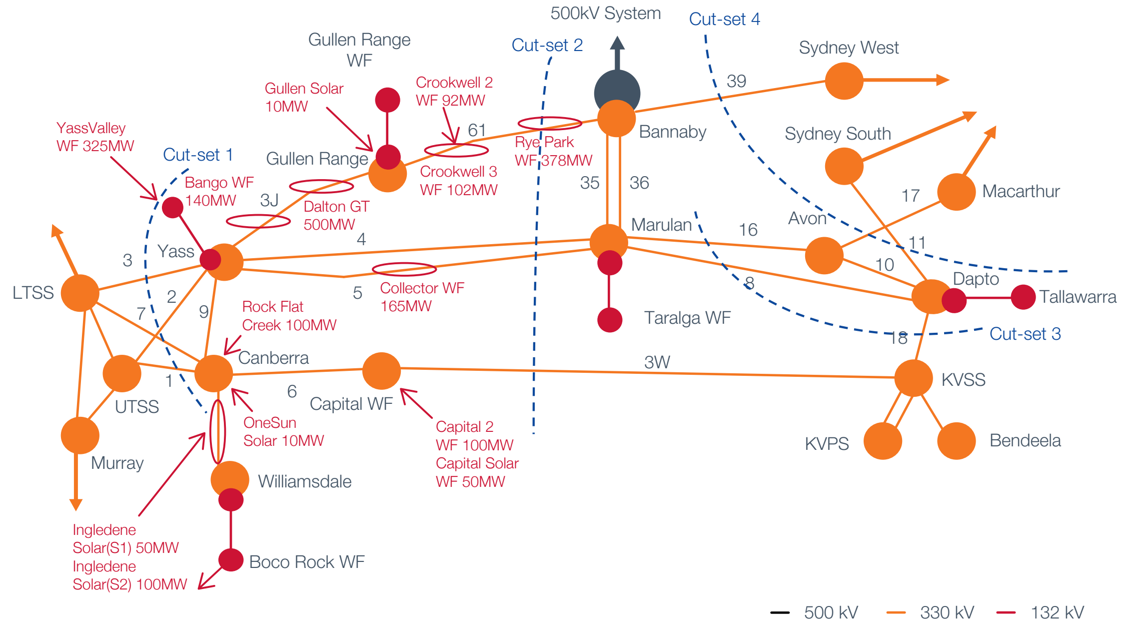
4.4.1 Capacity of the Snowy to Sydney network

Background

The loading of the Snowy to Sydney network depends on the distribution of load and generation within the NSW region. Preliminary market modelling of scenarios involving retirement of some of the existing coal fired generating units, indicates there may be net market benefits if parts of the network between Snowy to Sydney were to be up-rated if additional generation is established in the southern NSW area..

The balance of this item considers four parts of the network between Snowy and Sydney, namely cut-sets 1, 2, 3 and 4 in the figure below.

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



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

The 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 this temperature.

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

> Increased Snowy generation

> Increased import from SA and Vic at times of high NSW and Qld load

> Load growth in Qld and NSW

> Decommissioning or reduction of coal fired generation in NSW.

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

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 Vic and Snowy is transferred to NSW to the maximum capacity allowed by those works

> The present and future wind farms connected to the southern network generate power at, or near, their rated capacities.

	3. Capacity of Bannaby/Avon/Dapto – Sydney (cut-set 4) The Bannaby – Sydney West line 39 capacity could be exceeded if Gullen Range, Boco Rock and Taralga wind farms operate at their maximum capacity, even without any increase in the Snowy to Yass/Canberra capacity. Constraints in this part of the network would increase if other proposed generation comes to fruition.
Nature of the constraint	Any network development would be driven by net benefits to the market. It is expected to be contingent on new generation development in southern NSW. Given the uncertainties surrounding generation developments, decommissioning, mothballing and re-powering, the time at which there may be net market benefits from any option is difficult to predict.
Target date	The target date 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.
Load reduction to delay constraint and non-network option requirements	**Feasibility:** Non-network options are considered alongside network options where feasible and cost-effective to do so. 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): > Implementing a system protection scheme and procuring a network support contract with a suitable load and generator > Upgrading the Upper Tumut – Yass and Upper Tumut – Canberra 330 kV lines. This requires work in the sensitive national park areas of the Snowy > Installing a power flow control plant, such as series capacitors or phase-shifting transformers (PSTs) 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): > Implementing a system protection scheme and procuring a network support contract with a suitable load and generator > Upgrading lines 4 and 5 to an operating temperature of 100°C > New 330 kV line development from Yass to Bannaby > New 330 kV line development from Yass to Marulan > Long term development of 500 kV link from Bannaby area to Yass 3. Capacity of Marulan/Kangaroo Valley – Dapto/Avon (cut-set 3): > Implementing a system protection scheme and procuring a network support contract with a suitable load and generator > Install a PST on line 18 at Dapto > Upgrading of line 18 to an operating temperature of 100°C > New 330 kV line development from Kangaroo Valley to Dapto > Rebuilding existing line 18 to a double circuit line 4. Capacity of Bannaby/Avon/Dapto – Sydney (cut-set 4): > Implementing a system protection scheme and procuring a network support contract with a suitable load and generator > Upgrading line 39 to an operating temperature of 100°C > Installing a PST on line 39 at Bannaby > Upgrading line 39 to an operating temperature of 100°C and installing a PST on line 39 at Bannaby > Replacing terminal equipment on line 11 at Dapto and Sydney South > Replacing terminal equipment on line 17 at Avon and Macarthur > Long term development of 500 kV transmission line from Bannaby to Sydney area
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 present, there is no preferred network option. However, should any network upgrading be appropriate, it is expected that it could entail one or more of the following: > Uprating line 01 to an operating temperature of 100°C > Uprating line 39 to an operating temperature of 100°C > Uprating lines 4 and 5 to an operating temperature of 100°C > Replacing terminal equipment on line 11 at Dapto and Sydney South > Replacing terminal equipment on line 17 at Avon and Macarthur > Uprating line 18 to an operating temperature of 100°C.

4.4.2 Supply adequacy to Macarthur area

Background	The Endeavour Energy 66 kV network in the Macarthur area is supplied from TransGrid's Ingleburn and Macarthur substations and Endeavour Energy's Nepean substation.
Nature of the constraint	An outage of the Macarthur 330/66 kV transformer may result in an overload of the Nepean 132/66 kV transformers. An outage of the Macarthur 330/132 kV transformer or 85L Macarthur – Nepean 66 kV line may result in an overload of the Macarthur 330/66 kV transformer.
Possible network options	Options available to address the constraints are currently being investigated via the joint planning process and include: > Installation of a second 330/66 kV transformer at Macarthur substation > Installation of an additional 132/66 kV transformer at Nepean substation. However, this may still result in an overload of the 66 kV network between Nepean and Macarthur > Implement a transfer/tripping scheme to a portion of 66 kV load to be supplied from Ingleburn > Implement a transfer/tripping scheme to supply the Nepean 132 kV bus from Liverpool by closing the 9L5 Denham Court – Nepean 132 kV line.
Load reduction to delay constraint and non-network option requirements	**Feasibility:** There are a number of gas fired generators embedded within the 66 kV network available at a number of different collieries. It may be possible to defer the need for a network development through network support arrangements with those generators. At this stage, the timing of any major work is not clear. Consequently, the performance required of non-network options cannot be defined.
Preferred network option	The preferred network and non-network options are currently being assessed.

4.4.3 Line switchbays for distributor requirements within five to ten years

The following table summarises possible projects occurring within five to ten years to provide line switchbays to meet NSW distributors' requirements.

