IPART
New South Wales

Independent Pricing and Regulatory Tribunal

Electricity transmission reliability standards

An economic assessment

Energy — Issues Paper
December 2015

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Invitation for submissions

IPART invites written comment on this document and encourages all interested parties to provide submissions addressing the matters discussed.

Submissions are due by 22 January 2016.

We would prefer to receive them electronically via our online submission form <www.ipart.nsw.gov.au/Home/Consumer_Information/Lodge_a_submission>.

You can also send comments by mail to:

Electricity transmission reliability standards
Independent Pricing and Regulatory Tribunal
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Late submissions may not be accepted at the discretion of the Tribunal. Our normal practice is to make submissions publicly available on our website <www.ipart.nsw.gov.au> as soon as possible after the closing date for submissions. If you wish to view copies of submissions but do not have access to the website, you can make alternative arrangements by telephoning one of the staff members listed on the previous page.

We may choose not to publish a submission—for example, if it contains confidential or commercially sensitive information. If your submission contains information that you do not wish to be publicly disclosed, please indicate this clearly at the time of making the submission. IPART will then make every effort to protect that information, but it could be disclosed under the *Government Information (Public Access) Act 2009* (NSW) or the *Independent Pricing and Regulatory Tribunal Act 1992* (NSW), or where otherwise required by law.

If you would like further information on making a submission, IPART's submission policy is available on our website.

Contents

1 Introduction

The current reliability standards that TransGrid must consider when making its investment decisions are set at a very high level of reliability. These standards may not reflect the value electricity customers place on reliability.

While the reliability of the transmission network is important and supply interruptions may have wide-spread effects, customers may be willing to accept a slightly lower level of reliability if the cost of their electricity supply is reduced.

In late 2013, the Australian Energy Market Commission (AEMC) recommended a national framework for setting reliability standards for transmission networks within the National Electricity Market (NEM). Among other things, this framework includes a transparent and public process for setting reliability standards, and an economic assessment of different levels of reliability using the associated cost of investment and the value consumers place on reliability.[1]

In 2014, the Council of Australian Governments (COAG) Energy Council endorsed a set of principles and minimum requirements for reliability standards that reflect the AEMC's framework.[2] These principles and requirements are to guide a national approach to reliability.

The NSW Government has decided to broadly adopt the approach to transmission standard setting recommended by the AEMC. In line with this approach:

- The NSW Minister for Industry, Resources and Energy (the Minister) is the "standard setter", and is responsible for setting the transmission reliability standards for NSW.
- The Independent Pricing and Regulatory Tribunal (IPART) is the "economic advisor" and is responsible for conducting the economic assessment and recommending transmission reliability standards to the Minister.

1 AEMC, *Review of the national framework for transmission reliability*, *Final Report*, November 2013, p ii.

2 COAG Energy Council, Response to the Australian Energy Market Commission's Review of the National Framework for Distribution Reliability and Review of the National Framework for Transmission Reliability, December 2014.

On 28 September 2015, the NSW Government asked IPART in the role of economic advisor to review and recommend transmission reliability standards for TransGrid for the next regulatory control period (commencing 1 July 2018).

Because there is already capacity to accommodate forecast electricity demand at high levels of reliability in most parts of NSW and because of the long-term nature of transmission assets, a reduction in the reliability standards has the potential to deliver significant savings in the longer term, and there may be some smaller savings in the short term.

1.1 What has IPART been asked to do?

Our terms of reference for this review ask us to do two tasks. The first is to develop an economic assessment methodology for estimating efficient transmission reliability standards. In developing this methodology, we are to have regard to:

- the AEMC's recommended framework for setting reliability standards, and
- the most recent values of customer reliability (VCR) published by the Australian Energy Market Operator (AEMO).

The terms of reference indicate that the methodology should use probabilistic analysis (or other appropriate analytical techniques) to evaluate how efficient network capital and operating costs vary under different reliability scenarios, and to compare the expected level of expenditure required to achieve different levels of reliability to the value customers place on reliability.

The second task is to apply the economic assessment methodology to recommend transmission reliability standards to the Minister for each bulk supply point on TransGrid's network for the regulatory control period.

The terms of reference **do not** ask us to determine TransGrid's efficient costs in the regulatory control period (this is part of the Australian Energy Regulator's role as the economic regulator for Transmission Network Service Providers (TNSPs)). Nor do they cover reliability standards for the electricity **distribution** networks. However, TransGrid utilises some Ausgrid and Essential Energy assets to achieve its required level of network reliability.

A copy of the terms of reference is provided in Appendix A.

1.2 How do we propose to conduct the review?

For this review, we will conduct a public consultation process and undertake detailed analysis. We will consult with TransGrid, and other stakeholders to ensure we select appropriate reliability scenarios to undertake our economic assessment.

This Issues Paper is the first step in our consultation process. It outlines TransGrid's approach to developing reliability scenarios, describes the four scenarios we are intending to assess, and explains our proposed approach to undertaking the economic assessment.

It also identifies the issues on which we particularly seek stakeholder input. We invite all interested parties to make submissions in response to the paper by 22 January 2016. (See page iii for information on how to make a submission.)

Once we have considered these submissions, we will select feasible reliability scenarios and we will undertake an economic assessment of each scenario. We will release a Draft Report in March 2016 that will set out the results of this economic assessment, explain our draft decisions on the efficient transmission reliability standards, and seek further submissions. We will also hold a public hearing in April to provide stakeholders with another opportunity to comment.

We will consider all submissions and public hearing comments before making our final recommendations on the efficient reliability standards and providing our Final Report to the Minister in May 2016.

To assist with the analysis of TransGrid's modelling inputs for our economic assessment we have engaged a consultant, WSP Parsons Brinckerhoff.

Table 1.1 provides an indicative timetable for our review process. We will update this timetable on our website as the review progresses.

Once we have provided our Final Report and Recommendations, the Minister will set reliability standards for TransGrid. We expect that our Final Report and Recommendations will be publicly released once this decision is made. The new reliability standards will apply to the regulatory control period commencing 1 July 2018.

Table 1.1 Indicative review timetable

Key milestones	Timing
Receive submissions to Issues Paper	22 January 2016
Release Draft Report	March 2016
Hold Public Hearing	April 2016
Receive submissions to Draft Report	April 2016
Deliver Final Report and Recommendations to the Minister	May 2016

1.3 What does the rest of this paper cover?

The rest of this paper provides more detailed information on this review and our proposed methodology and approach:

- Chapter 2 explains the context for the review, including what we mean by transmission reliability standards, why they are important, and TransGrid's current reliability standards and performance.
- Chapter 3 discusses the matters we are required to consider in this review, including the AEMC's recommended framework for setting reliability standards, and the AEMO's most recent VCR.
- Chapter 4 outlines TransGrid's approach to developing reliability scenarios and describes the four scenarios we propose to assess.
- Chapter 5 explains our proposed economic assessment methodology, and how we propose to apply this methodology and formulate our recommendations on the efficient transmission reliability standards.

Chapters 4 and 5 highlight questions on issues which we particularly seek comment. For your convenience, these questions are also listed below. You are also welcome to provide input on any other issue within the scope of the review.

1.4 List of issues on which we seek comment

2 Context for the review

As Chapter 1 discussed, IPART is undertaking an economic assessment of transmission reliability standards to recommend efficient standards to apply to the TransGrid network from 1 July 2018. As context for this review, the sections below outline:

- the role of transmission networks and reliability standards
- TransGrid's current reliability standards and reliability performance aspects of the National Electricity Rules that are relevant to our review, and
- TransGrid's long term lease (privatisation).

2.1 Role of transmission networks

Transmission networks are a key part of the electricity network system. As Box 2.1 illustrates, they transport electricity from the generation plants to the distribution networks (which then deliver it to residential, commercial and industrial consumers) or to directly connected customers (typically large industrial consumers). In NSW, TransGrid's network comprises:

- **97 substations,** where the voltage of the electricity is either raised for efficient transportation through the transmission network, or lowered for safe transportation through the distribution network
- **over 12,900 kilometres of transmission lines and cable,** which transport the electricity around NSW, and
- **400 connection points**, which connect the transmission network to the distribution network or directly to customers.[3]

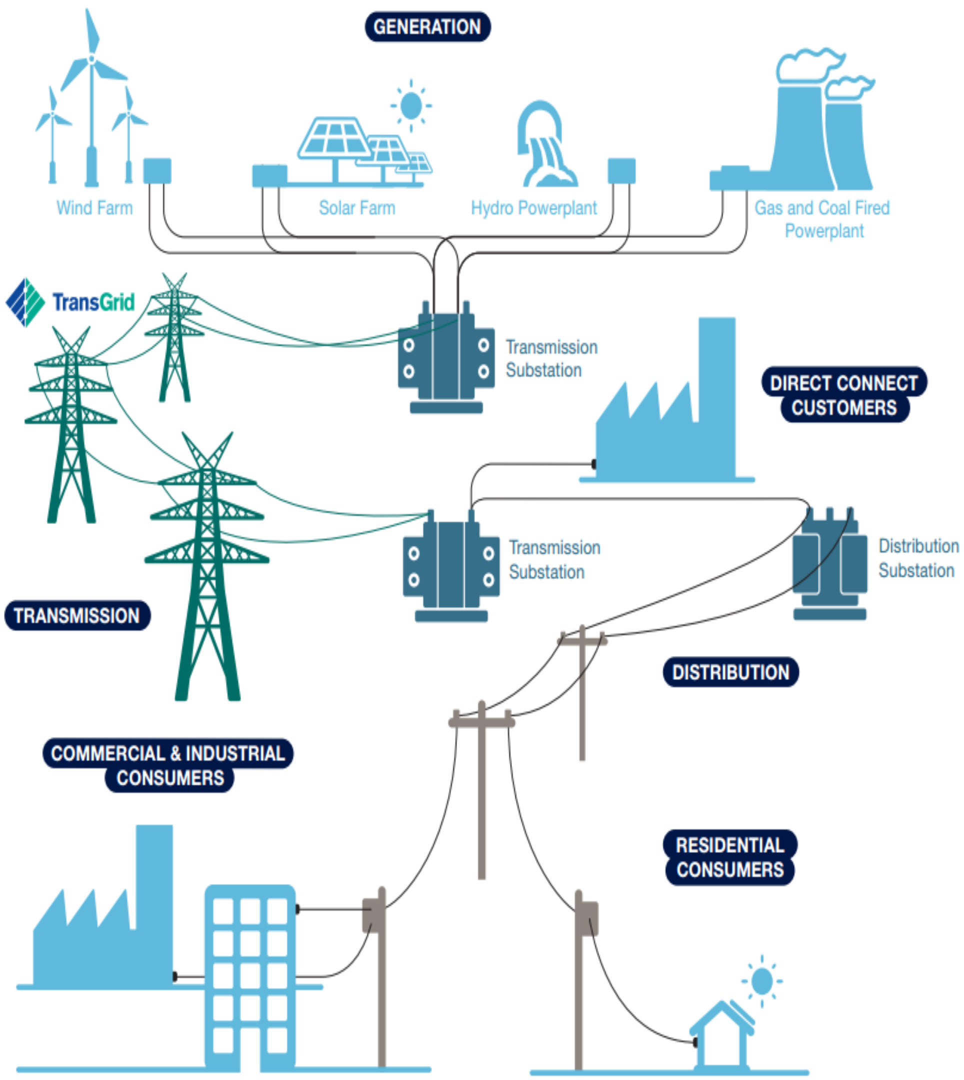
Transmission networks also play a key role in overall electricity system security, including the functioning of the National Electricity Market (NEM). TransGrid's network is interconnected with the Victorian and Queensland transmission networks. Thus, it enables the trading of electricity between the three largest

[3] TransGrid, Our Network, https://www.transgrid.com.au/what-we-do/our-network/Pages/default.aspx, accessed 2 December 2015. Note: A bulk supply point may consist of several customers (Distribution Network Service Providers or directly connected customers) connected to it. The count "400 connection points" treats these connections individually.

states on the East Coast, and supports the competitive wholesale electricity market.[4]

Transmission network charges account for approximately 7% of the average electricity bill for residential and small business electricity consumers.[5]

Box 2.1 The electricity supply chain



Source: TransGrid, *NSW Transmission Annual Planning Report*, July 2015, p 14

4 TransGrid, *NSW Transmission Annual Planning Report*, July 2015, p 13.
5 TransGrid, *Revenue proposal 2014/15 – 2018/19*, p 18.

2.2 Role of reliability standards

Reliability refers to the extent to which consumers have a continuous supply of electricity. Reliability standards establish the level of reliability that a transmission network is required to provide.

Due to their role, outages in transmission networks could cause severe disruptions to the supply of electricity that affect very large areas and numbers of consumers. For this reason, their reliability standards are set at a high level, to ensure that the number of outages that occur as a result of transmission faults is very low.

