IPART
New South Wales

Independent Pricing and Regulatory Tribunal

Electricity transmission reliability standards

Unserved energy allowances for Inner Sydney and Broken Hill, Molong, Mudgee, Munyang and Wellington Town

Energy — Supplementary Final Report
November 2016

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ISBN 978-1-76049-016-4

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1 Executive summary

The Independent Pricing and Regulatory Tribunal (IPART) has been asked to recommend reliability standards for electricity transmission in NSW to apply from the next regulatory period which starts on 1 July 2018.[1]

Historically the level of reliability provided by the NSW electricity transmission network has been high. This has, at least in part, been driven by reliability standards that were set without reference to the value customers place on reliability.

As required by our Terms of Reference for the review, we have developed reliability standards by applying an economic assessment that aims to identify the level of reliability that would provide the most value to customers. This assessment takes into account both the cost of providing reliability, which is paid for by customers through their electricity prices, and the costs to customers of experiencing outages.

We made final recommendations to the Minister for Industry, Resources and Energy on 31 August 2016 setting out recommended standards, which include a level of redundancy and an annual unserved energy allowance at each bulk supply point across TransGrid's network. However, there are a number of supply points where we considered further analysis and consultation were required before finalising the value of the expected unserved energy allowance. Those supply points are Inner Sydney, Broken Hill, Munyang, Wellington Town, Molong, and Mudgee.

The wording of the standards and the proposed level of redundancy for these areas was included in our Final Report to the Minister in August 2016. For Inner Sydney, we recommended that the required level of redundancy remains unchanged at modified N-2. For the other bulk supply points we have recommended that the required level of redundancy remains unchanged at N.

Our recommendations on the unserved energy allowances for these supply points are set out in this Supplementary Final Report. We applied the same methodology to determine the expected unserved energy allowance at these bulk supply points that we used for our final recommendations to the Minister for the other supply points.

1 The Terms of Reference are in Appendix A.

Appendix B contains our recommended reliability standards in full, including both the recommendations in this Supplementary Final Report and those included in our Final Report for the review.

1.1 Purpose of this report

This Supplementary Final Report specifically considers the unserved energy allowance for Inner Sydney, Broken Hill, Munyang, Wellington Town, Molong, and Mudgee.

We considered that the additional round of consultation following the Final Report was necessary for these supply points because:

- For Inner Sydney we proposed a separate consultation process in our Draft Report released in May 2016, because:
  - At that time TransGrid and Ausgrid (the distribution network service provider for the Inner Sydney area) were exploring options for the relief of emerging supply constraints.
  - The complexity of the network in the Inner Sydney area, particularly the meshing of the transmission and distribution networks, makes the modelling for this area more complex.
  - It is likely that substantial investment will need to be made over the next regulatory period and this investment will be costly and will affect a substantial number of people over a long period.
- For the other regions, the inclusion of supply point specific information in our modelling following release of our Draft Report led to material differences in the optimal unserved energy compared to our draft recommendations – increases for Munyang and Wellington Town, and reductions for Broken Hill, Molong and Mudgee.

We issued a Supplementary Draft Report and consulted on the unserved energy allowances for these bulk supply points (BSPs) before finalising our recommendations. For Inner Sydney, Wellington Town, Mudgee and Molong, the recommendations set out in this Supplementary Final Report on the unserved energy allowances are the same as those in the Supplementary Draft Report. Our final recommended energy allowance for Munyang is lower than in our Draft Report, and our final recommendation for Broken Hill is to group the bulk two supply points as one, instead of having separate unserved energy allowances for each point.

1.2 Overview of the recommendations in this report

We recommend that the annual unserved energy (USE) allowance included in the reliability standards to apply from 1 July 2018 for each of the bulk supply points is set equal to the value determined by our optimisation model, shown in Table 1.1.

The recommended standards do not prescribe how TransGrid must meet them. Instead, they explicitly provide for TransGrid to determine the combination of network and non-network solutions required to provide reliability. Through the regulatory revenue determination process with the Australian Energy Regulator (AER), TransGrid will be required to demonstrate that any investments it proposes are efficient, and where relevant, necessary to meet the reliability standards that are in place.

Table 1.1 Final recommendations on annual USE in minutes at average demand

	IPART final recommendation	IPART Draft Report	IPART Supplementary Draft Report	TransGrid estimate of current network
Inner Sydney	0.6	n/a	0.6	Around 0[a]
Munyang	14	10	191	Less than 1
Broken Hill 22kV	10[b]	5	14	Around 5
Broken Hill 220kV		n/a[c]	5	Around 10
Wellington Town	21	10	21	Around 21[d]
Molong	46	16	46	Around 100
Mudgee	14	3	14	Around 30

[a] Estimate based on the impact of both a single asset failure (n-1 contingency) and a simultaneous outage of a single 330kV cable and any 132kV feeder based on expected actual probabilities of outages and historical outage durations.