TABLE 4.3 – Possible line switchbays for distributor requirements within five to ten years

Location	Installation	Indicative date	Distributor
Vineyard 330/132 kV substation	One 132 kV switchbay	2021 to 2026	Endeavour Energy
Haymarket 330/132 kV substation	Connection of replacement AusGrid cables	2021 to 2026	AusGrid
Beaconsfield West 330/132 kV	Connection of replacement AusGrid cables	2021 to 2026	AusGrid
Macarthur 330/66 kV substation	One 66 kV switchbay	2021 to 2026	Endeavour Energy
Canberra 330/132 kV substation	One 132 kV switchbay	2022	ActewAGL

4.4.4 Other possible network asset replacements within five to ten years

The following table summarises other possible network asset replacement projects within five to ten years

TABLE 4.4 – Other possible network asset replacements within five to ten years

Project	Location	Scope of works	Possible commissioning date	Indicative cost
Forbes No 1 and No 2 132/66 kV transformer replacement	Central Western NSW	Replacement of the existing 60 MVA transformers	2021	$8m
21 Sydney North – Tuggerah 330 kV transmission line: 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 from Sydney North to Sterland	2021	$1.5m
Murrumburrah 132 kV substation secondary systems replacement	Murrumburrah substation Southern NSW	Replacement of the secondary systems	2022	$7m
Wellington No.1 reactor	Wellington	Reactor replacement	2022	$4.5m
Deniliquin 132/66 kV substation: secondary systems replacement	Deniliquin substation, Southern NSW	Replacement of secondary systems	2023	$2m
22 Sydney North – Vales Point 330 kV transmission line and tower life extension	Central Coast NSW	Painting of all tension towers	2023	$6m
Marulan No.4 transformer	Marulan	Transformer renewal	2023	$2m

4.5 Developments beyond ten years

The following table summarises possible projects that have been reassessed since the publication of TAPR 2015 and are now expected to arise further into the future.

TABLE 4.5 – Projects deferred since publication of TAPR 2015

Project	Location	TAPR 2015 Section	Comments
Condition of Munmorah 330/132 kV substation	Munmorah 330/132 kV substation	6.2.5	Some essential items have been replaced at Munmorah. Equipment will continue to be monitored for replacement as required.
Condition of Burrinjuck substation	Burrinjuck 132 kV substation	6.2.7	The project is currently under review.
Murraylink runback control scheme	Murraylink	6.2.8	TransGrid's portion of the work is completed. This project will not be reported in future.
Multiple contingency protection scheme	Various transmission lines	6.2.9	This program is to be delivered in a piecemeal fashion focusing on the highest priority parts of the network.
ANM 132 kV substation: secondary systems replacement	Southern NSW	6.2.11	This project is not proceeding at this stage.
1 and 2 Snowy – Yass/Canberra 330 kV transmission lines remediation	Southern NSW	6.2.11	This project is not proceeding at this stage.
Hume 132 kV substation secondary systems replacement	Southern NSW	6.2.11	This project is not proceeding at this stage.
Condition of Newcastle substation	Newcastle 330 kV substation	6.3.6	The transformers at Newcastle were replaced in 2014. Replacement of other equipment at Newcastle substation has been deferred due to reduced risk. Equipment will continue to be monitored for replacement as appropriate.
99J Yanco – Griffith 132 kV transmission line rebuild	Southern NSW	6.3.10	This project is not proceeding at this stage.

4.6 Reporting under NER Clause 5.12.2(c)

NER Clause 5.12.2(c)(4) concerns constraints expected to arise in one, three and five years and requires that we indicate our intent to issue a Request for Proposal (RfP) with respect to those constraints. The following two sections describe constraints that are expected to arise in one, three and five years, and include constraints that are expected to emerge in two and four years as well.

4.6.1 Forecast constraint information

The required forecast constraint information is provided in Table 4.6. The season in which the constraint is expected to arise is given, rather than the month and year.

TABLE 4.6 – Forecast constraint information

Anticipated constraint or constraint	Reason for constraint	Bulk supply point(s) at which MW reduction would apply	MW at time that constraint is reached
Supply to the Gunnedah/ Narrabri area	Thermal overload	Gunnedah and/or Narrabri	Refer to Section 4.2.1
Capacity of cable 41, Sydney South – Beaconsfield	Thermal overload	Primarily Beaconsfield and Haymarket	Refer to Section 4.2.3

4.6.2 Intent to issue Request for Proposals

Table 4.7 indicates our intent to issue an RfP for non-network services

TABLE 4.7 – Anticipated Issue of an RfP for non-network services

Anticipated constraint	Intend to Issue RfP	Date
Supply to the Gunnedah/Narrabri area	To be assessed	
Capacity of cable 41, Sydney South – Beaconsfield	To be assessed	

Appendix 1

Individual bulk supply point projections

This appendix provides the maximum demand projections supplied by our customers for individual bulk supply points, based on local knowledge and the availability of historical data.

A1 Individual bulk supply point projections

Our customers have provided maximum demand projections, in terms of both megawatts (MW) and megavolt ampere reactive (MVAr), for individual bulk supply points between the NSW transmission network and the relevant customer's network. These projections are produced using methodologies that are likely to have been tailored to the circumstances relating to the load(s) at particular bulk supply point(s) such as the degree of local knowledge and the availability of historical data. The projections are given in the tables below.

Some large and relatively stable industrial loads that we isolate for modelling purposes have been removed from the bulk supply point projections and aggregated. The removal of this data affects the projections shown for Broken Hill. Other industrial loads are included in 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) at the time of maximum NSW Region demand are given in Tables A1.11 and A1.12.

Tables A1.1 to A1.12 represent projections of maximum demand occurring during a particular season at a particular bulk supply point (or group of bulk supply points) on the NSW transmission network. They do not represent projections of demand contributions at these bulk supply points to the overall NSW region maximum demand.

Load profile information for critical bulk supply points is provided in Appendix 2.

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 or loads are to be assumed when calculating the diversities. 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

> 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 national electricity market. Consequently, there can be considerable variation in diversity factors at a particular location from year to year[2].

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

> 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 the AEMO NSW region forecasts and the aggregated distribution network service provider forecasts, TransGrid uses diversity factors of 4% in both summer and winter[4].

Information on particular diversity factors is available from TransGrid, notwithstanding the above difficulties. Contact details are provided on the inside of the back 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 the TransGrid network, 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 the TransGrid 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 the TransGrid 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 that 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 very 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 very 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 A1.1 – Ausgrid bulk supply point summer maximum demand[5]

	2016/17		2017/18		2018/19		2019/20		2020/21		2021/22		2022/23		2023/24		2024/25		2025/26	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Beaconsfield West 132 kV	352	-118	365	-97	362	-83	371	-76	376	-81	384	-51	516	39	523	53	533	74	537	72
Rookwood Rd 132 kV	275	-21	287	-1	280	-6	291	2	293	0	294	-10	206	13	210	10	214	12	220	28
Haymarket 132 kV	431	-111	449	-71	446	-54	458	-61	465	-52	475	-30	533	70	536	58	546	78	551	77
Liddell 33 kV	25	12	25	12	25	12	25	12	25	12	25	12	25	12	25	12	25	12	25	12
Munmorah 132 kV & 33 kV	119	25	112	27	113	24	120	28	127	30	132	35	139	43	141	44	141	44	143	42
Muswellbrook 132 kV	214	127	228	136	227	136	228	137	229	138	230	139	231	139	232	140	232	140	233	141
Newcastle 132 kV	426	125	424	113	425	114	429	101	433	104	440	124	442	112	445	114	446	112	449	114
Sydney East 132 kV	499	-30	491	-34	533	-15	543	-10	553	-6	563	-1	571	4	580	8	586	12	596	16
Sydney North 132 kV	772	155	781	165	803	161	800	184	813	211	836	236	710	261	724	280	734	289	745	307
Sydney South 132 kV	1048	195	1042	205	1033	224	1068	249	1078	245	1093	266	1157	264	1174	281	1182	278	1204	304
Tomago 132 kV	206	26	209	44	210	44	211	40	214	41	217	47	218	44	220	45	221	45	223	46
Tuggerah 132 kV	177	69	180	67	182	70	187	72	192	75	196	74	202	83	204	86	205	83	208	88
Vales Point 132 kV	98	18	98	19	99	17	101	18	102	18	102	19	103	15	103	13	104	17	105	15
Waratah West 132 kV	198	60	202	61	204	62	213	83	216	85	220	72	224	91	227	93	228	93	229	94