Transmission services are a natural monopoly and are therefore not subject to competition. To protect customers from excessive prices, the amount of revenue a TNSP can collect from customers and the method it uses to charge customers (its pricing methodology) are regulated. Reliability standards are also regulated to counterbalance the incentive for TNSPs to increase profits by cutting expenditure to the extent it would reduce reliability levels.

The regulation of standards also helps counterbalance the incentive for TNSPs to under-provide network reliability that results from their intermediary role in the electricity supply chain. This intermediary role means they are not directly accountable to small business and residential consumers.

It is important to set transmission reliability standards at the right level because they ultimately drive the TNSP's investment decisions:

- If a standard is set too high, the business will be required to invest to ensure the network provides reliability levels that are higher than consumers are willing to pay for.
- If a standard is set too low, the business will have an incentive to invest less and reliability levels may fall below those consumers want and are willing to pay for.

Therefore, in setting reliability standards, it is important to consider both what assets the network requires to meet a certain level of reliability ('inputs'), **and** what reliability performance consumers value ('outputs').

2.3 TransGrid's current reliability standards

The NSW Government is responsible for setting the transmission reliability standards for the TransGrid network. In all other jurisdictions of the NEM, transmission standards are also set independently of the TNSP. In most cases, they are set by the relevant state government or jurisdictional regulator.[6] The exception is Victoria, where investment decisions (and hence reliability outcomes) are made by the AEMO on a project-by-project basis, using an economic cost-benefit assessment.[7]

TransGrid's current reliability standards are set out in the Transmission Network Design and Reliability Standard for NSW (the Transmission Standard), which is issued by Industry and Investment NSW.[8] The Transmission Standard reflects a deterministic approach to standard setting. It focuses on the standards that TransGrid should achieve in planning the network ('input standards'), rather than the network reliability performance the network must deliver ('output standards').

Consistent with the Transmission Standard, TransGrid plans its network to meet specified redundancy criteria that are expressed in terms of a deterministic N-x:

- For the most of NSW, an N-1 standard applies. This means that TransGrid is required to build sufficient redundancy to ensure supply is not interrupted if one element of the transmission network fails.
- For the Sydney CBD, a modified N-2 standard applies. This means that TransGrid is required to build sufficient redundancy into the network to ensure supply to the CBD is not interrupted if two elements of the transmission network fail. The higher level of redundancy required for the Sydney CBD reflects the greater economic cost associated with supply disruptions to the CBD area, compared with other parts of the transmission network.[9]

There are also some bulk supply points where there is no network redundancy. The transmission customers that connect to these points (usually the Distribution Network Service Providers) usually have an alternative supply via distribution networks or using standby generation. Normally there would be a short interruption before the changeover of the supply, in the event the supply from the transmission system is interrupted.[10]

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6 AEMC, *Review of the national framework for transmission reliability*, *Final Report*, November 2013, p 7.

7 AEMC, *Review of the national framework for transmission reliability*, *Final Report*, November 2013, pp 109- 110.

8 Industry and Investment NSW, *Transmission Network Design and Reliability Standard for NSW*, December 2010. (Industry and Investment NSW is now the NSW Department of Industry.)

9 The standard is a 'modified' N-2 standard, as it refers to no inadvertent loss of load under agreed combinations of two circuits, two transformers or a circuit and a transformer (rather than all possible combinations of two elements). (HoustonKemp, *Electricity Networks Service Standards: An Overview*, p 6.)

10 TransGrid, *Reliability Scenario; NSW Electricity Transmission System*, November 2015, p 2.

If TransGrid forecasts that the network will not meet these standards in the future, it may decide to build additional assets to address the shortfall. Planning and building new assets can take up to 10 years. It may also decide to use non-network solutions (eg, load curtailment or local generation) to address some or all of the shortfall. These decisions are subject to TransGrid's annual planning review (described in section 2.6 below).

2.4 TransGrid's reliability performance

TransGrid reports its reliability performance against incentive targets that are determined as part of the Australian Energy Regulator's (AER) revenue determination (see below). If it does not achieve the targeted level of performance, it is not eligible to receive the relevant performance payments. However, non-achievement of targets does not necessarily mean the network is unreliable.

Indeed, the reliability performance of the TransGrid network is very high. As Table 2.1 shows, over the five years from 2009-10 to 2013-14, the level of network availability has been between 98.2% and 99.1%, and system minutes not supplied has been at or below 2.2 minutes. TransGrid has also achieved its target level of maintenance.

In addition, analysis undertaken by HoustonKemp[11] indicates that based on system minutes of energy not supplied, NSW and the ACT enjoyed the highest reliability performance in Australia between 2002–03 to 2011-12.

Table 2.1 TransGrid – performance statistics

	2009-10	2010-11	2011-12	2012-13	2013-14
Energy usage (GWh)	75,278	74,950	72,318	68,826	67,238
Maximum summer peak demand (MW)	14,039	14,907	12,207	13,997	12,169
Network reliability (system minutes[a] lost)	1.3	2.2	0.4	1.1	0.64
Network availability (%)	98.2	99.0	99.1	98.9	98.6
Percentage of maintenance achieved[b]	97	97	96	98	99

[a] A system minute is the amount of energy which would not be supplied if the whole NSW system was unavailable for a minute at peak usage.

[b] Maintenance achievement is calculated by comparing the maintenance work carried out during the year to the work specified by TransGrid's maintenance policies. TransGrid strives to complete at least 96% of planned work during the year with any outstanding work being completed during the first three months of the next financial year.

Source: TransGrid, *NSW Transmission Annual Planning Report 2015*, pp 27, 29. TransGrid, *Annual Report 2014*, p 55.

11 HoustonKemp, *Electricity Network Service Standards: An Overview*, 2 September 2014, p 27.

2.5 AER determination

Under the National Electricity Rules (NER), the Australian Energy Regulator (AER) is responsible for the economic regulation of electricity transmission in the NEM.

The AER determines the amount of revenue TransGrid can recover from consumers over a defined regulatory control period. It must take the reliability standards as an independent obligation on the business and determine the efficient expenditure required to meet this obligation. The current regulatory control period commenced 1 July 2015 and ends on 30 June 2018. We are reviewing the reliability standards that will apply in the following regulatory control period which commences 1 July 2018.

Under the AER's price determination, the Service Target Performance Incentive Scheme adjusts the maximum allowed revenue each year based on a TNSP's service performance in the preceding year. The AER approves parameter values for each TNSP as part of its determination.

Also as part of its determination the AER must approve TransGrid's pricing methodology and negotiating framework. The revenue cap and pricing methodology only apply to TransGrid's prescribed transmission services which are those services which TransGrid is required to provide and are subject to regulated performance requirements.[12]

2.6 Annual transmission planning requirements

The NER require TransGrid to undertake an annual planning review. The purpose of the review is to identify an optimum level of transmission investment so that TransGrid can deliver its services efficiently. The annual review identifies any emerging constraints within the transmission network and identifies possible options to overcome them including considering non-network solutions.

12 The NER define which transmission network services are 'prescribed services' and 'negotiated services'. (See National Electricity Rules - Glossary, available at: http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Current-Rules, accessed 3 December 2015.)

In planning transmission augmentations, TransGrid must apply the regulatory investment test for transmission (RIT-T) to most planned investments. The RIT-T involves cost benefit analysis to identify the investment option that maximises net economic benefits and, where applicable, meets the relevant jurisdictional or Electricity Rule based reliability standards.[13] The process considers all credible options that are technically and economically feasible, including non-network options.

The NSW Government has directed TransGrid to implement the Transmission Standard in developing its investment plans. [14]

Its investment plans must also consider the demand for electricity (ie, load). To understand the likely changes in the demand for electricity, TransGrid looks at forecast annual energy use published by the AEMO for the NSW region, and forecast maximum demands for the NSW region (including the ACT). The need for network augmentation is driven by maximum demand, but energy forecasts can usefully reflect broader drivers that may impact the future use of the network.

For the 2015 annual planning review, the forecasts that TransGrid relies on indicate that annual electricity consumption in the NSW region (including the ACT) is likely to grow by an average of 1% per annum for the next 10 years, driven mainly by lower energy prices, population growth and increased income.[15] In comparison, the projected annual growth rate in the 2014 annual planning review was 0.4%.[16] Maximum demand is projected to grow at 1.2% per annum in summer and 1.4% in winter, based on 50% Probability of Exceedance (POE) conditions (see Box 2.2).[17]

While the aggregated maximum demand is increasing, individual bulk supply point forecasts increase at some locations, and decrease at others. Annual average rates of change in maximum demand for each bulk supply point are summarised in Appendix B.

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13 The RIT-T does not apply in circumstances where the estimated capital cost of new network investment is less than $5 million. Further, where transmission investment is subject to the RIT-T and the preferred option does not exceed a cost threshold of $35 million, the network service provider preparing the RIT-T may be exempted from parts of the RIT-T consultation procedures (AER, *Cost Thresholds Review for the Regulatory Investment Test for Transmission*, November 2012, p 5).

14 TransGrid, *NSW Transmission Annual Planning Report 2015*, p 18.

15 TransGrid, *NSW Transmission Annual Planning Report 2015*, pp 8, 23, 27.

16 TransGrid, *NSW Transmission Annual Planning Report 2015*, pp 8, 23.

17 TransGrid, *NSW Transmission Annual Planning Report 2015*, pp 8, 29, 30.

Box 2.2 Maximum demand forecasts

The AEMO produces maximum demand forecasts for the NEM and each of the five NEM regions, including NSW, over a 20-year outlook period. It has also produced transmission bulk supply point forecasts for 2015-16 to 2024-25.

The maximum demand for a bulk supply point or region is the highest level of electricity drawn from the transmission network in that area in any half hour increments It is measured in megawatts (MW).

The maximum demand forecasts are based on 10%, 50% and 90% POE, for both summer (2015-16 to 2024-25) and winter (2015 to 2024) A POE refers to the likelihood that a maximum demand forecast will be met or exceeded at least once during the season. For any given season:

- The 10% POE implies that there is a 10% probability of the forecast maximum being met or exceeded at least once during the season.
- The 50% POE implies that there is a 50% probability of the forecast maximum being met or exceeded at least once during the season.

The key driver of variability in demand is usually ambient temperature.

The bulk supply point forecasts are "non-coincident". Non-coincident forecasts are the maximum demand forecasts of a bulk supply point, regardless of when the system peak occurs. Coincident forecasts are the maximum demand forecasts of a bulk supply point at the time the system peak occurs.

Sources: AEMO, *Detailed Summary of 2015 Electricity Forecasts; 2015 National Electricity Forecasting Report*, Published: June 2015; AEMO, *2015 AEMO Transmission Connection Point Forecasting Report; For New South Wales Including (sic) The Australian Capital Territory*, Published: June 2015.

TransGrid identified that the only areas where load growth is expected to lead to network limitations are the Gunnedah/Narrabri area and the Beryl/Mudgee area.[18]

TransGrid's Transmission Annual Planning Report 2015 takes into account the AER's final revenue determination for the 2014-15 to 2017-18 regulatory control period.[19]

18 TransGrid, *NSW Transmission Annual Planning Report 2015*, p 35.
19 TransGrid, *NSW Transmission Annual Planning Report 2015*, p 20.

2.7 Long-term lease of transmission assets

The NSW Government is leasing 49% of the NSW electricity networks (including transmission and distribution). The lease to the consortium NSW Electricity Networks includes 100% of the TransGrid network.[20]

The Government is also proceeding with the partial lease of two of NSW's distribution network service providers - Ausgrid and Endeavour Energy. The state's other distribution network service provider, Essential Energy, will remain wholly Government owned.

The framework for setting reliability standards, and the reliability standards themselves, are independent of ownership. These arrangements, and the reliability outcomes the businesses are required to meet, will therefore not change as a consequence of the proposed lease of the businesses.[21]

As part of the NSW Government's leasing of electricity distribution and transmission service providers, it has transferred the electricity safety and reliability regulatory functions to IPART from the NSW Department of Industry. This transfer took effect from 5 June 2015 when the *Electricity Network Assets (Authorised Transactions) Act 2015* was enacted.

20 NSW Government, *NSW achieves outstanding result in $10.258 billion TransGrid lease*, Media Release, 25 November 2015.

21 HoustonKemp, *Electricity Networks Service Standards: An Overview*, 2 September 2014, p 1.

3 Matters we are required to consider in the review

Our terms of reference for this review indicate that the NSW Government has decided to broadly adopt the approach to transmission reliability standard setting recommended by the AEMC. They also indicate that in undertaking the review, we should have regard to this approach and to the most recent VCR published by AEMO.

3.1 Terms of reference

Our terms of reference require us to develop an economic assessment methodology having regard to, among other considerations, the most recent VCR published by AEMO.