[b] This is a 'group' standard across both supply points.

[c] Following release of the Draft Report we identified that our model did not correctly calculate the level of unserved energy in instances where a bulk supply point had no transformers. This resulted in a very high value of unserved energy at the Broken Hill 220kV bulk supply point. We have now corrected this.

[d] Revised following release of the Supplementary Draft Report.

Source: IPART calculations and TransGrid indicative compliance assessment (provided to IPART on a confidential basis), TransGrid submission to IPART Supplementary Draft Report, 26 October 2016, p 2.

For the Inner Sydney area, our final recommendation is that the value should be 0.6 minutes per year, at average demand. This value would apply as a weighted average for the five Inner Sydney bulk supply points (Beaconsfield West, Haymarket, Rookwood Rd, Sydney North and Sydney South) as a single group. Our recommendations would likely result in a small increase in the expected value of unserved energy in the Inner Sydney area. However, we consider that our recommendations would not result in a significant change to the level of reliability experienced by customers.

A significant proportion of the 0.6 minutes of annual unserved energy we are recommending for Inner Sydney reflects an allowance for non-catastrophic transformer failures. Because backup capacity is available, a non-catastrophic failure would lead to an outage lasting only as long as it takes to switch to the backup capacity. We used TransGrid's historical rates of non-catastrophic failure and repair times to estimate this allowance. Although TransGrid has not calculated the level of expected unserved energy in its network that is associated with non-catastrophic events, we consider that our allowance is likely to be consistent with the current level of expected unserved energy associated with these types of failures.

The reliability at Munyang is currently very high. The recommendation in our Supplementary Draft Report was for the expected unserved energy allowance to increase to 191 minutes per year. This was largely driven by the very low load factor at his bulk supply point resulting from its very pronounced seasonality – it supplies the ski fields. As a result, the maximum peak demand is more than 10 times higher in winter compared to summer. Following further consultation, we have decided to use the ski-season load factor for Munyang in our final recommendations to reflect the time of the year when the bulk of the energy is being used. We have also updated the maximum demand at this bulk supply point to refer to ski-season maximum demand. As a result, our final recommendation is an unserved energy allowance of 14 minutes for Munyang.

For our final recommendations for Broken Hill, we have jointly modelled the Broken Hill 22 kV and 220 kV bulk supply points to establish a group unserved energy allowance. This is because the two bulk supply points are related in terms of the available backup arrangements (backup generation). The recommended unserved energy allowance of 10 minutes is consistent with the current expected unserved energy.

For Wellington Town we recommend an expected unserved energy allowance of 21 minutes per year at average demand. For Molong we recommend 46 minutes per year at average demand and for Mudgee we recommend 14 minutes. Information provided by TransGrid suggests that these unserved energy allowances may require TransGrid to improve its reliability in these areas.

The differences in the expected unserved energy allowance between the different supply points reflect the value different customers place on reliability, the cost of providing it, and specific characteristics of the bulk supply point, such as the load profile and maximum demand.

The value that customers place on reliability (known as value of customer reliability or VCR) is expressed as a dollar value per kWh of energy not delivered. This value is multiplied by the expected amount of unserved energy to obtain a customer value that is compared with the direct cost of providing reliability.

Our Terms of Reference require us to have regard to the most recent VCRs published by the Australian Energy Market Operator (AEMO). We received submissions that raised a number of concerns with the use of the AEMO estimates. Those concerns include that the AEMO estimates are calculated from a very small sample size, are overly dependent on the methodology used, that long duration outages are not accounted for, and that respondents' VCRs are based on an outage time that is the worst for them.

We agree that more work is required to better understand the true value that different customers place on reliability. This work should involve customer input and would require periodical updating. In our Final Report provided to the Minister in August 2016 we supported a nationally consistent approach to the VCR. We made a recommendation for the NSW Government to ask IPART to determine VCRs for NSW 12 months prior to the next review of reliability standards if updated nationally consistent VCRs are not available. If this is the case, we expect that we would commence a review on determining NSW VCRs in 2019-20.

1.3 Stakeholder engagement for this review

As part of our process for this review, we conducted public consultation together with targeted consultation, sought expert advice, and conducted our own analysis. We:

- Released an Issues Paper in December 2015, and we received six submissions in response.
- Advertised the review in the Sydney Morning Herald and Daily Telegraph on 10 February 2016 and 22 June 2016.
- Released a Draft Report in May 2016 accompanied by two consultant reports. We received six submissions to the Draft Report.
- Held a public hearing in June 2016. The transcript is available on our website.
- We released a Supplementary Draft Report for further consultation in October 2016. We received five submissions. Our responses to these submissions are contained in Appendix E.