TABLE A1.2 – Ausgrid bulk supply point winter maximum demand[5]

	2016		2017		2018		2019		2020		2021		2022		2023		2024		2025	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Beaconsfield West 132 kV	291	-120	335	-119	339	-120	341	-118	346	-127	351	-135	358	-107	480	-2	486	1	493	7
Rookwood Rd 132 kV	216	-61	255	-54	258	-44	260	-21	267	-8	270	-3	269	-14	191	-7	197	-4	201	-2
Haymarket 132 kV	353	-111	409	-111	414	-113	416	-110	422	-121	428	-116	436	-97	485	4	491	7	498	14
Liddell 33 kV	33	16	33	16	33	16	33	16	33	16	33	16	33	16	33	16	33	16	33	16
Munmorah 132 kV & 33 kV	120	24	112	26	113	26	116	28	123	30	131	35	136	41	143	46	146	51	147	49
Muswellbrook 132 kV	180	111	204	129	218	139	219	139	219	140	220	142	222	143	223	144	224	144	224	145
Newcastle 132 kV	353	71	353	72	358	75	362	62	368	67	377	96	380	77	388	106	393	108	396	110
Sydney East 132 kV	569	-30	575	-30	581	-26	633	-7	642	-3	652	1	665	-10	675	14	687	24	695	28
Sydney North 132 kV	782	-48	662	-15	680	5	692	-2	708	48	722	62	745	83	636	126	649	136	659	144
Sydney South 132 kV	871	13	988	149	1023	159	1042	204	1064	241	1080	254	1091	267	1153	271	1172	282	1187	305
Tomago 132 kV	160	21	160	21	162	21	164	18	167	19	168	8	173	23	174	11	177	13	179	14
Tuggerah 132 kV	186	65	194	63	194	60	200	61	206	73	212	78	216	69	224	84	226	80	229	86
Vales Point 132 kV	101	19	102	20	102	20	104	18	105	15	106	13	108	21	108	16	109	16	110	14
Waratah West 132 kV	175	43	176	43	183	49	190	69	197	74	199	63	207	81	208	69	212	71	213	72

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

TABLE A1.3 – Endeavour Energy bulk supply point summer maximum demand[6]

	2016/17		2017/18		2018/19		2019/20		2020/21		2021/22		2022/23		2023/24		2024/25		2025/26	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Dapto 132 kV	567	45	568	45	571	45	570	45	569	45	568	45	568	45	569	45	569	45	569	45
Holroyd 132 kV	312	90	314	90	313	90	314	90	315	91	317	91	320	92	323	93	325	94	328	94
Ingleburn 66 kV	139	31	142	31	142	31	142	31	143	31	143	31	144	32	144	32	145	32	145	32
Liverpool 132 kV	361	69	367	70	373	71	379	72	384	73	389	74	393	75	396	75	399	76	402	76
Macarthur 132 kV & 66 kV	304	70	315	72	324	75	335	77	348	80	364	84	381	88	398	92	413	95	428	99
Marulan 132 kV	68	27	68	27	68	27	68	27	68	27	68	27	68	27	67	27	67	27	67	27
Mount Piper 66 kV & Ilford 132 kV	30	14	41	20	41	20	41	20	41	20	45	21	44	21	44	21	44	21	44	21
Regentville 132 kV	261	69	264	70	264	70	263	69	262	69	261	69	260	68	259	68	258	68	257	68
Sydney North 132 kV	32	3	32	3	31	3	31	3	31	3	31	3	31	3	31	3	30	3	30	3
Sydney West 132 kV	1105	149	1107	149	1107	149	1106	149	1109	150	1112	150	1113	150	1114	150	1114	150	1114	150
Vineyard 132 kV	419	107	440	112	474	121	480	123	497	127	516	132	535	137	555	142	571	146	588	150
Wallerawang 132 kV & 66 kV	59	18	59	18	59	18	59	18	58	18	58	18	58	18	58	18	58	17	57	17

TABLE A1.4 – Endeavour Energy bulk supply point winter maximum demand[7]

	2016		2017		2018		2019		2020		2021		2022		2023		2024		2025	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Dapto 132 kV	641	44	650	45	650	45	653	45	653	45	653	45	654	45	654	45	657	45	659	45
Holroyd 132 kV	282	130	286	132	286	132	286	132	286	132	286	132	287	132	287	132	287	132	287	133
Ingleburn 66 kV	115	15	116	15	116	15	117	15	118	15	118	15	119	15	119	15	119	15	120	15
Liverpool 132 kV	265	31	272	31	278	32	284	33	288	33	293	34	297	34	301	35	305	35	308	36
Macarthur 132 kV & 66 kV	257	42	270	44	276	45	283	46	291	47	301	49	313	51	324	53	335	54	347	56
Marulan 132 kV	88	28	89	29	89	29	90	29	90	29	90	29	90	29	90	29	90	29	90	29
Mount Piper 66 kV & Ilford 132 kV	30	12	42	17	42	17	42	17	42	17	44	18	44	18	44	18	44	18	44	18
Regentville 132 kV	208	55	211	56	212	56	214	56	214	56	214	56	214	56	214	56	214	56	214	56
Sydney North 132 kV	30	3	30	3	30	3	30	3	30	3	30	3	30	3	30	3	30	3	30	3
Sydney West 132 kV	878	36	865	36	889	37	891	37	890	37	892	37	894	37	896	37	897	37	899	37
Vineyard 132 kV	277	60	285	62	318	69	329	71	332	72	346	75	360	78	374	81	386	83	397	86
Wallerawang 132 kV & 66 kV	72	24	72	24	72	24	72	24	72	24	72	24	72	24	72	24	72	24	72	24

6 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.

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 2% in winter should be applied to obtain the forecast total winter load at Marulan.

TABLE A1.5 – Essential Energy (North) bulk supply point summer maximum demand

	2016/17		2017/18		2018/19		2019/20		2020/21		2021/22		2022/23		2023/24		2024/25		2025/26	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Armidale 66 kV	25	7	26	7	26	7	26	7	26	7	26	7	26	7	26	7	26	7	26	7
Boambee South 132 kV	21	4	22	4	22	4	23	4	23	4	23	4	23	4	24	4	24	4	24	4
Casino 132 kV	27	5	27	5	27	5	27	5	27	5	27	5	27	5	27	5	27	5	27	5
Coffs Harbour 66 kV	49	9	48	9	48	9	47	10	47	10	46	10	46	10	46	10	46	10	46	10
Dorrigo 132 kV	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1
Dunoon 132 kV	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1
Glen Innes 66 kV	8	-2	8	-2	8	-2	8	-2	8	-2	8	-2	8	-2	8	-2	8	-2	8	-2
Gunnedah 66 kV	25	2	25	2	25	2	25	2	25	2	25	2	25	2	25	2	25	2	25	2
Hawks Nest 132 kV	8	1	8	1	8	1	9	1	9	1	9	1	9	1	9	1	9	1	9	1
Herons Creek 132 kV	8	3	8	3	8	3	8	3	8	3	8	3	8	3	8	3	8	3	8	3
Inverell 66 kV	31	3	31	3	35	3	35	3	37	3	37	3	37	3	36	3	36	3	36	3
Kempsey 33 kV	24	5	24	5	24	5	24	5	23	5	23	5	23	5	23	5	23	5	23	5
Koolkhan 66 kV	48	4	48	4	48	4	47	4	47	4	47	4	47	4	47	4	47	4	47	4
Lismore 132 kV	79	-10	78	-11	77	-11	76	-11	75	-11	75	-11	74	-11	74	-11	74	-11	74	-11
Macksville 132 kV	8	2	8	2	8	2	8	2	8	2	8	2	8	2	8	2	8	2	8	2
Moree 66 kV	26	2	26	2	26	2	27	2	27	2	27	2	27	2	27	2	27	2	27	2
Mullumbimby 132 kV	35	-5	34	-5	34	-5	34	-5	33	-5	33	-5	33	-5	33	-5	33	-5	33	-5
Nambucca 66 kV	6	1	6	1	6	1	6	1	6	1	5	1	5	1	5	1	5	1	5	1
Narrabri 66 kV	45	6	44	6	44	6	44	6	44	6	43	6	43	6	43	6	43	6	43	6
Port Macquarie 33 kV	56	10	55	10	55	10	55	10	54	10	54	10	54	10	54	10	54	10	54	10
Raleigh 132 kV	8	2	7	2	7	2	7	2	7	2	7	2	7	2	7	2	7	2	7	2
Stroud 132 kV	34	-1	34	-1	34	-1	34	-1	34	-1	34	-1	35	-1	35	-1	35	-1	35	-1
Tamworth 66 kV	103	20	102	20	101	21	101	21	100	21	100	21	100	21	99	21	99	21	99	21
Taree 33 kV	25	6	25	6	24	6	24	6	24	6	24	6	24	6	24	6	24	6	24	6
Taree 66 kV	48	12	48	12	47	12	47	12	47	12	47	12	47	13	47	13	47	13	47	13
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	79	-6	79	-6	80	-6	80	-6	80	-6	80	-6	80	-6	80	-6	80	-6	80	-6