After developing the methodology, we are to:

- select a range of feasible reliability scenarios from reliability scenarios developed by the NSW Transmission Operator (a role performed by TransGrid) in consultation with its customers
- undertake an economic assessment using probabilistic analysis, or other appropriate analytical techniques, to evaluate how efficient network capital and operating costs vary with different levels of reliability, and then compare the level of expected capital and operating expenditure against the value that customers place on reliability for each selected scenario, and
- recommend the transmission reliability standards for the NSW Transmission Operator to the Minister to apply to the regulatory control period commencing 1 July 2018.

When recommending the transmission reliability standards to the Minister, we are to consider the transmission reliability standards recommended by the AEMC (if any) and any other matter considered relevant including:

- a required level of network capability informed by an economic assessment process to be expressed in terms of a network redundancy/N-x standard, and
- a requirement relating to when supply would need to be restored following planned and unplanned interruptions at a bulk supply point.

3.2 AEMC's recommended approach to transmission reliability standard setting

The AEMC reviewed transmission reliability at the request of the COAG Energy Council and released its final report in February 2013.[22] In this report, it recommended a framework for setting and regulating reliability standards in all jurisdictions of the NEM. This framework involves:

- understanding how the costs of building and operating the transmission network vary with different reliability outcomes, and
- using the costs to customers of interruptions to their electricity supply to guide the setting of the reliability standards.[23]

The AEMC considers that the framework will promote greater efficiency, transparency and community consultation in the standard setting process.

For the purpose of our review, the key features of the framework are the expression of the reliability standards and the economic assessment component of the standard setting process.

3.2.1 Expression of reliability standards

Under the AEMC framework, transmission reliability standards are set for each bulk supply point in the network. At a minimum, the standards contain two measures for each bulk supply point:

- a required level of network capability to be informed by an economic assessment process and expressed in terms of network redundancy (N-x), and
- a requirement relating to when supply needs to be restored following an interruption to supply.

The AEMC considers that the expression of reliability standards in terms of N-x does not imply that a standard can only be met by undertaking network investment. Demand-side options (eg, load curtailment) and local generation in combination with the existing network can also be used to deliver the required level of network capability.

22 AEMC, *Review of the national framework for transmission reliability*, *Final Report,* November 2013.
23 AEMC, *Review of the national framework for transmission reliability*, *Final Report,* November 2013, p i.

3.2.2 Economic assessment process

The AEMC framework sets out a number of stages in the reliability setting process and identifies the parties responsible. Under this framework, the economic advisor (IPART):

- selects a range of feasible reliability scenarios from scenarios developed by TransGrid following a customer consultation process
- conducts an economic assessment to assess the costs and benefits of each reliability scenario to identify the level of reliability that delivers the maximum net benefit
- prepares and publishes a draft report and allows for customer consultation, and
- prepares and publishes a final report on the outcomes of the economic assessment for the range of reliability scenarios considered.

The economic assessment process involves assessing the costs and benefits of each reliability scenario. The steps involved in this process are:

- assessing how the costs of building and operating the network vary under the different reliability scenarios
- estimating the costs of interruptions, based on the probability of load lost, the expected duration, the nature of the load affected, and the associated value of customer reliability, and
- using the costs to customers of interruptions to their supply of electricity to identify the reliability standard which delivers the maximum net benefit to customers.

This process evaluates the trade-off between network costs and different levels of reliability using cost estimates and estimates of the value of customer reliability.

More detail on the AEMC's recommended approach can be found in its Final Report (See http://www.aemc.gov.au/Markets-Reviews-Advice/Review-of-the-national-framework-for-transmission).

3.3 Most recent values of customer reliability published by AEMO

AEMO has recently conducted a review of VCR at the request of the then Standing Council of Energy and Resources (now the COAG Energy Council).

The purpose of the review was to better understand the level of reliability customers expect by producing a range of VCR for residential and business customers across the NEM. These measures, expressed as dollars per kilowatt-hour, indicate the value different types of customer place on having reliable electricity supply.

Overall, AEMO found that the NEM-wide value ($2014) of customer reliability for:

- residential customers is $25.95 per kilowatt-hour (kWh) of unserved energy
- agricultural, commercial, and industrial business customers ranges from $44.06 per kWh to $47.67 per kWh of unserved energy, and
- direct connect customers is $6.05 per kWh of unserved energy.[24]

AEMO found that the aggregated NEM-wide value of reliability for all customer types is $33.46 per kWh of unserved energy.

We propose to use the AEMO's VCR to estimate the value of expected unserved energy for each scenario. Further information on how we propose to apply the values is provided in section 5.3.2.

24 AEMO, *Value of Customer Reliability Review - Final Report*, September 2014, p 2.

4 Selecting the feasible reliability scenarios

As Chapter 3 discussed, for this review we are required to select a range of feasible reliability scenarios based on those developed by TransGrid following its customer consultation process. Then we are to undertake an economic assessment of each of these scenarios and publish the results in our draft report.

TransGrid has developed four reliability scenarios, which it proposes we use for our assessment. The sections below:

- outline how TransGrid developed these scenarios
- explain how it has expressed the scenarios
- summarise these scenarios, and
- discuss how we propose to select the range of scenarios we will use for our economic assessment.

Chapter 5 explains our proposed approach for this economic assessment.

4.1 Developing the reliability scenarios

On 4 August 2015, TransGrid held a workshop on reliability standards in Sydney. It also held a webinar on 19 August.[25] The purpose of these consultation events was to understand customer preferences for TNSP reliability levels in NSW. They included presentations from TransGrid and the AEMO, as well as Q&A sessions, discussions and scenario-based activities with participants. At these events:

- Most participants agreed that the best way to express the reliability standard is as 'an economically justified reliability standard (n-x)' because it is easy to understand.
- Participants had widely different opinions on what constitutes acceptable supply interruptions, but many suggested that there should be minimal interruptions to supplying critical loads in the CBD.[26]

25 NewGate, *TransGrid's Reliability Standards Consultation*, 31 August 2015, p 3.
26 NewGate, *TransGrid's Reliability Standards Consultation*, 31 August 2015, pp 10, 12.

Based on the outcomes of this consultation, TransGrid developed four reliability scenarios that it considers are feasible and reflect customer preferences:

- Scenario 1 is the base case and reflects the current reliability standards across the transmission network
- Scenario 2 involves a small decrease in overall transmission reliability
- Scenario 3 involves a slightly bigger decrease in transmission reliability, and
- Scenario 4 involves a small increase in transmission reliability.

4.2 Expressing the reliability scenarios

TransGrid has grouped bulk supply points into three different categories. In the base case scenario, Category 1 includes a number of special cases, such as Broken Hill, where investment in network redundancy is likely to be very expensive; Category 2 includes most of NSW; and Category 3 includes the Sydney CBD.

In all four scenarios:

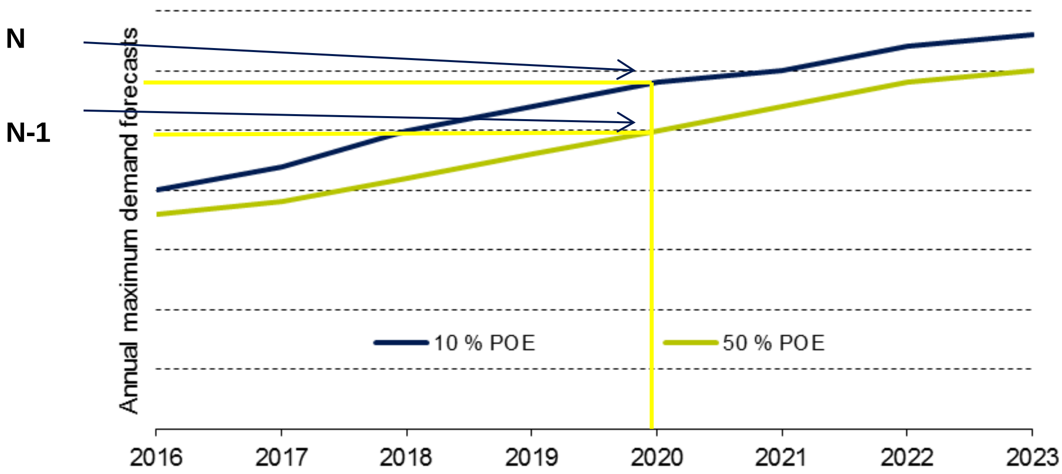
- Category 1 bulk supply points are required to meet an N base standard (ie, no network redundancy).
- Category 2 bulk supply points are required to meet an N-1 base standard (ie, one level of network redundancy).
- Category 3 bulk supply points are required to meet an N-2 base standard (ie, two levels of network redundancy).

The scenarios vary in terms of the maximum load (MW) that the network must be capable of delivering to each bulk supply point and at each level of redundancy. They also vary in terms of the amount of energy (MWh) that may be at risk of not being supplied.

In addition, in the scenarios that involve a decrease in reliability, TransGrid has assigned more bulk supply points to Category 1. That is, under Scenarios 2 and 3, more connections points would be subject to the N standard and fewer would be subject to the N-1 standard. We show which connections are re-categorised in our description of the scenarios below.

In each scenario, the maximum load (MW) that the network is expected to be capable of delivering to each bulk supply point is described with reference to the AEMO’s maximum demand forecasts, described in Box 2.2. In particular, it has used the maximum demand forecasts for each bulk supply point that is based on a 10% and a 50% POE. Figure 4.1 shows a stylised example of how maximum demand forecasts are used to inform the network capacity TransGrid must deliver. For example, in 2020, the network is built to an N-1 standard with an equivalent capacity of 50 % POE maximum demand and an N standard with an equivalent capacity of 10 % POE maximum demand.

Figure 4.1 Using maximum demand forecasts in network planning



Note: Stylised example.

For Scenarios 2 and 3 (small and slightly bigger decrease in reliability), TransGrid has used the same maximum load forecasts for each scenario but reduced the percentage of maximum forecast demand that it can meet each year. For Scenario 4 (small increase in reliability), it has used a higher maximum load forecast for Category 2 and 3 bulk supply points. In general, using higher maximum demand forecasts in network planning leads to higher levels of capital and operating costs (all other things being equal). The higher costs are ultimately paid for by electricity customers. However, capital and operating costs may be able to be reduced by adopting non-network solutions to meet the required level of reliability.

In all scenarios, TransGrid has expressed the maximum energy at risk of not being supplied in terms of a percentage of the maximum forecast demand that it may not meet, rather than how long the supply interruption will last. As section 3.2 noted, under the AEMC's framework, transmission reliability standards should include a requirement related to when supply needs to be restored following an interruption to supply. TransGrid has advised that the time for restoration of a failed transmission asset depends on the asset's type and the level of damage to it, and could vary from several hours to several months. The restoration times cannot be significantly improved, unless redundant assets are maintained at the sites themselves – either as energised in-service units or de-energised standby units. (Appendix C provides more detail on restoration times, including historical restoration times observed for TransGrid's assets.)

TransGrid considers that including a requirement related to energy at risk of not being supplied is a more flexible alternative to one about when supply needs to be restored following an interruption to supply.

IPART seeks comment on the following

1 Do you agree that bulk supply points should be classified into three categories based on level of network redundancy (none, one or two levels of redundancy) for each scenario? Are there alternative ways of classifying bulk supply points and/or should there be more categories?

2 Do you agree that variation in the level of reliability should be expressed in terms of the maximum load (MW) that the network must be capable of delivering to each bulk supply point and at each level of redundancy, and the amount of energy (MWh) that may be at risk of not being supplied? Are there other measures we should include in the expression of reliability standards?

3 Do you agree with TransGrid's proposal to include in the reliability standards a requirement related to energy at risk rather than include specific restoration times after a planned or unplanned supply interruption? If not, how could we include restoration times in the scenarios?

4.3 TransGrid's four scenarios

The sections below provide a summary of TransGrid's four reliability scenarios. The full scenarios, including the categorisation of bulk supply points, can be found in Appendix C. Box 4.1 provides an example of how these scenarios would apply to a Category 2 (one level of redundancy) bulk supply point.

4.3.1 Reliability scenario 1 – maintaining the current level of transmission reliability

The first reliability scenario (or base case) involves no change in the prescribed levels of reliability. The network capacity for each level of redundancy and for each type of bulk supply point is summarised in Table 4.1.

Table 4.1 Reliability scenario 1 – network capacity

Bulk supply point category	N	N-1	N-2
Category 1 (13 bulk supply points)	100% of 10% POE	NA	NA
Category 2 (85 bulk supply points)	100% of 10% POE	100% of 50% POE	NA
Category 3 (Sydney Inner Metropolitan area)	100% of 10% POE	100% of 50% POE	100% of 50% POE

Source: TransGrid's reliability scenarios (see Appendix C of this Issues Paper).

Under this scenario:

- For Category 1 bulk supply points, TransGrid will provide N security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults.
- For Category 2 bulk supply points, TransGrid will provide N-1 security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults, and 100% of the 50% POE maximum demand forecast when there is one asset fault.
- For Category 3 bulk supply points, TransGrid will provide N-2 security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults, and 100% of the 50% POE maximum demand forecast when there is a simultaneous outage of a 330 kV and a 132 kV asset.

TransGrid will endeavour to ensure that there is no unserved energy in a 12-month period. In the event of an interruption, for each category, TransGrid will endeavour to restore N, N-1 or N-2 equivalent capacity as soon as possible.

4.3.2 Reliability scenario 2 – a small reduction in transmission reliability

The second reliability scenario involves a small reduction in the prescribed reliability levels (relative to scenario 1). The network capacity for each level of redundancy and for each type of bulk supply point is summarised in Table 4.2. In addition, all bulk supply points with 50% POE maximum demand forecast of less than 15 MW would be classified as Category 1. This means that the following bulk supply points move from an N-1 standard to an N standard in scenario 2, compared to the base case:

- Balranald 22 kV
- Boggabri East
- Brandy Hill 132 kV
- Coleambally 132 kV
- Cooma 11 kV
- Glen Innes 66 kV
- Macksville 132 kV
- Manildra 132 kV
- Molong 66 kV
- Nambucca 66 kV
- Raleigh 132 kV
- Tenterfield 22 kV
- Yass 66 kV

Table 4.2 Reliability scenario 2 – network capacity

Bulk supply point category	N	N-1	N-2
Category 1 (26 bulk supply points)	100% of 10% POE	NA	NA
Category 2 (72 bulk supply points)	100% of 10% POE	95% of 50 % POE	NA
Category 3 (Sydney Inner Metropolitan area)	100% of 10% POE	95% of 50 % POE	95% of 50% POE

Source: TransGrid's reliability scenarios (see Appendix C of this Issues Paper).

Under this scenario:

- For Category 1 bulk supply points, TransGrid will provide N security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults.
- For Category 2 bulk supply points, TransGrid will provide N-1 security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults, and **95%** of the 50% POE maximum demand forecast when there is one asset fault.
- For Category 3 bulk supply points, TransGrid will provide N-2 security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults, and **95%** of the 50% POE maximum demand forecast when there is a simultaneous outage of a 330 kV and a 132 kV asset.

In the event of an interruption, for each category, TransGrid will endeavour to restore N, N-1 or N-2 equivalent capacity as soon as possible. For Category 2 and Category 3 bulk supply points, TransGrid will endeavour to ensure that the expected total unserved energy in a 12-month period is less than the equivalent of 5% of the 50% POE maximum demand forecast not served over a 20-hour period.

4.3.3 Reliability scenario 3 – a slightly bigger reduction in transmission reliability

The third reliability scenario involves a larger decrease in prescribed reliability levels. The network capacity for each level of redundancy and for each type of bulk supply point is summarised in Table 4.3. In addition, all bulk supply points with a 50% POE maximum demand forecast of less than 30 MW would be classified as Category 1. This means that the following bulk supply points move from an N-1 standard to an N standard in scenario 2, compared to the base case:

- Balranald 22 kV
- Boambee South 132 kV
- Boggabri East
- Boggabri North
- Brandy Hill 132 kV
- Coleambally 132 kV
- Cooma 11 kV
- Cooma 66 kV
- Finley 66 kV
- Glen Innes 66 kV
- Gunnedah 66 kV
- Kempsey 33 kV
- Macksville 132 kV
- Manildra 132 kV
- Molong 66 kV
- Nambucca 66 kV
- Parkes 66 kV
- Raleigh 132 kV
- Taree 33 kV
- Tenterfield 22 kV
- Wagga North 66 kV
- Yass 66 kV

Table 4.3 Reliability scenario 3 – network capacity

Bulk supply point category	N	N-1	N-2
Category 1 (35 bulk supply points)	100% of 10% POE	NA	NA
Category 2 (63 bulk supply points)	100% of 10% POE	90% of 50% POE	NA
Category 3 (Sydney Inner Metropolitan area)	100% of 10% POE	90% of 50% POE	90% of 50% POE

Source: TransGrid's reliability scenarios (see Appendix C of this Issues Paper).

Under this scenario:

- For Category 1 bulk supply points, TransGrid will provide N security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults.
- For Category 2 bulk supply points, TransGrid will provide N-1 security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults, and **90%** of the 50% POE maximum demand forecast when there is one asset fault.

- For Category 3 bulk supply points, TransGrid will provide N-2 security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults, and **90%** of the 50% POE maximum demand forecast when there is a simultaneous outage of a 330 kV and a 132 kV asset.

In the event of an interruption, for each category, TransGrid will endeavour to restore N, N-1 or N-2 equivalent capacity as soon as possible. For Category 2 and Category 3 bulk supply points, it will endeavour to ensure that the expected total unserved energy in a 12-month period is less than the equivalent of 10% of the 50% POE maximum demand forecast not served over a 20-hour period.

Reliability scenario 4 – a small increase in transmission reliability

The fourth reliability scenario involves a small increase in prescribed reliability levels (relative to Scenario 1). The network capacity for each level of redundancy and for each type of bulk supply point is summarised in Table 4.4.

Table 4.4 Reliability scenario 4 – network capacity

Bulk supply point category	N	N-1	N-2
Category 1 (13 bulk supply points)	100% of 10% POE	NA	NA
Category 2 (85 bulk supply points)	100% of 10% POE	100% of 10% POE	NA
Category 3 (Sydney Inner Metropolitan area)	100% of 10% POE	100% of 10% POE	100% of 10% POE

Source: TransGrid's reliability scenarios (see Appendix C of this Issues Paper).

Under this scenario:

- For Category 1 bulk supply points, TransGrid will provide N security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults.
- For Category 2 bulk supply points, TransGrid will provide N-1 security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults, and **100%** of the **10%** POE maximum demand forecast when there is one asset fault.
- For Category 3 bulk supply points, TransGrid will provide N-2 security – ie, the network must have the capacity to supply 100% of the 10% POE maximum demand forecast when there are no asset faults, and **100%** of the **10%** POE maximum demand forecast when there is a simultaneous outage of a 330 kV and a 132 kV asset.

TransGrid will endeavour to ensure that there is no unserved energy in a 12-month period. In the event of an interruption, for each category, TransGrid will endeavour to restore N, N-1 or N-2 equivalent capacity as soon as possible.

Box 4.1 Applying the reliability scenarios to a Category 2 bulk supply point

Port Macquarie is a Category 2 bulk supply point under all four of TransGrid's reliability scenarios. For 2017-18, the AEMO's 10% POE forecast maximum demand is 71.1 MW and the 50% POE forecast maximum demand is 67.9 MW.

Under all four scenarios, the transmission network must be able to deliver 71.1 MW to this bulk supply point (the 10% POE forecast maximum demand).

Under the base case, scenario 1, if there is one asset fault, the network must be able to deliver **67.9 MW** (100% of the 50% POE) to this bulk supply point. In the event of an interruption to supply (two asset faults), the TNSP will endeavour to restore 67.9 MW equivalent capacity as soon as reasonable (100% of the 50% POE).

Under scenario 2, if there is one asset fault, the network must be able to deliver **64.5 MW** (95% of 50% POE)**.** The maximum amount of energy that may not be met in a 12-month period is less than **67.9 MWh** (5% of the 50% POE for a 20-hour period).

Under scenario 3, if there is one asset fault, the network must be able to deliver **61.1 MW (**90% of the 50% POE). The maximum amount of energy that may not be met in a 12-month period is less than **135.8 MWh** (10% of the 50% POE for a 20-hour period).

Under scenario 4, if there is one asset fault, the network must still be able to deliver **71.1 MW** (100% of the 10% POE). In the event of an interruption to supply, the TNSP will endeavour to restore 71.1 MW equivalent capacity as soon as reasonable (100% of the 10% POE).

Source: IPART using AEMO connection point forecasts (AEMO, Dynamic interface for connection points in for New South Wales, including the Australian Capital Territory, available: http://www.aemo.com.au/Electricity/Planning/Forecasting/AEMO-Transmission-Connection-Point-Forecasting/Transmission-Connection-Point-Forecasts-for-NSW-including-the-ACT, accessed: 16 November 2015).

4.4 Selecting the range of feasible reliability scenarios to be assessed

We are seeking stakeholder comments on these four scenarios. Depending on the outcome of this consultation, we may make changes to these scenarios, or add additional scenarios, before proceeding with our economic assessment (discussed in Chapter 5).

In our preliminary view, the selected reliability scenarios should include a base case that reflects the reliability standards that TransGrid currently uses in its investment planning decisions. The alternative reliability scenarios should be materially different from the base case and each other in terms of the reliability levels the transmission network would have to achieve.

We expect that any change in the reliability standards in the longer term will change the level of TransGrid's operating and capital expenditures.

IPART seeks comment on the following

4 Do you agree with TransGrid's proposed categorisation of bulk supply points for each scenario? In particular, should some bulk supply points be allocated to a different category? (See Appendix C of this Issues Paper for detail on the proposed categorisation.)

5 Are the parameter values (% of maximum demand forecast to be delivered in the event of asset failure(s), and hours of expected unserved energy in the event of an interruption to supply) suitable to obtain material differences in reliability for modelling?

6 Are there any additional scenarios IPART should consider?

5 Our proposed economic assessment methodology

As Chapter 4 indicated, once we have selected a range of feasible reliability scenarios, we will undertake an economic assessment of these scenarios. We will consider the outcomes of this assessment to form our recommendations to the Minister on the transmission reliability standards to apply to the NSW transmission network from 1 July 2018.

We have developed a methodology for this economic assessment that is based on the framework developed by the AEMC.[27] This framework provides a robust methodology to identify the level of reliability that provides the highest net benefits, taking into account:

- the expected network costs of providing a given level of network reliability, and
- the expected value of unserved energy to consumers associated with that level of reliability, based on the probabilities of transmission equipment failure, the expected duration of outages, and the value that customers place on reliability.

The sections below provide an overview of our proposed methodology, and discuss the first two steps in more detail.

5.1 Overview of proposed economic assessment methodology

Our proposed economic assessment involves, for each of the selected reliability scenarios:

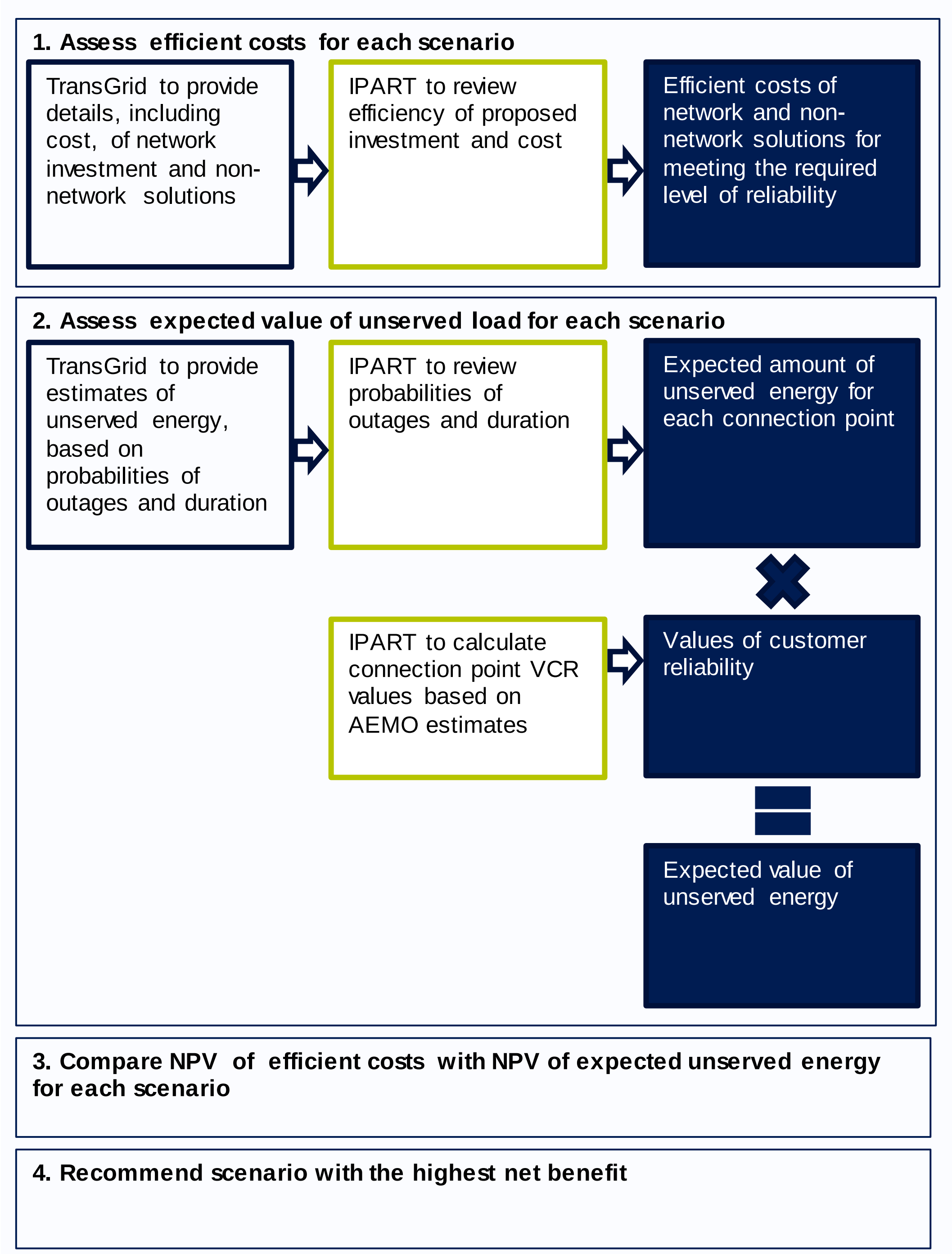
1. Assessing the expected efficient cost of meeting the reliability levels under the scenario, including capital and operating network costs and the cost of non-network solutions.
2. Assessing the expected amount of unserved energy under the scenario (using the probability of supply interruptions and the nature and duration of expected outages) and the value of this unserved energy to customers (using AEMO's latest VCR).