TABLE A1.6 – Essential Energy (North) bulk supply point winter maximum demand

	2016		2017		2018		2019		2020		2021		2022		2023		2024		2025	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Armidale 66 kV	38	6	39	6	40	6	40	6	41	6	41	6	42	6	42	6	42	6	42	6
Boambee South 132 kV	17	3	17	3	18	3	18	3	18	3	18	3	18	3	18	3	18	3	18	3
Casino 132 kV	21	4	21	4	21	4	21	4	21	4	21	4	21	4	21	4	21	4	21	4
Coffs Harbour 66 kV	52	6	51	6	49	6	48	6	47	6	47	6	46	6	46	6	45	6	45	6
Dorrigo 132 kV	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	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	22	2	22	2	22	2	22	2	22	2	22	2	22	2	22	2	22	2	22	2
Hawks Nest 132 kV	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1
Herons Creek 132 kV	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2
Inverell 66 kV	30	-2	32	-2	32	-2	36	-2	37	-2	39	-2	39	-2	39	-2	39	-2	39	-2
Kempsey 33 kV	28	5	28	5	28	5	28	5	28	5	28	5	28	5	28	5	28	5	28	5
Koolkhan 66 kV	44	2	44	2	43	2	43	2	43	2	43	2	42	2	42	2	42	2	42	2
Lismore 132 kV	75	-8	75	-8	75	-8	75	-8	75	-8	75	-8	76	-8	76	-8	76	-8	76	-8
Macksville 132 kV	9	2	9	2	9	2	9	2	9	2	9	2	9	2	9	2	9	2	9	2
Moree 66 kV	37	4	38	4	38	4	39	4	40	4	40	4	41	4	41	4	41	4	41	4
Mullumbimby 132 kV	46	4	46	4	45	4	45	4	45	4	45	4	44	4	44	4	44	4	44	4
Nambucca 66 kV	8	1	8	1	8	1	8	1	8	1	8	1	8	1	8	1	8	1	8	1
Narrabri 66 kV	45	8	44	8	44	8	44	8	44	8	44	8	44	8	44	8	44	8	44	8
Port Macquarie 33 kV	68	8	68	8	68	8	68	8	68	8	67	8	67	8	67	8	67	8	67	8
Raleigh 132 kV	9	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2	10	2
Stroud 132 kV	29	-5	29	-5	28	-5	28	-5	28	-5	28	-5	28	-5	28	-5	27	-5	27	-5
Tamworth 66 kV	91	15	91	15	91	15	91	16	90	16	90	16	90	16	90	16	90	16	90	16
Taree 33 kV	23	4	23	4	22	4	22	4	22	4	22	4	21	4	21	4	21	4	21	4
Taree 66 kV	48	7	47	7	46	7	46	7	45	7	45	7	44	7	44	7	44	7	43	7
Tenterfield 22 kV	6	1	6	1	6	1	6	1	6	1	6	1	6	1	6	1	6	1	6	1
Terranora 110 kV	82	-6	82	-6	82	-6	83	-6	83	-6	83	-6	83	-6	83	-7	84	-7	84	-7

TABLE A1.7 – Essential Energy (Central) bulk supply point summer maximum demand

	2016/17		2017/18		2018/19		2019/20		2020/21		2021/22		2022/23		2023/24		2024/25		2025/26	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Beryl 66 kV	63	23	66	23	67	24	69	24	70	24	71	24	71	24	71	24	71	25	71	25
Cowra 66 kV	30	5	30	5	30	5	30	5	30	5	30	5	30	5	30	5	30	5	30	5
Forbes 66 kV	31	2	31	2	31	2	31	2	31	2	30	2	30	2	30	2	30	2	30	2
Manildra 132 kV	10	4	10	4	10	4	10	4	10	4	10	4	10	4	11	4	11	4	11	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	21	3	21	3	21	3	21	3	21	3	21	3
Orange 66 kV	48	20	48	20	49	20	49	20	49	20	49	20	49	20	49	20	49	20	49	20
Orange 132 kV	140	32	142	32	144	32	145	32	147	32	148	32	148	32	149	32	149	32	149	32
Panorama 66 kV	59	23	58	23	58	23	57	23	57	23	56	23	56	23	56	23	56	23	56	23
Parkes 66 kV	25	5	25	5	25	5	25	5	25	5	25	5	25	5	25	5	25	5	25	5
Parkes 132 kV	29	12	29	12	29	12	29	12	29	12	29	12	29	12	29	12	29	12	29	12
Wallerawang 66 kV	3	2	3	2	3	2	3	2	4	2	4	2	4	2	4	2	4	2	4	2
Wallerawang 132 kV	20	13	21	13	21	13	21	13	21	13	21	13	21	13	21	13	21	13	21	13
Wellington Town 132 kV	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0
Wellington 132 kV	165	18	165	18	164	18	164	18	164	18	163	18	163	18	163	18	163	18	163	18

TABLE A1.8 – Essential Energy (Central) bulk supply point winter maximum demand

	2016		2017		2018		2019		2020		2021		2022		2023		2024		2025	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Beryl 66 kV	64	17	66	17	68	18	69	18	71	18	71	18	71	18	71	18	71	19	71	19
Cowra 66 kV	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0
Forbes 66 kV	25	-5	24	-5	24	-5	24	-5	24	-5	24	-5	24	-5	24	-5	24	-5	24	-5
Manildra 132 kV	10	3	10	3	10	3	10	3	10	3	10	3	10	3	10	3	10	3	10	3
Molong 66 kV	5	-1	5	-1	5	-1	5	-1	5	-1	5	-1	5	-1	5	-1	5	-1	5	-1
Mudgee 132 kV	21	1	21	1	21	1	21	1	21	1	21	1	21	1	21	1	21	1	21	1
Orange 66 kV	61	16	61	16	62	16	62	16	62	16	62	16	63	16	63	16	63	16	63	16
Orange 132 kV	129	38	132	38	134	38	136	38	137	38	139	38	140	38	141	38	142	38	142	38
Panorama 66 kV	68	18	68	18	68	18	68	18	68	18	68	18	68	18	68	18	68	18	68	18
Parkes 66 kV	22	3	22	3	22	3	22	3	22	3	22	3	22	3	22	3	22	3	22	3
Parkes 132 kV	30	13	30	13	30	13	30	13	30	13	30	13	30	13	30	13	31	13	31	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	19	12	19	12	19	12	19	12	19	12	19	12	19	12	19	12	19	12	19	12
Wellington Town 132 kV	8	0	8	0	8	0	8	0	8	0	8	0	8	0	8	0	8	0	8	0
Wellington 132 kV	150	2	150	2	150	2	150	2	150	2	150	2	150	2	150	2	150	2	150	2

TABLE A1.9 – Essential Energy (South and Far West) and ActewAGL bulk supply point summer maximum demand[8]

	2016/17		2017/18		2018/19		2019/20		2020/21		2021/22		2022/23		2023/24		2024/25		2025/26	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Albury 132 kV	112	20	112	20	112	20	111	20	111	20	111	20	111	20	111	20	111	20	111	20
Balranald 22 kV	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0
Broken Hill 22 kV	37	12	38	12	38	12	38	12	39	12	39	12	39	12	39	12	39	12	39	12
Canberra 132 kV	351	149	360	153	367	156	368	157	378	161	370	158	369	157	375	160	383	163	385	164
Coleambally 132 kV	10	6	10	6	11	6	11	6	11	6	11	6	11	6	11	6	11	6	11	6
Cooma 66 kV	17	1	17	1	17	1	17	1	17	1	17	1	17	1	17	1	17	1	17	1
Cooma 132 kV	40	5	40	5	40	5	40	5	40	5	40	5	40	5	40	5	40	5	40	5
Darlington Pt 132 kV	17	5	17	5	18	5	18	5	18	5	18	5	18	5	18	5	18	5	18	5
Deniliquin 66 kV	45	14	45	14	45	14	45	14	45	14	45	14	45	14	45	14	45	14	45	14
Finley 66 kV	18	5	18	5	18	5	18	5	18	5	18	5	18	5	18	5	18	5	18	5
Griffith 33 kV	80	21	81	21	81	21	82	21	82	21	82	21	83	21	83	21	83	21	83	21
Marulan 132 kV	36	11	36	11	36	11	36	11	36	11	36	11	36	11	36	11	36	11	36	11
Morven 132 kV	7	2	7	2	7	2	7	2	7	2	7	2	7	2	7	2	7	2	7	2
Munyang 33 kV	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4
Murrumbateman 132 kV	4	1	4	1	4	1	4	1	4	1	4	1	4	1	4	1	4	1	4	1
Murrumburrah 66 kV	36	12	36	12	36	12	36	12	36	12	35	12	35	12	35	12	35	12	35	12
Queanbeyan 66 kV	60	18	61	18	63	19	65	20	66	20	68	21	69	21	69	21	71	22	72	22
Queanbeyan 132 kV	8	3	8	3	8	3	8	5	9	5	9	4	9	5	9	5	9	6	10	6
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	32	14	32	14	32	14	32	14	32	14	32	14	32	14	32	14	32	14	32	14
Wagga 66 kV	78	33	75	33	72	33	70	33	69	33	68	33	67	33	66	33	66	33	66	33
Wagga North 132 kV	56	4	55	4	54	4	54	4	53	4	53	4	52	4	52	4	52	4	52	4
Wagga North 66 kV	20	9	20	9	20	9	20	9	20	9	20	9	20	9	20	9	20	9	20	9
Williamsdale 132 kV	174	63	165	60	180	65	176	64	177	64	170	62	171	62	168	61	179	65	186	67
Yanco 33 kV	38	6	38	6	38	6	38	6	38	6	38	6	38	6	38	6	38	6	38	6
Yass 66 kV	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0

8 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 A1.10 – Essential Energy (South and Far West) and ActewAGL bulk supply point winter maximum demand[9]

	2016		2017		2018		2019		2020		2021		2022		2023		2024		2025	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Albury 132 kV	86	10	85	10	84	10	84	10	83	10	83	10	82	10	82	10	82	10	82	10
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	34	6	34	6	34	6	35	6	35	6	35	6	35	6	35	6	35	6	35	6
Canberra 132 kV	431	126	432	126	435	127	433	126	442	129	427	124	426	124	426	124	430	125	437	127
Coleambally 132 kV	6	4	6	4	6	4	6	4	6	4	6	4	6	4	6	4	6	4	6	4
Cooma 66 kV	31	2	30	2	29	2	29	2	28	2	28	2	28	2	27	2	27	2	27	2
Cooma 132 kV	46	-1	46	-1	46	-1	46	-1	46	-1	46	-1	46	-1	46	-1	46	-1	46	-1
Darlington Pt 132 kV	15	2	16	2	16	2	16	2	16	2	16	2	17	2	17	2	17	2	17	2
Deniliquin 66 kV	33	7	33	7	33	7	34	7	34	7	34	7	34	7	34	7	34	7	34	7
Finley 66 kV	15	3	15	3	15	3	15	3	15	3	15	3	15	3	15	3	15	3	15	3
Griffith 33 kV	48	14	48	14	48	14	48	14	48	14	48	14	48	14	48	14	48	14	48	14
Marulan 132 kV	46	7	46	7	46	7	46	7	46	7	46	7	45	7	45	7	45	7	45	7
Morven 132 kV	6	1	6	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1	7	1
Munyang 33 kV	27	25	26	25	26	25	26	25	26	25	26	25	26	25	26	25	26	25	25	25
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	32	7	32	7	32	7	33	7	33	7	33	7	33	7	33	7	33	7	33	7
Queanbeyan 66 kV	69	13	71	14	72	15	72	15	74	15	74	15	75	16	76	16	76	16	78	17
Queanbeyan 132 kV	8	3	8	3	8	3	8	3	8	5	8	5	8	5	9	5	9	5	9	5
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	34	8	34	8	34	8	34	8	34	8	34	8	34	8
Wagga 66 kV	66	13	64	13	63	13	62	13	61	13	60	13	59	13	59	13	58	13	58	13
Wagga North 132 kV	46	-2	55	-2	55	-2	55	-2	55	-2	55	-2	54	-2	54	-2	54	-2	54	-2
Wagga North 66 kV	25	5	16	5	17	5	17	5	17	5	17	5	17	5	18	5	18	5	18	5
Williamsdale 132 kV	161	40	162	41	158	39	164	41	156	39	175	44	169	42	170	43	172	43	163	41
Yanco 33 kV	30	0	30	0	30	0	30	0	30	0	30	0	31	0	31	0	31	0	31	0
Yass 66 kV	13	-2	13	-2	13	-2	13	-2	13	-2	13	-2	13	-2	13	-2	13	-2	13	-2

TABLE A1.11 – Major industrial customers – Sum of individual summer maximum demands

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Industrial Loads	1035	1034	1032	1032	1031	1031	1031	1031	1031	1031

TABLE A1.12 – Major industrial customers – Sum of individual winter maximum demands

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Industrial Loads	1033	1033	1033	1033	1033	1033	1033	1033	1033	1033

9 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.

2 Appendix

Load profiles and load at risk

This appendix provides information for potential providers of network support about a possible network constraint in the Gunnedah/Narrabri area.

The possible constraint is one that may be able to be addressed via a non-network solution. The information provided includes forecasts of loads, the magnitude of load at risk for the critical seasons, typical load profiles for the day of maximum demand, and general information about the possible variations in the periods over which network support may be required.

This information is provided for the benefit of potential providers of network support.

A2 Load profiles and load at risk

Supply to the Gunnedah/Narrabri area

The nature of the constraints in the network supplying the Gunnedah/Narrabri area is described in Section 4.3.1. The forecast summer loads in the area together with the expected amount of load at risk are given in Table A2.1. Table A2.2 shows the winter quantities.

TABLE A2.1 – GUNNEDAH/NARRABRI AREA SUMMER LOAD FORECAST AND EXPECTED LOAD AT RISK (MW)

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
Gunnedah	25.0	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1
Narrabri	44.5	44.3	44.0	43.8	43.6	43.5	43.4	43.3	43.3	43.3
Boggabri area mines	11.1	11.5	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8
Total	81	81	81	81	81	80	80	80	80	80
Expected load at risk	8	8	8	8	8	8	8	8	8	8

TABLE A2.2 – GUNNEDAH/NARRABRI AREA WINTER LOAD FORECAST AND EXPECTED LOAD AT RISK (MW)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Gunnedah	22.4	22.4	22.4	22.4	22.4	22.4	22.5	22.5	22.5	22.5
Narrabri	44.6	44.4	44.2	44.1	43.9	43.8	43.7	43.7	43.6	43.6
Boggabri area mines	11.1	11.5	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8
Total	79	78	78	78	78	78	78	78	78	78
Expected load at risk	2	2	2	2	2	2	2	2	2	2

Prior to commissioning of the new mines, there were minor variations in the load profiles on the day of summer and winter maximum demands from year to year. Since the mines were commissioned, there has been more variation.