27 AEMC, *Review of the national framework for transmission reliability*, Final Report, November 2013.

3. Comparing the NPV of the expected unserved energy to the NPV of the expected efficient cost of meeting the reliability levels under the scenario. And then,
4. identifying the scenario that results in the highest net benefits for consumers of electricity.

This approach is summarised in the figure below.

Figure 5.1 Proposed economic assessment methodology



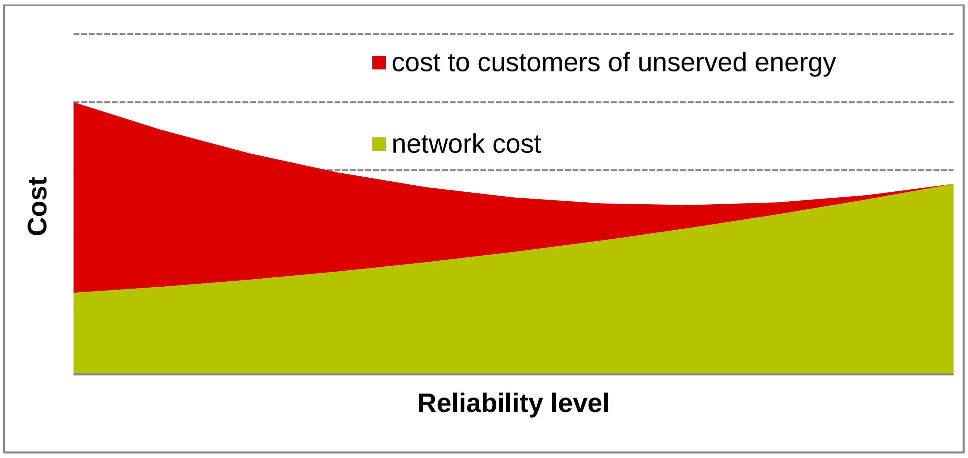
The purpose of applying this economic assessment methodology is to compute the efficient level to set transmission reliability standards. At this efficient level, the cost of meeting the reliability standards is equal to the cost to customers of interruptions to supply (based on the value customers place on reliability).

To illustrate this approach, Figure 5.2 shows a stylised example of the relationship between the annual cost of building and operating a transmission network and the cost of interruptions to supply:

- The upward sloping curve shows that the costs of meeting the required standard rise as the level of reliability increases.
- The downward sloping curve shows that the costs to customers of interruptions to supply fall as the level of reliability increases.

The efficient level of reliability is the point where the cost of unserved energy to customers is minimised. This level of reliability results in maximum net benefits to consumers of electricity. For any departure from this point, either the additional costs of providing a higher level of reliability would outweigh the additional benefits of this higher reliability to customers, or the savings from providing a lower level of reliability would be outweighed by the reduction in benefits of higher reliability.

Figure 5.2 Estimating the efficient level of network reliability



Note: Stylised example not based on actual data.

IPART seeks comment on the following

7 Do you agree with our proposed economic assessment methodology?

5.2 Assessing efficient cost of meeting reliability levels under each scenario

The first step of our proposed methodology is to assess the expected efficient cost of meeting the reliability levels under each of the selected scenarios. In general, the purpose of considering the efficiency of costs is to ensure that outputs are provided at least cost. For this review, the outputs are specific levels of network reliability.

For each scenario, we will ask TransGrid to provide the forecast capital and operating costs of meeting the required level of reliability for each bulk supply point, including the assumptions it made about non-network solutions in developing these cost forecasts. With assistance from our consultant, we will then assess the efficiency of its forecast costs and review its assumptions on non-network solutions.

5.2.1 Assessing efficiency of TransGrid's forecast costs

We do not propose to conduct a full efficiency review of TransGrid's capital and operating costs as part of our review, as the Australian Energy Regulator (AER) does this as part of its maximum revenue determinations. Nor can we rely on the results of the AER's most recent determination. To make our recommendations, we need to consider the efficient costs to meet different levels of reliability. In contrast, the AER's determination reflects the efficient costs to meet the reliability standards in place at the time of its decision.

We propose to use two approaches to assess the efficiency of TransGrid's forecast costs for each bulk supply point:

1. Compare TransGrid's unit costs to equivalent unit costs proposed for similar works by TransGrid's peers.
2. Assess the forecast costs taking into account required network capacity, non-network solutions, probabilities of supply interruptions, expected duration of outages, and age and state of equipment to form a judgement about the efficiency of the cost forecasts provided by TransGrid.

As an alternative to the benchmarking approach (or to complement this approach), we could use TransGrid's cost functions and the probabilities of network failures to model the efficient costs under each scenario. This option is more complex. However, our preference is to rely on the two approaches outlined in dot points one and two above. For this review, we are concerned about how the efficient costs change with changes in the level of reliability than the quantum of these costs.

5.2.2 Reviewing TransGrid's assumptions on non-network solutions

We consider that non-network solutions must be included in our economic assessment methodology since direct investment may not always be the most efficient way to meet a required level of reliability.

TransGrid currently assesses non-network options alongside network solutions to address network constraints where feasible and cost-effective to do so. By taking this approach, it may be able to defer or avoid significant capital costs associated with network investment and deliver benefits to consumers through lower transmission prices. TransGrid currently considers a variety of non-network measures in its network planning. These include:

- Load curtailment. For example, in the CBD it may offer money to businesses willing to reduce their energy consumption during peak periods.
- On-site or local generation or storage. Consumers generate their own electricity to offset their impact on the network and possibly provide supply for other consumers during peak times.

We consider there is scope to implement non-network solutions that are cost effective for investors and energy users.

IPART seeks comment on the following

8 Do you agree with our proposed approach for assessing TransGrid's efficient costs?

9 What is the best way to assess the value and availability of non-network solutions?

5.3 Assessing expected value of unserved energy under each scenario

For the second step in our approach, we will ask TransGrid to provide the likely **amount (MWh)** of unserved energy at each bulk supply point under each scenario. We expect that TransGrid will estimate these amounts by modelling the probabilities of supply interruptions and their likely duration, taking into account the age of its network and other factors.

We propose to review these probabilities and durations to check they are reasonable. Then we will calculate the expected **value ($)** of unserved energy at each bulk supply point under each scenario by multiplying the expected amount of unserved energy by the relevant VCR ($ value per MWh).

5.3.1 Reviewing probabilities of outages and duration

With assistance from our consultant, we will review the analysis and modelling TransGrid undertook to estimate the amounts of unserved energy at each bulk supply point. We intend to benchmark TransGrid's probabilities of outages and their durations against those of similar businesses, and assess how they would change if the availability of non-network solutions changes.

5.3.2 Calculating expected value of unserved energy

To calculate the expected value of unserved energy, we will have regard to the most recent VCR published by AEMO (see section 3.3).

Different customers have different VCRs. For example, the value of reliability for business customers is generally higher than that for residential customers.[28] Different business customers will also have different VCRs. The AEMO's work captures some of these differences by disaggregating values by business sector and size, and by state for residential customers.

Because the mix of customers at each bulk supply point varies, we intend to calculate representative VCRs that take into account the types of customers that would be affected by an interruption to supply. We will inflate these values for future years if necessary. AEMO recommends using the CPI for indexation.[29] We will also explore modelling sensitivities around the estimates for the different customer categories in NSW. The AEMO considers +/-30%VCR is reasonable for sensitivity analysis.[30]

IPART seeks comment on the following

10 Is benchmarking a robust approach for reviewing TransGrid's probabilities of outages and their duration?

11 The AEMO has estimated values of customer reliability for different customer groups in NSW. What other estimates of the VCRs could be relevant for our review?

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28 AEMO, *Value of Customer Reliability Review - Final Report*, September 2014, p 1.

29 AEMO, *Value of Customer Reliability – Application Guide; Final Report*, December 2014, p 23.

30 AEMO, *Value of Customer Reliability – Application Guide; Final Report*, December 2014, p 15.

Appendices

A Terms of Reference

NSW GOVERNMENT

Premier of New South Wales

IPART

Doc No

File No

RECEIVED

INDEPENDENT PRICING & REGULATORY TRIBUNAL

Reference: A1330398

28 SEP 2015

Dr Peter Boxall
Chairman
Independent Pricing and Regulatory Tribunal
PO Box K35
HAYMARKET POST SHOP NSW 1240

Dear Dr Boxall

Pursuant to section 12A of the *Independent Pricing and Regulatory Tribunal Act 1992*, I am referring the following matter to the Tribunal for investigation and report: Transmission Reliability Standards. The Terms of Reference are enclosed.

This investigation should result in the development of a set of transmission reliability standards in advance of the next regulatory control period for the NSW Transmission Operator (currently known as TransGrid), commencing on 1 July 2018.

If your officers wish to discuss this matter they should contact Laura Christie, Director, Resources and Land Use Branch, Economic Policy Group, Department of Premier and Cabinet on 9228 4213.

Yours sincerely

MIKE BAIRD MP
Premier

GPO Box 5341, Sydney NSW 2001 ▪ P: (02) 9228 5239 ▪ F: (02) 9228 3935 ▪ www.premier.nsw.gov.au

A1330398

Terms of Reference

I Michael Bruce Baird, Premier of New South Wales, pursuant to section 12A of the *Independent Pricing and Regulatory Tribunal Act 1992*, refer the following matter to the Independent Pricing and Regulatory Tribunal "IPART" for investigation and report:

The recommendation of Electricity Transmission Reliability Standards

In November 2013 the Australian Energy Market Commission "AEMC" recommended a new framework for setting and regulating transmission reliability standards in its report *Review of the national framework for transmission reliability*, 1 November 2013 "the AEMC November 2013 Report".

In December 2014, the COAG Energy Council published its *Response to the Australian Energy Market Commission's Review of the National Framework for Distribution Reliability and Review of the National Framework for Transmission Reliability* "the COAG Energy Council Response".

The NSW Government has decided to broadly adopt the approach to standard setting recommended by the AEMC in the AEMC November 2013 Report and the National Electricity Network Reliability Principles and the Minimum Requirements for setting reliability targets set out in the COAG Energy Council Response.

IPART's investigation will result in a set of transmission reliability standards being recommended to the NSW Minister for Industry, Resources and Energy (the "Minister") in time for the standards to be set in advance of the next regulatory control period for the NSW Transmission Operator (currently known as TransGrid) commencing on 1 July 2018.

Consistent with this, IPART, under this reference, is to provide advice to the Minister and carry out the role of economic advisor as set out in the AEMC November 2013 Report:

- **Standard setter**. As standard setter, the Minister will set the transmission reliability standards for NSW.

  IPART is to assist the Minister in this role by:
  a. selecting the reliability scenarios to be economically assessed from scenarios initially provided by the NSW Transmission Operator; and
  b. recommending the transmission reliability standards to the Minister.

  When recommending the transmission reliability standards to the Minister, IPART should consider the transmission reliability standards recommended by the AEMC (if any) and any other matter considered relevant including:
  i. a required level of network capability informed by an economic assessment process to be expressed in terms of a network redundancy/N-x standard; and
  ii. a requirement relating to when supply would need to be restored following planned and unplanned interruptions at a connection point.

- **Economic advisor.** IPART should undertake an economic assessment of the efficient costs and reliability impact for each selected reliability scenario, based on information obtained from the NSW Transmission Operator and any other information considered relevant by IPART and provide a report to the Minister on its assessment.