Figure A2.1 shows the envelope that fits the profiles for the past five years. Figure A3.2 shows the winter envelope. The "less smooth" envelopes (compared to those in TAPR 2015) result from the inclusion of the new mining loads in the profiles this year.

FIGURE A2.1 – Gunnedah / Narrabri area load profile on day of summer maximum demand

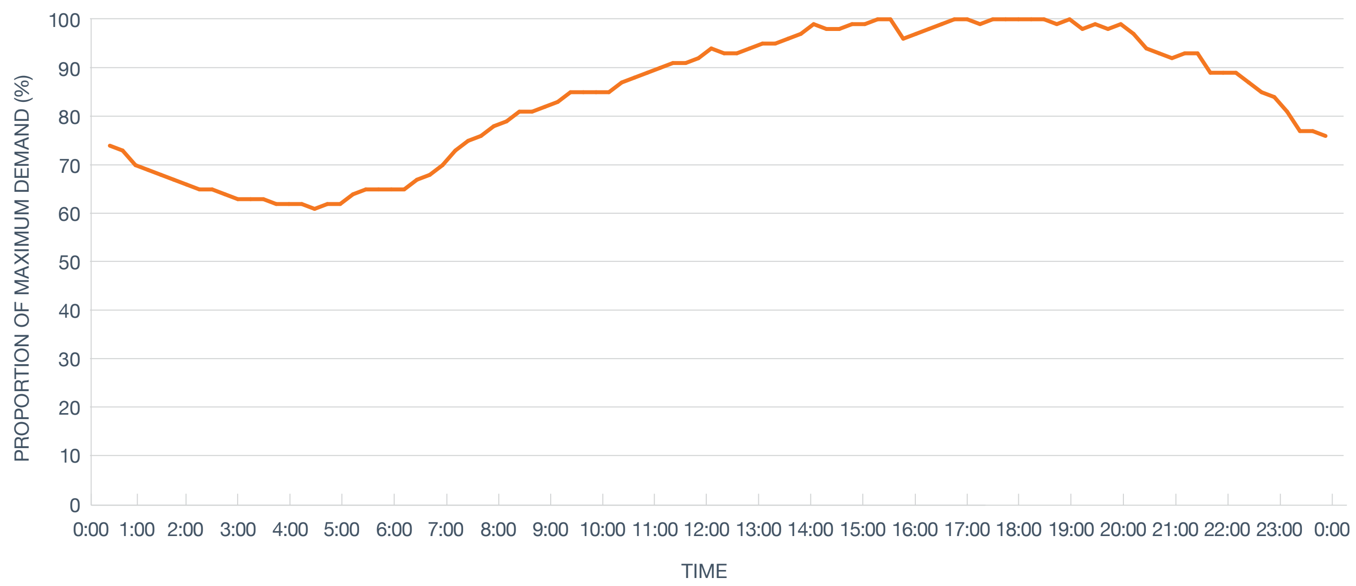
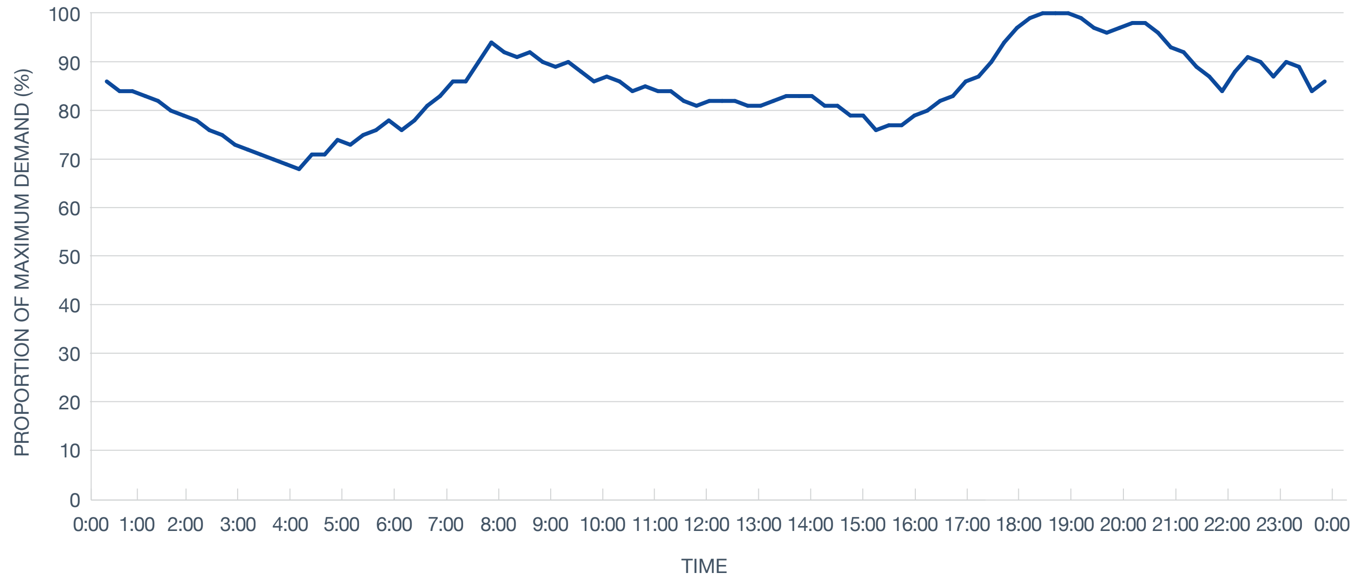


FIGURE A2.2 – Gunnedah / Narrabri area load profile on day of winter maximum demand



Variability in the periods over which network support may be required

There can be considerable variation in weather conditions over seasons, and this 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].

Appendix 4 of TAPR 2015 and Appendix 4 of TAPR 2014 each contained analyses that showed that the periods over which network support may be required, was quite variable from year to year. Those analyses have not been updated this year. However, the conclusions remain the same:

> Actual weather conditions in a season can significantly affect the need for network support

> Given the inability to forecast weather more than a few days in advance, it is not possible to provide meaningful estimates of the amount of network support which may be required or the period(s) for which it may be required, more than a few days in advance

We welcome feedback on this issue and on any other information which may be of use to potential suppliers of network support. Contact details are provided on the inside of the back cover.

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/enso

3 Appendix

Planning proposals for future connection points

This appendix describes planning proposals for future connection points for the next five years that have been initiated by generators or customers, or that have arisen as the result of joint planning with a distributor.

These planning proposals cover provision of new bulk supply points, provision of additional switchbays for new connections at existing bulk supply points, and developments that may increase the capability of a bulk supply point, such as installation of new transformers or capacitors.

A3 Planning proposals for future connection points

The NER requires that the TAPR set out planning proposals for future connection points. The proposals can be initiated by generators or customers, or arise as the result of joint planning with a distributor.

As the NER does not define the term, planning proposal, we have taken a broad interpretation in previous TAPRs, covering developments up to five years into the future that relate to:

- > Provision of new bulk supply points
- > Provision of additional switchbays for new connections at existing bulk supply points
- > Developments that may increase the capability of a bulk supply point, such as installation of new transformers or capacitors.

For consistency, we have maintained this approach in TAPR 2016, even though it includes developments that are not considered to be proposed under TransGrid's network investment process, that do not relate to connection points as defined in the NER, and that involve existing bulk supply points.

TABLE A3.1 – Connection point

Bulk supply point	Development	Proposed service date	TAPR 2016 section
Orange 132/66 kV substation	Replacement of 66 kV substation equipment and additional 66 kV capacitor	2019	3.3.1
Orange 132/66 kV substation	Additional capacitor	2019	3.3.2
Tamworth 132/66 kV substation	Condition based substation replacement	Early 2017	3.3.2
Williamsdale 330/132 kV substation	New 132 kV switchbay connection	2018	4.3.2
Macarthur 330/132 kV substation	Two new 66 kV switchbays	2018 – 2020	4.3.2
Beryl 132/66 kV substation	Additional or expanded capacitor	2016/17	3.4.1
Vales Point 330/132 kV substation	Condition based substation replacement	2018	3.3.1
Canberra 330/132 kV substation	Condition based equipment replacement	2019	3.4.1
Beaconsfield West 330/132 kV substation	Condition based transformer replacement	2018	3.3.2
Wagga 132/66 kV substation	Condition based substation replacement	2019	3.3.1
Connection of Munmorah	Connection to new Ausgrid substation	2017	3.4.1
Vineyard 330/132 kV substation	One new 132 kV switchbay	2021 – 2026	4.4.3
Macarthur 330/66 kV substation	One 66 kV switchbay	2021 – 2026	4.3.3
Canberra 330/132 kV substation	One new 132 kV switchbay	2022	4.4.3

The following connection point works were completed in 2015/16:

TABLE A3.2 – Completed connection points

Bulk supply point	Development	Service date	TAPR 2015 section
Cooma 132/66/11 kV substation	Condition based substation replacement	November 2015	3.2.1
Yanco 132/33 kV substation	Condition based substation replacement	September 2015	3.2.1
Riley Street (site acquisition)	Site acquisition has been completed		3.2.1
Beryl 132/66 kV substation	New 66 kV switchbay	September 2015	3.2.2
Vineyard 330/132 kV substation	New 132 kV switchbay	February 2016	3.2.2
Molong 132/66 kV substation	New 66 kV switchbay	March 2016	3.2.2

4 Appendix

Progress of developments reported in TAPR 2015

A4 Progress of developments reported in TAPR 2015

The following table lists the developments reported in TransGrid's TAPR 2015 and where they have been reported in this TAPR, along with a brief comment to indicate the current status of each development.

Development	TAPR 2015 section	TAPR 2016 section	Comment
Redevelopment of Orange 132/66 kV substation	5.3.1	3.3.1	Committed, with expected completion 2019.
Strategic land acquisition at Riley Street	5.3.1	3.2.1	Completed Sept 2015
Rehabilitation of Upper Tumut switching station	5.3.1	3.3.1	Committed, with expected completion July 2016
Replacement of the Cooma substation	5.3.1	3.2.1	Completed November 2015
Refurbishment of the Yanco substation	5.3.1	3.2.1	Completed September 2015
Dynamic line ratings	5.3.1	3.3.1	Committed, with first installations completed November 2015, remaining installations expected spring 2016
Quality of supply monitoring	5.3.1	3.3.1	Committed, with expected completion June 2017
Point on wave switching control	5.3.1	3.3.1	Committed, with expected completion January 2018
Provision of a 66 kV line switchbay at Beryl 132/66 kV substation	5.3.2	3.2.2	Completed September 2015
Provision of a 66 kV transformer switchbay at Molong 132/66 kV substation	5.3.2	3.2.2	Completed March 2016
Provision of a new 132 kV line switchbay at Vineyard 330/132 kV switchyard	5.3.2	3.2.2	Completed February 2016
Sydney West 330 kV substation: 132 kV fault rating	5.3.2	3.2.2	Completed February 2016
Beaconsfield West 330/132 kV substation: No 1 and 2 transformer replacement	5.3.2	3.3.2	Committed, with expected completion 2018
Buronga 220 kV switching station: Reactor X2 replacement	5.3.2	3.2.2	Completed July 2015
Broken Hill 220/22 kV substation: No 1 and No 2 shunt reactor replacement	5.3.2	3.2.2	Completed winter 2016
Orange 132/66 kV substation: additional 66 kV capacitor bank	5.3.2	3.3.2	Part of the redevelopment of Orange 132 kV substation. Committed, with expected completion 2019.
Armidale 330/132 kV substation: replacement of the SVC control system	5.3.2	3.2.2	Completed September 2015
Tamworth 132/66 kV substation: substation rebuild	5.3.2	3.3.2	Committed, with expected completion early 2017
Kangaroo Valley 330 kV substation: secondary systems replacement	5.3.2	3.2.2	Completed February 2016
Sydney West 330/132 kV substation: secondary systems replacement	5.3.2	3.3.2	Committed, with expected completion mid 2016
Sydney North 330/132 kV substation: secondary systems replacement	5.3.2	3.3.2	Committed, with expected completion late 2018
Sydney South 330 kV substation: replacement of the 415-VAC system and LV cables	5.3.2	3.2.2	Completed February 2016
Haymarket 330 kV substation: Removal of SICAM (control and monitoring system) from GIS	5.3.2	3.3.2	Committed, with expected completion mid 2016
Albury 132/22 kV substation: secondary systems replacement	5.3.2	3.3.2	Committed, with expected completion late 2016
970 Burrinjuck – Yass 132 kV transmission line: pole replacements	5.3.2	3.3.2	Committed, with expected completion 2017
Condition of Vales Point 330/132 kV substation	5.4.1	3.3.1	Committed, with expected completion 2018
Development of southern supply to the ACT	5.4.1	3.4.1	Required by 2020. Preferred site is near Stockdill Drive
Condition of Wagga 132/66 kV substation	5.4.1	3.3.1	Committed, with expected completion June 2019
Supply to the Beryl/Mudgee area	5.4.1	3.4.1	Indicative date: summer 2016/17
Taree 132/66/33 kV substation: secondary systems replacement and 33 kV switchyard condition	5.5	3.3.2	Committed, with expected completion September 2017
Haymarket 330/132 kV substation: secondary systems replacement	5.5	3.2.2	Completed August 2015
97K Cooma – Munyang 132 kV transmission line rehabilitation	5.5	3.5	Planned, with expected completion 2018
96H Coffs Harbour – Koolkhan 132 kV transmission line: pole replacements	5.5	3.3.2	Committed, with expected completion 2018
Supply to the Gunnedah/Narrabri area	6.2.1	4.2.1	Refer to Section 4.2.1 and Appendix 3
Condition of Tamworth No 2 330/132 kV transformer	6.2.2	4.2.2	Indicative date: 2019
Capacity of cable 41, Sydney South – Beaconsfield	6.2.3	4.1.1	Anticipated within five years
Connection of Ausgrid's new subtransmission substation in the Munmorah/Doyalson area	6.2.4	3.4.1	Indicative date: 2017
Condition of Munmorah 330 kV substation	6.2.5	4.4	Some essential items have been replaced at Munmorah. Equipment will continue to be monitored for replacement as required.
Condition of Canberra substation	6.2.6	3.4.1	Planned project, with indicative date of 2019
Condition of Burrinjuck substation	6.2.7	4.4	The project is currently under review.
Murraylink runback control scheme	6.2.8	4.4	TransGrid's portion of the work is completed. This project will not be reported in future

Development	TAPR 2015 section	TAPR 2016 section	Comment
Multiple contingency protection scheme	6.2.9	4.4	The program is to be delivered in a piecemeal fashion focusing on the highest priority parts of the network.
Provision of a new 132 kV line switchbay at Williamsdale 330/132 kV substation	6.2.10	4.2.3	Indicative date: 2018
21 Sydney North – Tuggerah 330 kV transmission line: tower life extension	6.2.11	4.3.4	Indicative date: 2021
959/92Z Sydney North – Sydney East 132 kV transmission line: tower life extension	6.2.11	4.2.1	Now included in transmission lines program. Anticipated between one and ten years.
Deniliquin 132/66 kV substation: secondary systems replacement	6.2.11	4.3.4	Indicative date: 2023
ANM 132 kV substation: secondary systems replacement	6.2.11	4.4	This project is not proceeding at this stage.
01 and 2 Canberra – Upper Tumut and Upper Tumut – Yass 330 kV transmission lines remediation	6.2.11	4.4	This project is not proceeding at this stage.
Low spans northern tower lines	6.2.11	4.2.4	Indicative date: 2018
Low spans northern pole lines	6.2.11	3.3.2	Committed, with expected completion late 2017
Low spans central tower lines	6.2.11	3.5	Planned project with indicative date of late 2017
Low spans central pole lines	6.2.11	4.2.4	Indicative date: 2019
Low spans southern tower lines	6.2.11	4.2.4	Indicative date: 2019
Low spans southern pole lines	6.2.11	4.2.4	Indicative date: 2019
22 Sydney North – Vales Point 330 kV transmission line: tower life extension	6.2.11	4.3.4	Indicative date: 2023
Murrumburrah 132/66 kV substation: secondary systems replacement	6.2.11	4.3.4	Indicative date: 2022
Hume 132 kV substation: secondary systems replacement	6.2.11	4.4	This project is not proceeding at this stage.
NSW to Queensland transmission capacity	6.3.1	4.1.2	Limitation will be reviewed in five to ten years
Tamworth and Armidale 330 kV switchyards	6.3.2	4.1.2	Anticipated between five and ten years
Hunter Valley – Tamworth – Armidale 330 kV system	6.3.3	4.1.2	Anticipated between five and ten years
Voltage control in Northern NSW	6.3.4	4.1.2	Anticipated between five and ten years
'Powering Sydney's Future' Supply to the Sydney Inner Metropolitan Area	6.3.5	4.1.1	Limitation is expected to arise within five years. Joint strategy being developed with Ausgrid.