As part of undertaking its investigation:

2

IPART is to develop an economic assessment methodology having regard to, amongst other considerations, the most recent values of customer reliability published by AEMO. That methodology is to be used during the standard setting process in formulating IPART's recommendations

After development of the methodology, IPART is to:

a. select a range of feasible reliability scenarios from reliability scenarios developed by the NSW Transmission Operator following a customer consultation process;
b. undertake an economic assessment using probabilistic analysis, or other appropriate analytical techniques, to evaluate how efficient network capital and operating costs vary with different levels of reliability, and then compare the level of expected capital and operating expenditure against the value that customers place on reliability for each selected scenario; and
c. recommend the transmission reliability standards for the NSW Transmission Operator to the Minister to apply to the regulatory control period commencing 1 July 2018.

Consultation

IPART should, when undertaking its investigation, conduct a public consultation process at appropriate stages of the review to ensure that the standard setting process is open and transparent and involves all relevant stakeholders.

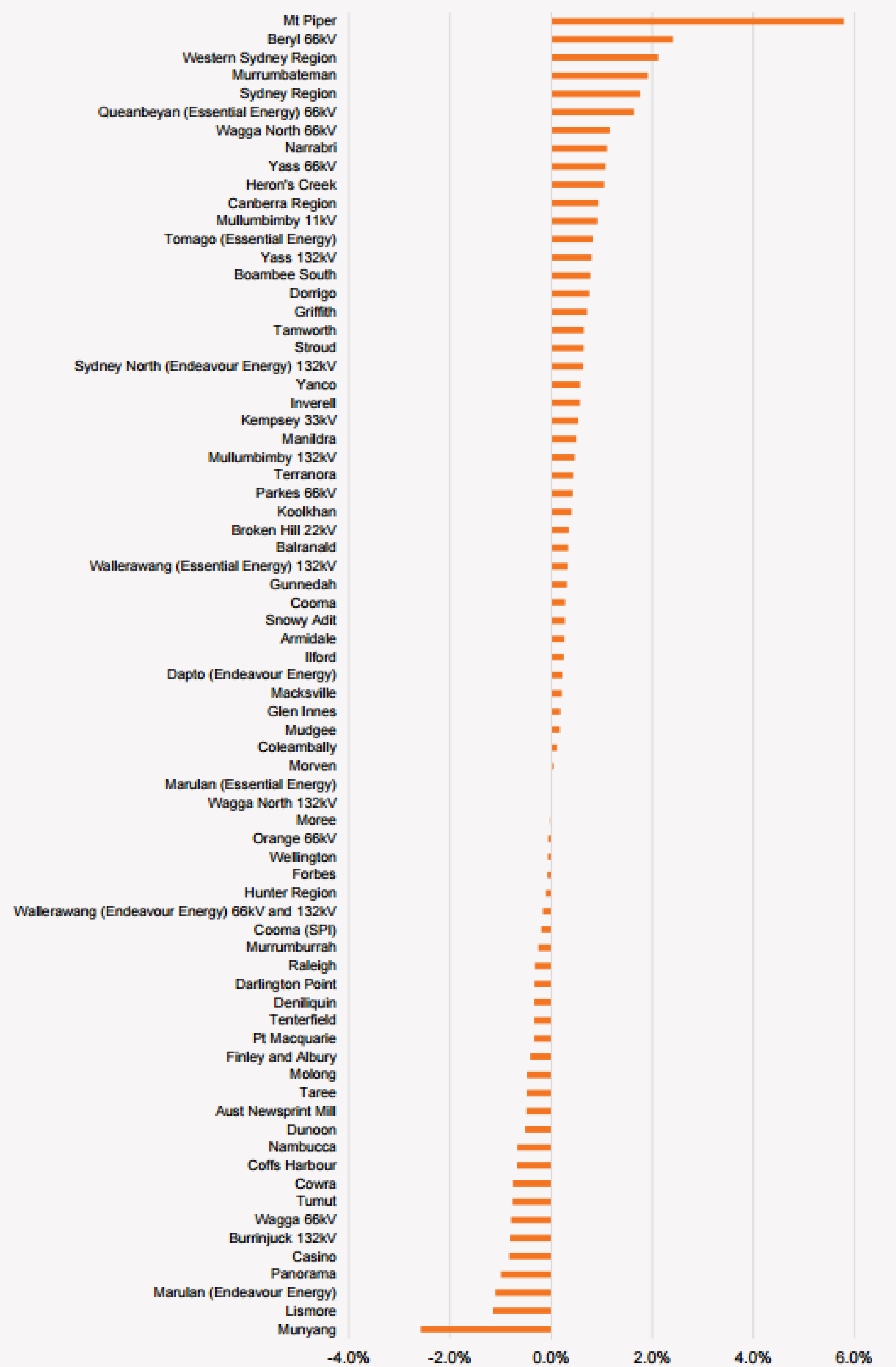
Timeline

IPART is to conduct the review and publish a draft report on its economic assessment on selected scenarios within 6 months of receiving TransGrid's scenarios and will provide a final report to the Minister and recommendations on reliability standards within a further 3 months from publishing its draft report.

The target date for the final report recommending reliability standards to the Minister is end May 2016, however it is recognised that meeting this date will depend upon the NSW Transmission Operator providing reliability scenarios to the Tribunal by October 2015.

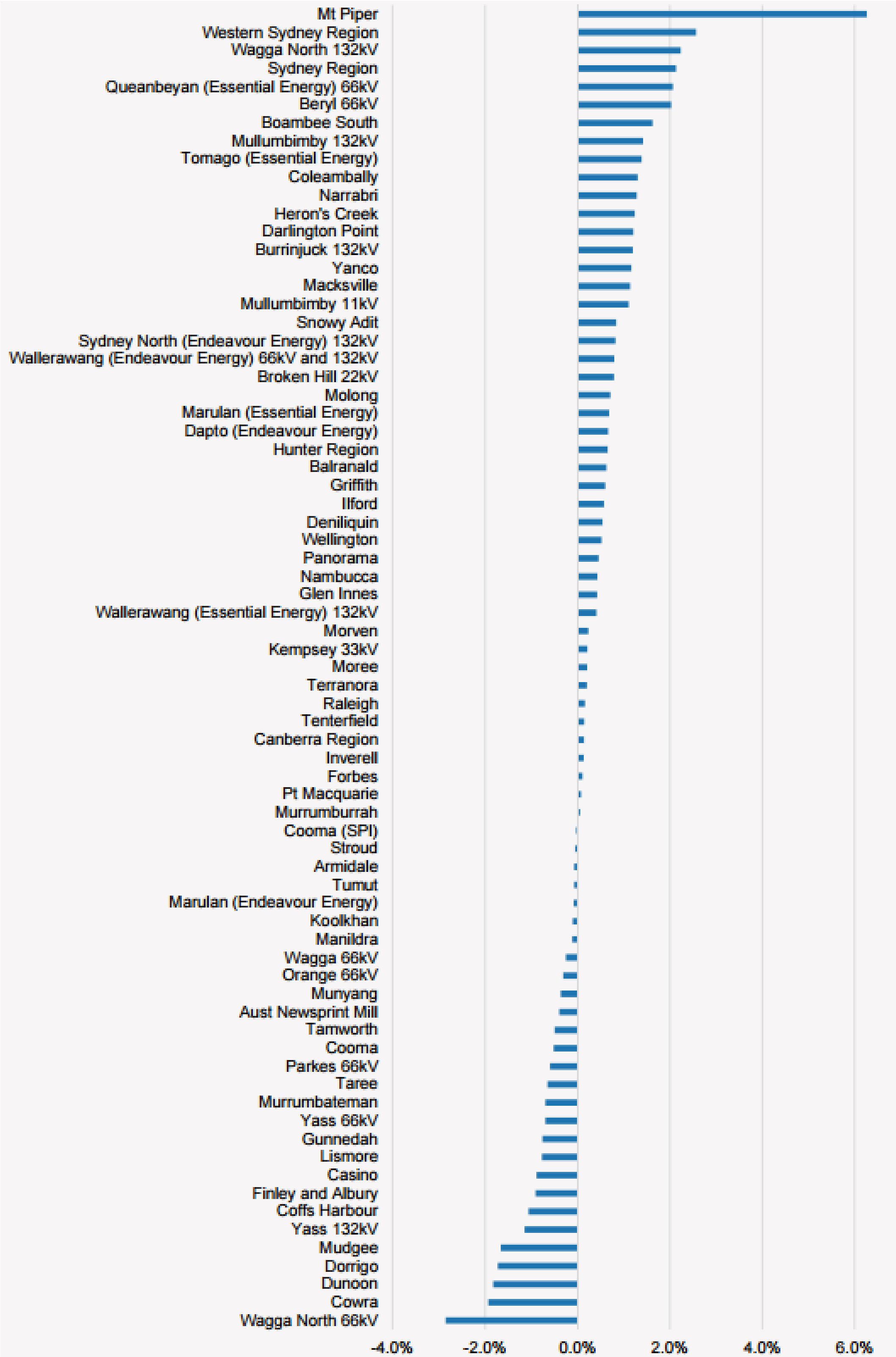
B Maximum demand forecasts - annual change by bulk supply point

Figure B.1 Summer average annual rates of change in MD (50% POE)



Source: AEMO, 2015 AEMO Transmission Connection Point Forecasting Report, p 13.

Figure B.2 Winter average annual rates of change in MD (50% POE)



Source: AEMO, 2015 AEMO Transmission Connection Point Forecasting Report, p 14.

C Reliability scenarios

TransGrid

Reliability Scenarios

NSW Electricity Transmission System

November 2015

Introduction

TransGrid is the owner and operator of the high voltage electricity transmission network in NSW and the ACT, its network plays an integral part in connecting homes and businesses across the state to the electricity they use 24 hours a day, 7 days a week.

An outage on the transmission network could cause widespread and severe disruptions to the supply of electricity. As a result, TransGrid designs and builds its network to provide a high level of reliability to ensure that the number of outages is low.

Under the AEMC's review of the national framework for transmission reliability standards, and to ensure that our network economically meets the needs of our customers, TransGrid has worked with IPART to establish a range of reliability scenarios. These will play a key part in how TransGrid outlines its forecast expenditure based on the final reliability standard which will be set in 2016.

In August 2015, to help develop our reliability scenarios, TransGrid consulted with stakeholders representing large energy users, consumer, business and industry groups and network providers through a rigorous consultation process to determine areas of importance to stakeholders and the types of standards that should apply.

This document outlines a number of reliability scenarios that TransGrid has developed taking into account stakeholders needs and will be used to help inform IPARTs economic assessment.

Overview

The reliability criteria is applied only to the bulk supply points in New South Wales, which are supplied from TransGrid's transmission network or Distribution Network Service Provider dual function assets.

The bulk supply points which are relied upon for providing supply reliability to other jurisdictions (e.g. ACT) may be built and maintained for a higher level of reliability, if required as specified under the supply licences for those jurisdictions.

In terms of the level of reliability presently provided to the bulk supply points emanating from TransGrid's transmission system, the supply points can be divided into three categories:

- Category 1 supply points:
  - These include connection points supplied via T connections, a single transformer or a single transmission line. Please see the attached list (Appendix 1).
  - The customers (usually the Distribution Network Service Providers) arranged to have an alternative supply via distribution networks or using standby generation. Normally there would be a short interruption before the changeover of the supply, in the event the supply from the transmission system is interrupted.
- Category 2 supply points:
  - These cover all the bulk supply points in the NSW transmission network, which are not categorised either as Category 1 or Category 3. Please see the attached list (Appendix 2).
- Category 3 supply points:
  - These include the bulk supply points located within the Sydney inner metropolitan area, supplied from TransGrid's transmission network as well as Ausgrid's transmission network. Please see the attached list (Appendix 3).

In relation to the supply reliability standard, the maximum demand to be supplied at each bulk supply point is recommended to be considered as the maximum demand forecast by AEMO with the appropriate level of likelihood or probability of exceedance (POE).

The POE associated with the demand forecast is mainly attributed to the variation in the ambient temperature. 10% POE demand forecast is higher than the 50% POE, and the difference is approximately 10% of the forecast demand.

In response to "The recommendation of Electricity Transmission Reliability Standards" referred to IPART by the Premier of New South Wales, for the consultation and economic assessment by IPART, TransGrid proposes the following reliability scenarios.

Reliability scenarios for New South Wales electricity transmission system

TransGrid's consultation process with stakeholders enabled it to clearly see the balancing needs of different energy users. When discussing the need to have flexibility in reliability standards, participants pointed out that some business' cannot compromise on the reliability of electricity while others would accept an occasional outage if it meant lower costs for them. With stakeholders' preferences in mind, we have outlined the following 4 scenarios:

1. Reliability scenario 1 – status quo
2. Reliability scenario 2 – a decrease in reliability levels
3. Reliability scenario 3 – a larger decrease in reliability levels
4. Reliability scenario 4 – a small increase in reliability levels

Reliability scenarios

Reliability scenario 1 – status quo

> Category 1 supply points:

Provide "N" equivalent capacity for at least 100% of the forecast 10% POE maximum demand.

In the event of an interruption, the transmission network service provider uses its reasonable endeavours to restore "N" equivalent capacity as soon as possible.

> Category 2 supply points:

(a) Provide "N " equivalent capacity for at least 100% of the forecast 10% POE maximum demand.

(b) Provide "N - 1" equivalent capacity for at least 100% of the forecast 50% POE maximum demand.

In the event of an interruption, the transmission network service provider uses its reasonable endeavours to restore "N - 1" equivalent capacity as soon as possible.

> Category 3 supply points:

(a) Provide "N " equivalent capacity for at least 100% of the forecast 10% POE maximum demand.

(b) Provide "N - 1" equivalent capacity for at least 100% of the forecast 50% POE maximum demand.

In the event of an interruption, the transmission network service provider uses its reasonable endeavours to restore "N - 1" equivalent capacity as soon as possible.

(c) Provide "N - 2" equivalent capacity for at least 100% of the forecast 50% POE maximum demand, for the following combination of simultaneous outages two transmission assets:

330 kV assets	132 kV assets
A 330 kV cable (or overhead line), and	A 132 kV cable (or overhead line) or
	A 330 kV / 132 kV transformer or
	A 132 kV bus section

In the event of an interruption, the transmission network service provider uses its reasonable endeavours to restore "N - 2" equivalent capacity as soon as possible.

Reliability scenario 2 – a decrease in reliability levels

This scenario is similar to the reliability scenario 1 described above, but for:

(a) all supply points with forecast 50% POE maximum demand less than 15 MW will be considered as category 1 supply points

(b) the "N-1" equivalent capacity provided for the category 2 supply points or the "N-2" equivalent capacity provided for category 3 supply points will be at least equal to the 95% of the forecast 50% POE maximum demand,

(c) category 2 or category 3 supply points, the expected total energy not served in a 12 month period will be less than an equivalent of 5% of forecast 50% POE maximum demand not served over a 20 hour period.

Reliability scenario 3 – a larger decrease in reliability levels

This scenario is similar to the reliability scenario 1 described above, but for:

(a) all supply points with forecast 50% POE maximum demand less than 30 MW will be considered as category 1 supply points

(b) the "N-1" equivalent capacity provided for the category 2 supply points or the "N-2" equivalent capacity provided for category 3 supply points will be at least equal to the 90% of the forecast 50% POE maximum demand,

(c) category 2 or category 3 supply points, the expected total energy not served in a 12 month period will be less than an equivalent of 10% of forecast 50% POE maximum demand not served over a 20 hour period.

Reliability scenario 4 – a small increase in reliability levels

This scenario is similar to the reliability scenario 1 described above, but the "N-1" or "N-2" equivalent capacity provided for category 2 or 3 supply points respectively, will be at least equal to the forecast 10% POE maximum forecast demand.

Implementation

TransGrid will endeavour to provide:

(a) a level of reliability higher than that is prescribed in the standards to the customers where:
- it is required by the customers and
- can be provided through prescribed assets at an economic cost or
- can be provided using non-prescribed assets where the cost is borne by the customer(s).

(b) a level of reliability lower than is prescribed in the standards to the customers where:
- it is required by the customers,
- has no impact on the other customers and,
- can be provided through non-prescribed assets at a reduced cost.

TransGrid may not meet the prescribed levels of reliability under extraordinary circumstances, such as an extensive failure of one or more transmission assets during a force majeure event or circumstances beyond TransGrid's control such as the deliberate destruction by a third party. In these circumstances TransGrid will work with AEMO and the NSW Government to restore its transmission network as soon as possible.

Supply reliability restoration times

Time for restoration of a failed transmission asset depends on the type of the asset and the level of damage to the asset, and could vary from several hours to several months. In order to minimise the restoration times, TransGrid maintains an optimum level of spares, at different locations in the state. Usually the restoration delays are due to the time required for:

(i) Identification of the severity of damage to the assets
(i) availability of suitably safe access tracs for site access
(ii) transportation of spares from stores to the site
(iii) local availability of trained staff

The restoration times cannot be significantly improved, unless redundant assets are maintained at the sites themselves, either as, energised, in service units or, un-energised, standby units.

Historical restoration times observed for TransGrid's assets are given in the Appendix 4.

TransGrid employs its reasonable endeavours to return an asset to service as soon as possible due to the uncertainty associated with asset restoration times. TransGrid would need to make a substantial investment in providing redundant assets to consider making a firm assurance of return to service times. TransGrid recommends that asset restoration times are not to be included in the reliability standards.

Supply reliability during maintenance outages

TransGrid maintains its assets during the off-seasons (mostly in spring and fall), where the demand supplied from the transmission network is low. During maintenance, the level of supply provided to the bulk supply points are likely to be reduced below the prescribed levels.

The outages for carrying out maintenance are usually planned such that the supply reliability can still be maintained with the remaining assets.

Where the supply is likely to be at risk for a long period of time, temporary risk mitigation measures are made in consultation with the customers so that the supply restoration time can be minimised to acceptable levels. The mitigation measures to be employed may include non-network solutions (including standby generation) or making provisions to have a spare asset (e.g. a transformer) temporarily moved into the site.

For some maintenance outages a large quantity of load (approximately 400 MW – 600 MW) may be required to be supplied under "N" security.

However such situations are rare and limited to a small number of maintenance activities such as onsite refurbishment of transformers or maintenance of 330 kV transmission lines supplying regional load centres.

A.1 Appendix 1

Category 1 Supply Points

Connection Point	Forecast Maximum Demand (MVA) Note 1	Firm Capability (MVA) Note 2	Reliability Category	Comments
Broken Hill 22 kV	38	100	1	2 x 100 MVA transformers, Supplied through a single circuit radial 220 kV line from Buronga (X2). Backup from Essential Energy's Broken Hill Gas Turbines
Broken Hill 220 kV	23	0	1	Single Essential Energy 220 kV line (to the mines)
Casino 132 kV	27	0	1	1 x 60 MVA Essential Energy transformer, T connection to Lismore – Tenterfield 132 kV(96L) line, Backup by 66 kV Essential network from Lismore 132/66 kV
Dorrigo 132 kV	3	0	1	1 x 10 MVA Essential Energy transformer, T connection to Coffs Harbour – Armidale 132 kV(96C) line, Backup by 66 kV Essential network from Coffs Harbour 330/132/66 kV
Finley 132 kV		0	1	Single Essential Energy 132 kV line (to Mulwala which is connected to Corowa and Albury). Load depends on main system flows.
Hawks Nest 132 kV	8	0	1	1 x 50 MVA Essential Energy transformer, T connection to Taree - Tomago 132 kV(963) line, Half of the supply point is backup by 33 kV Essential network from Stroud, and the other half of the supply point is backup by AusGrid network from Salt Ash area
Herons Creek 132 kV	10	0	1	1 x 30 MVA Essential Energy transformer, T connection to Port Macquarie – Taree 132 kV(964) line, Backup by 66 kV Essential network from Taree 132/66 kV
Ilford 132 kV		0	1	1 x 30 MVA Essential Energy transformers. Load (approximately 5 MVA) included in Mount Piper 66 kV forecast. T connection to Mt Piper – Beryl 132 kV(94M) line, Backup by 66 kV Endeavour network from Mt Piper 132/66 kV
Morven 132 kV	8	0	1	1x 30 MVA Essential Energy transformer, T connection to Wagga – ANM 132 kV(996)

TransGrid

				line, Backup by 66 kV Essential network from Wagga 132/66 kV
Mudgee 132 kV	22	0	1	1 x 30 MVA Essential Energy transformer, T connection to Mt Piper – Beryl 132 kV(94M) line, Backup by 66 kV Essential network from Beryl 132/66 kV
Murrumbateman 132 kV	6	0	1	1 x 10 MVA Essential Energy transformer, T connection to Yass – Canberra 132 kV(976/2) line, Backup by 11 kV Essential network from Yass 66/11 kV
Snowy Adit 132 kV		0	1	1 x 15 MVA Essential Energy transformer. Load (of around 10 MVA) included in Cooma 66 kV forecast
Wellington Town	12	0	1	1 x 15 MVA Essential Energy transformer, T connection to Wellington – Molong 132 kV(945) line, Backup by 66 kV Essential network from Dubbo 132/66 kV

Notes:

1. The greater of the forecast connected customer loads in summer 2015/16 and winter 2016.
2. Based on the capacity of TransGrid's (or the customer's) transformers or, where there are no transformers, the capacity of the customer's lines (or TransGrid's switchbays connecting those lines). Note that the capability of TransGrid's network may limit supply to groups of connection points (such as those serving a particular area). Those limitations cannot meaningfully be included in the individual connection point capabilities.

A.2 Appendix 2

Category 2 Supply Points

Connection Point	Forecast Maximum Demand (MVA) Note 1	Firm Capability (MVA) Note 2	Reliability Category	Comments
Albury 132 kV	123	341	2	2 x 44 MVA and 1 x 35 MVA Essential Energy transformers plus three Essential Energy 132 kV lines.
ANM 132 kV	110	90	2	3 x 45 MVA customer transformers
Armidale 66 kV	38	60	2	2 x 60 MVA transformers
Balranald 22 kV	4	0	2	1 x 30 MVA transformer, Backup by 66 kV Essential network from Deniliquin 132/66 kV
Beryl 66 kV	65	120	2	2 x 120 MVA transformers
Boambee South 132 kV	21	60	2	2 x 60 MVA Essential Energy transformers
Boggabri East	8	10	2	2 x 10 MVA customer transformers
Boggabri North	15	16	2	2 x 16 MVA customer transformers
Brandy Hill 132 kV	10	38	2	2 x 37.5 MVA Ausgrid transformers
Canberra 132 kV Note 3	478	1,150	2	2 x 375 MVA and 2 x 400MVA transformers
Coffs Harbour 66 kV	54	120	2	2 x 120 MVA transformers
Coleambally 132 kV	13	25	2	2 x 25 MVA Essential Energy transformers

Cooma 11 kV	13	20	2	3 x 10 MVA 11 kV voltage regulators
Cooma 66 kV	21	40	2	2 x 20 MVA (66 kV winding) plus 1 x 30 MVA transformer
Cooma 132 kV	50	110	2	Two Essential Energy 132 kV lines
Cowra 66 kV	30	60	2	2 x 60 MVA transformers
Dapto 132 kV	677	1,125	2	4 x 375 MVA transformers
Darlington Point 132 kV Note 3	18	280	2	2 x 280 MVA transformers
Deniliquin 66 kV	48	60	2	2 x 60 MVA transformers
Finley 66 kV	20	60	2	2 x 60 MVA transformers
Forbes 66 kV	33	60	2	2 x 60 MVA transformers
Gadara (132 kV & 11 kV)	70	32	2	1 x 31.5 MVA (TransGrid) and 1 x 55 MVA (Customer) transformer
Glen Innes 66 kV	12	60	2	2 x 60 MVA transformers
Griffith 33 kV	88	120	2	3 x 60 MVA transformers
Gunnedah 66 kV	26	60	2	2 x 60 MVA transformers
Haymarket 132 kV	382	800	2	3 x 400 MVA transformers
Holroyd 132 kV	402	375	2	2 x 375 MVA transformers
Ingleburn 66 kV	135	250	2	2 x 250 MVA transformers
Inverell 66 kV	36	120	2	2 x 120 MVA transformers
Kempsey 33 kV	27	60	2	2 x 60 MVA transformers

Koolkhan 66 kV	47	120	2	3 x 60 MVA transformers
Liddell 330 kV (33 kV supply via Mac Gen)	38	100	2	2 x 100 MVA Macquarie Generation transformers
Lismore 132 kV Note 3		375	2	2 x 375 MVA transformers. Load depends on Directlink flows.
Liverpool 132 kV	377	750	2	3 x 375 MVA transformers
Macarthur 132 kV	298	0	2	1 x 375 MVA transformer
Macarthur 66 kV		0	2	1 x 250 MVA transformer
Macksville 132 kV	9	30	2	2 x 30 MVA Essential Energy transformers
Manildra 132 kV	10	30	2	2 x 30 MVA Essential Energy transformers
Marulan 132 kV	144	0	2	1 x 160 MVA
Molong 66 kV	5	0	2	1 x 30 MVA transformer
Moree 66 kV	39	60	2	2 x 60 MVA transformers
Mount Piper 66 kV	42	120	2	2 x 120 MVA transformers
Munmorah 330 kV (via old Power Stn Txs)		80	2	2 x 80 MVA Ausgrid transformers
Munyang 33 kV	39	60	2	2 x 60 MVA transformers
Murrumburrah 66 kV	40	60	2	2 x 60 MVA transformers
Muswellbrook 132 kV	246	375	2	2 x 375 MVA transformers
Nambucca 66 kV	9	60	2	2 x 60 MVA transformers
Narrabri 66 kV	51	60	2	2 x 60 MVA transformers