Development	TAPR 2015 section	TAPR 2016 section	Comment
Condition of Newcastle substation	6.3.6	4.4	The transformers at Newcastle were replaced in 2014. Replacement of other equipment at Newcastle substation has been deferred due to reduced risk. Equipment will continue to be monitored for replacement as appropriate.
Snowy to Sydney network capacity	6.3.7	4.3.1	Cost effective options to be identified by market modelling.
Capacity of the Marulan – Avon, Marulan – Dapto and Kangaroo Valley – Dapto 330 kV lines	6.3.8	4.3.1	Reported with the "Capacity of the Snowy to Sydney network" in Section 4.3.6
Condition of 944 Wallerawang – Orange North 132 kV transmission line	6.3.9	4.3.3	The program of work has been rescoped. Based on their condition, a small number of poles have been identified for replacement.
Beryl 132 kV substation: secondary systems replacement	6.3.10	4.2.4	Now included in secondary systems program. Anticipated between one and ten years.
Armidale 330/132 kV substation: secondary systems replacement	6.3.10	4.2.4	Now included in secondary systems program. Anticipated between one and ten years.
Forbes 132/66 kV substation: No 1 and No 2 132/66 kV transformer replacement	6.3.10	4.3.4	Anticipated between five and ten years
99J Yanco – Griffith 132 kV transmission line rebuild	6.3.10	4.4	This project is not proceeding at this stage.
Supply to the Forster/Tuncurry Area	6.4.1	Not reported	Limitation not expected to arise within ten years due to moderating growth
Lismore 330/132 kV substation: two 132 kV switchbays	6.4.2	Not reported	Need is not expected to arise within ten years due to moderating growth
Tamworth 132/66 kV substation: one 66 kV line switchbay	6.4.2	Not reported	Need is not expected to arise within ten years due to moderating growth
Tumut 132/66 kV substation: one 66 kV switchbay	6.4.2	Not reported	Need is not expected to arise within ten years due to moderating growth

Appendix 5

Glossary

APPENDIX 5

A5 Glossary

Term	Explanation/Comments
AEMC	The Australian Energy Market Commission
AEMO	The Australian Energy Market Operator. Responsible for management of the NEM and has the role of Victorian JPB
AER ('the regulator')	The Australian Energy Regulator
Assets	TransGrid's 'poles and wires', all the substations and electricity transmission lines that make up the network
Augmentation	Expansion of the existing transmission system or an increase in its capacity to transmit electricity
Bulk supply point (BSP)	A point of supply of electricity from a transmission system to a distribution system
Connection point	The agreed point of supply established between the network service provider and another registered participant or customer
Constraint (limitation)	An inability of a transmission system or distribution system to supply a required amount of electricity to a required standard.
Consumers	Any end user of electricity, for example large users, such as paper mills, or small users, such as households
Demand	The total amount of electrical power that is drawn from the network by consumers. This is talked about in terms of 'maximum demand' (the maximum amount of power drawn throughout a given period) and 'total energy consumed' (the total amount of energy drawn across a period)
Demand management (DM)	A set of initiatives that are put in place at the point of end-use to reduce the total and/or maximum consumption of electricity
Direct customers	TransGrid's customers are those directly connected to our network. They are either Distribution Network Service Providers, directly connected generators, large industrial customers, customers connected through inter-regional connections or potential new customers
Distribution Network Service Provider, DNSP (Distributor)	An organisation that owns, controls or operates a distribution system in the National Electricity Market. Distribution systems operate at a lower voltage than transmission systems and deliver power from the transmission network to households and businesses
Easement	A designated area in which TransGrid has the right to construct, access and maintain our assets, while ownership of the property remains with the original land owner
Electricity Statement of Opportunities (ESOO)	A document produced by AEMO that focuses on electricity supply demand balance in the NEM
Embedded generation	A generating unit connected to the distribution network, or connected to a distribution network customer. (Not a transmission connected generator)
Generator	An organisation that produces electricity. Power can be generated from various sources, e.g. coal fired power plants, gas-fired power plants, wind farms
Interconnection	The points on an electricity transmission network that cross jurisdictional/state boundaries
Jurisdictional Planning Body (JPB)	The organisation nominated by a relevant minister as having transmission system planning responsibility in a jurisdiction of the NEM
Load	The amount of electrical power that is drawn from the network
Local generation	A generation or cogeneration facility that is located on the load side of a transmission constraint
LRET	Large Scale Renewable Energy Target
'N – 1' reliability	The system is planned for no loss of load on the outage of a single element such as a line, cable or transformer
National Electricity Law	Common laws across the states which comprise the NEM, which make the NER enforceable
National Electricity Market (NEM)	The National Electricity Market, covering Queensland, New South Wales, Victoria, South Australia and Tasmania
National Electricity Rules	
(NER or 'the Rules')	The rules that govern the NEM. The Rules are administered by the AEMC
Native energy (demand)	Energy (demand) that is inclusive of Scheduled, Semi-Scheduled and Non-Scheduled generation
Non-network options	Alternatives to network augmentation which address a potential shortage in electricity supply in a region, e.g. demand response or local generation
NSCAS	Network Support and Ancillary Services. Services used by AEMO that are essential for managing power system security, facilitating orderly trading, and ensuring electricity supplies are of an acceptable quality.
NTFP	National Transmission Flow Path
NTNDP	National Transmission Network Development Plan
Outage	An outage is when part of the network is switched off. This can be either planned (i.e. when work needs to be done on the line) or unplanned
PoE	Probability of Exceedence. This is the probability a forecast would be met or exceeded, e.g. a 50% POE demand implies there is a 50% probability of the forecast being met or exceeded
PV	Photovoltaic
Reliability	Reliability is a measure of a power system's capacity to continue to supply sufficient power to satisfy customer demand, allowing for the loss of generation capacity
RET	Renewable Energy Target
Secondary system	Equipment used to control, automate and monitor the network
Substation	A set of electrical equipment used to step high voltage electricity down to a lower voltage. Lower voltages are used to deliver power safely to small businesses and residential consumers
SVC	Static VAr Compensator. An electrical device installed on the high voltage transmission system to provide fast acting voltage control to regulate and stabilise the system
Transmission Annual Planning Report (TAPR)	A document that sets out issues and provides information to the market that is relevant to transmission planning in NSW.
Transmission line	A high voltage power line running at 500 kV, 330 kV, 220 kV or 132 kV. The high voltage allows delivery of bulk power over long distances with minimal power loss
Transmission Network Service Provider, TNSP	A body that owns controls and operates a transmission system in the NEM

The following table gives some of the common electricity measurements used:

Property	Unit
Voltage	Volts (V) and kilovolts (kV). 1 kV = 1000 V
Power	Watts (W), usually expressed in kilowatts (kW) and megawatts (MW). 1 MW = 1000 kW = 1 million W
Energy consumption	The amount of energy consumed in an hour is usually expressed as kilowatt-hours (kWh) or megawatt-hours (MWh). 1 MWh = 1000 kWh
Maximum power that a transformer can deliver	Usually expressed in megavolt-ampere (MVA)
Reactive power	Usually expressed in megavolt-ampere reactive (MVAr)

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