Newcastle 132 kV	462	750	2	3 x 375 MVA transformers
Orange North 132 kV	153	0	2	Single Essential Energy 132 kV line (to Cadia mine)
Orange 66 kV	62	60	2	2 x 60 MVA transformers
Panorama 66 kV	74	120	2	2 x 120 MVA transformers
Parkes 132 kV	33	0	2	Single Essential Energy 132 kV line (to North Parkes mine)
Parkes 66 kV	25	60	2	2 x 60 MVA transformers
Port Macquarie 33 kV	66	120	2	3 x 60 MVA transformers
Queanbeyan 66 kV	69	120	2	2 x 120 MVA transformers
Raleigh 132 kV	10	60	2	2 x 60 MVA Essential Energy transformers
Regentville 132 kV	283	375	2	2 x 375 MVA transformers
Rookwood Road 132 kV	256	750	2	3 x 375 MVA transformers
Stroud 132 kV	30	60	2	2 x 60 MVA Essential Energy transformers
Sydney East 132 kV	692	1,175	2	1x 375 MVA and 3 x 400MVA transformers
Sydney North 132 kV	917	1,500	2	5 x 375 MVA transformers
Sydney South 132 kV	930	1,875	2	6 x 375 MVA transformers
Sydney West 132 kV	1,263	1,500	2	5 x 375 MVA transformers
Tamworth 66 kV	117	120	2	3 x 60 MVA transformers
Taree 33 kV	24	60	2	2 x 60 MVA transformers
Taree 66 kV	49	60	2	2 x 60 MVA transformers

Tenterfield 22 kV	6	15	2	2 X 15 MVA transformers
Tomago 132 [Note 3]	229	750	2	3 x 375 MVA transformers
Tomago 330 kV	940	1,699	2	4 x 313 MVA and 2 x 447 MVA customer transformers
Tuggerah 132 kV	201	375	2	2 x 375 MVA transformers
Tumut 66 kV	38	60	2	2 x 60 MVA transformers
Vales Pt 132 kV	85	200	2	2 x 200 MVA transformers
Vineyard 132 kV	497	750	2	3 x 375 MVA transformers
Wagga 66 kV	96	120	2	3 x 60 MVA transformers
Wagga North 132 kV	60	0	2	Single Essential Energy 132 kV line (to Temora)
Wagga North 66 kV	27	0	2	1 x 60 MVA transformer
Wallerawang 132 kV [Note 3]	111	375	2	2 x 375 MVA transformers
Wallerawang 66 kV		60	2	2 x 60 MVA transformers
Waratah West 132 kV	156	375	2	2 x 375 MVA transformers
Wellington 132 kV [Note 3]	174	180	2	Two Essential Energy 132 kV lines
Williamsdale 132 kV [Note 3]	186	375	2	2 x 375 MVA transformers
Yanco 33 kV	38	60	2	2 x 60 MVA transformers
Yass 132 kV		200	2	2 x 200 MVA transformers, Single Essential Energy 132 kV line (backup supply to Essential Energy Goulburn and normal connection for Cullerin and Gunning wind farms)
Yass 66 kV	13	0	2	1 x 60 MVA transformer

Notes:

1. The greater of the forecast connected customer loads in summer 2015/16 and winter 2016.
2. Based on the capacity of TransGrid's (or the customer's) transformers or, where there are no transformers, the capacity of the customer's lines (or TransGrid's switchbays connecting those lines). Note that the capability of TransGrid's network may limit supply to groups of connection points (such as those serving a particular area). Those limitations cannot meaningfully be included in the individual connection point capabilities.
3. This 330/132 kV substation also supplies TransGrid 132 kV lines, the loadings on which are not included in the forecast.

A.3 Appendix 3

Category 3 Supply Points:

Sydney Inner Metropolitan electricity transmission system is defined as TransGrid's 330 kV cables 41, 42, 43 and 44, and the 330 / 132 kV substations at Rookwood Road, Beaconsfield, Haymarket, Sydney North and Sydney South together with Ausgrid's 132 kV transmission network that links those supply points.

Supplied from TransGrid electricity network	
Beaconsfield	Sydney North
Haymarket	Sydney South
Rookwood Road	

Supplied from Ausgrid electricity network						
STS (132/33kV)	**Primary (kV)**	**Secondary (kV)**		**Zone (132/11kV)**	**Primary (kV)**	**Secondary (kV)**
Bankstown	132	33		Bankstown 132_11kV	132	11
Bunnerong	132	33		Belmore Park 132_11kV	132	11
Canterbury	132	33		Berowra	132	11
Homebush	132	33		Burwood	132	11
Kurnell	132	33		Campbell St	132	11
Peakhurst	132	33		City Central	132	11
Port Hacking	132	33		City South	132	11
Pyrmont	132	33		City North	132	11
Rozelle	132	33		Clovelly	132	11
Strathfield	132	33		Cronulla	132	11
Surry Hills	132	33		Croydon	132	11
				Dalley Street	132	11
				Darling Harbour	132	11

Zone (132/11kV)	Primary (kV)	Secondary (kV)		Zone (132/11kV)	Primary (kV)	Secondary (kV)
Double Bay	132	11		Maroubra	132	11
Drummoyne	132	11		Marrickville	132	11
Engadine	132	11		Meadowbank	132	11
Flemington	132	11		Menai	132	11
Galston	132	11		Milperra	132	11
Green Square	132	11		Pennant Hills	132	11
Greenacre Park	132	11		Potts Hill	132	11
Gwawley Bay	132	11		RAC Heathcote	132	11
Homebush Bay	132	11		RIC Berowra 132_66kV	132	11
Hornsby	132	11		Revesby	132	11
Hurstville North	132	11		Rose Bay	132	11
Kingsford	132	11		Sefton	132	11
Kirrawee	132	11		St Peters	132	11
Kogarah	132	11		Top Ryde	132	11
Leichhardt	132	11		Waverley	132	11
Macquarie Park	132	11		Zetland	132	11

Appendix 4

Transformer failure rates and restoration times by voltage:

Voltage	**Failure Rates** (Failures per 100km per decade)	**Restoration Time (hours)**								
		Mean	Std Dev:	Percentiles						
				0% (min)	10%	25%	50% (median)	75%	90%	100% (max)
500kV	1.5	26.6	50.7	1.2	1.6	2.8	9.6	14.9	54.7	166.9
330kV	2.4	17.8	69.8	0.0	0.1	0.4	2.4	13.6	26.7	700.4
220kV	0.6	102.6	89.8	2.9	17.6	39.6	107.8	170.7	183.4	191.8
132kV	3.9	23.5	150.8	0.0	0.2	0.8	2.1	13.6	23.5	1993.1
Overall Aggregate (all voltages)	**3.5**	**23.8**	**119.4**	**0.0**	**0.1**	**0.8**	**2.3**	**13.7**	**27.2**	**1993.1**

Underground cables failure rates and restoration times:

Failure Rates (Failures per 100km per decade)	**Restoration Time (hours)**								
	Mean	Std. Dev	Percentiles						
			0% (min)	10%	25%	50% (median)	75%	90%	100% (max)
6.5	**1128.0**	**1923.8**	**0.1**	**7.0**	**17.4**	**34.6**	**1692.0**	**2686.4**	**3349.4**

Transformer failure rates by voltage and restoration times:

Voltage	**Failure Rates** (Failures per Population per Decade)	Restoration Time (hours)									Transformer Population (average)
		Mean	Std. Dev	Percentiles							
				0% (min)	10%	25%	50% (median)	75%	90%	100% (max)	
500kV	1.6	18.8	26.9	0.1	0.3	0.9	8.1	28.9	42.6	96.6	9.6
330kV	2.1	84.2	383.3	0.0	0.4	1.6	4.6	22.0	98.5	3320.3	88.7
220kV	4.1	358.8	615.8	0.9	1.8	3.2	5.6	537.7	857.0	1069.8	3.0
132kV	1.4	30.5	123.5	0.1	0.3	1.2	3.1	16.2	41.5	1065.3	89.4
Overall Aggregate (all voltages)	1.7	63.1	308.2	0.0	0.4	1.4	3.6	19.3	79.9	3320.3	190.7

Other connection point failure rates by voltage and restoration times:

Voltage	Failure Rates (Failures per Population per Decade)	Restoration Time (hours)								
		Mean	Std. Dev	Percentiles						
				0% (min)	10%	25%	50% (median)	75%	90%	100% (max)
500kV	0.7	17.0	17.5	4.5	7.0	10.8	17.0	23.2	26.9	29.4
330kV	0.7	37.9	126.5	0.1	0.3	1.4	4.0	19.1	49.7	700.4
220kV	0.9	107.8	79.1	51.9	63.1	79.8	107.8	135.8	152.5	163.7
132kV	0.7	31.5	203.6	0.0	0.4	0.8	1.6	5.8	21.4	1993.1
66kV	0.5	5.7	15.2	0.0	0.1	0.6	1.5	3.7	9.5	98.9
<= 33kV	1.2	5.0	12.6	0.0	0.2	0.8	1.5	3.3	9.2	98.9
Overall Aggregate (all voltages)	0.7	23.0	147.0	0.0	0.2	0.8	1.7	5.9	22.1	1993.1

D Glossary

Australian Energy Regulator (AER)	The AER is responsible for the economic regulation of electricity transmission in the NEM. It determines TransGrid's maximum allowed revenue and approves its pricing methodology and negotiating framework.
Australian Energy Market Commission (AEMC)	The AEMC makes rules which govern the electricity and natural gas markets. It also provides advice to the COAG Energy Council. The AEMC has proposed a national framework to establish better ways to set reliability standards which take account of the value placed on reliability by customers.
Australian Energy Market Operator (AEMO)	AEMO is the system operator for the NEM. Of relevance to this review, the AEMO publishes electricity demand forecasts and VCR values.
Direct connections	Reliability targets applied to direct connect customers will apply at the connection point on the prescribed services. At the Transmission Terminal Station (TTS) a number of customers may be connected. TransGrid's customers are DNSPs and direct connect customers. All shared assets are prescribed services. Where an asset is for the sole use of a direct connect customer, this is an alternate service. Where a direct connect customer connects to the network, known as the connection point, the direct connect customer will experience the reliability levels applied at that connection point.

Council of Australian Governments (COAG) Energy Council	The COAG Energy Council is responsible for pursuing priority issues of national significance and key reforms in the energy and resources sectors. The COAG Energy Council was formerly the Standing Council of Energy and Resources (SCER).
expected unserved energy	The amount of energy that is required by customers but cannot be supplied.
megawatt (MW)	A MW is a unit of power referring to the rate of energy conversion. 1 MW is equal to 1,000,000 W.
megawatt-hour (MWh)	A MWh is a unit of energy measuring the amount of electricity produced or consumed. Using 1 MW of power for 1 hour consumes 1 MWh of energy.
N-x	The N-x expression of transmission reliability is often used by TNSPs when planning augmentations of transmission networks. Starting from the 'Normal' network operating configuration, the N-x expression specifies the number (x) of network elements that can be out-of-service without causing load curtailment, system instability, thermal overloading, or cascading outages. With the value of x commonly set at one, and less often at zero (no redundancy) or two (two levels of redundancy), the N-x expression is easily applied to set the broad expectations of reliability at a connection point. The x value is applied as the required level of redundancy in the network, which can be achieved by either network or non-network approaches. Non-network approaches include use of standby generation, demand reduction schemes and voltage reduction schemes.
N reliability	N reliability means there is not network redundancy and there would be some loss of load on the outage of a single element such as a line, cable or transformer.

N–1 reliability	N–1 reliability means the system is planned for no loss of load on the outage of a single element such as a line, cable or transformer.
N-2 reliability	N reliability means the system is planned for no loss of load on the outage of two networks elements.
National Electricity Market (NEM)	The NEM is a wholesale electricity market. It spans Australia's eastern and south-eastern coasts and comprises five interconnected states: Queensland, New South Wales, Victoria, South Australia and Tasmania. TransGrid is one of five state-based transmission networks in the National Electricity Market.
National Electricity Rules (NER)	The National Electricity Rules govern the operation of the NEM.
values of customer reliability (VCR)	These measures, expressed as dollars per kilowatt-hour, indicate the value different types of customers place on having reliable electricity supply under different conditions. We have used VCR published by the AEMO.