We also presented at a stakeholder forum held by TransGrid in June 2016. This forum was organised by TransGrid and attended by a range of stakeholders including customers, consumer and industry representatives, regulatory bodies, researchers and Government departments. TransGrid also contacted its own stakeholders and let them know about our review and consultation processes.

During the review we received submissions, comments and questions from a range of stakeholders, including industry experts and consumer representatives. We also sought advice directly from a number of industry experts. We also consulted with other regulators including the Australian Energy Market

Commission (AEMC), AEMO, the AER, and the Essential Services Commission of South Australia (ESCOSA).

1.4 List of recommendations in this report

Our final recommendations on the unserved energy allowances at the remaining bulk supply points are:

1.5 Structure of this report

This Supplementary Final Report is structured as follows:

- Chapter 2 outlines IPART's approach to developing its recommendations on the NSW transmission reliability standards
- Chapter 3 discusses the unserved energy allowance for Inner Sydney
- Chapter 4 sets out the unserved energy allowances for the other bulk supply points that we are consulting on
- Appendix A provides the Terms of Reference for the review

- Appendix B sets our recommendations on the reliability standards in full, including both the recommendations in this Supplementary Final Report and those included in our Final Report for the review provided to the Minister in August 2016
- Appendix C includes a map of the Inner Sydney area
- Appendix D provides information on our modelling approach including the inputs and assumptions we have adopted
- Appendix E contains IPART's responses to submissions.

2 Overview of IPART's approach to the review

At the end of August 2016, we provided a Final Report and recommendations to the Minister for Energy on transmission reliability standards for NSW.

We recommended that the NSW transmission reliability standards should move away from being heavily based on network capability and should better focus on what customers value. The standards should also introduce the concepts of probabilistic analysis and positive expected unserved energy into TransGrid's decision making processes as well as making explicit provision for the standards to be met using non-network solutions.

We also recommended that the standards should be implemented as planning standards, which means that TransGrid must plan its network to meet the requirements set out in the standards.

This approach provides greater flexibility around how TransGrid meets the reliability standards. It also ensures that the reliability standards are more responsive to changes in technology. From the customers' point of view this approach is designed to deliver outcomes that are more closely aligned with their expectations around reliability and their willingness to pay for it.

2.1 Our objectives

We outlined the following objectives for the review:

- Move away from standards that are heavily based on network capability and towards standards that better focus on what customers value – we noted the high level of reliability being delivered by TransGrid and the fact that the existing standards were not developed with any reference to the value that customers place on the level of reliability.
- Introduce the concept of positive expected unserved energy into TransGrid's decision making processes – currently the standards that apply are deterministic. They focus on what happens in the event of different contingencies and require TransGrid to ensure it invests to reduce the expected unserved energy associated with these contingency events to zero. Requiring TransGrid to consider the likely probability and impact, in terms of expected unserved energy, of different assets failing provides a step away from a completely deterministic approach to setting reliability standards.

- Make explicit provision for the standards to be met using non-network solutions. The current standards are heavily focused on network capability. This effectively limits the scope for pursuing non-network solutions, even where these may be more economically desirable.
- Not result in a significant change from the current level of reliability experienced by customers – as this would be the first time an economic approach to setting reliability standards has been applied. There is significant uncertainty involved in some of the inputs, for example VCRs. We have undertaken sensitivity analysis but have also noted that there is further work that should be done to develop these concepts for future use.

We had regard to these objectives in developing our approach.

2.2 Overview of our methodology

In line with our Terms of Reference, we conducted an economic assessment to estimate the level of reliability that provides the most value to customers, having regard to the most recent VCRs published by AEMO. As part of our economic assessment, we developed an optimisation model which we then used to estimate the optimal amount (in MWh and minutes) of expected unserved energy per year for each bulk supply point in the network.

In response to our Supplementary Draft Report, GreenSync submitted that the proposed reliability standards do not have regard to the impact on customers.[2] However, the purpose of the optimisation modelling is to assess the reliability/cost trade-off for customers. Our methodology optimises the unserved energy allowance to minimise the combined total of the costs to customers of unserved energy and the costs of the infrastructure to avoid unserved energy. The model finds the level of unserved energy where customers would be indifferent to paying to have that energy supplied or incurring the energy loss (experiencing a black out). If the standards are too high, customers would prefer to pay less and have more minutes of unserved energy, whereas if they are too low, customers would prefer to pay more and have less minutes of unserved energy.

The optimal amount of expected unserved energy calculated by the optimisation model is influenced by the level of redundancy assumed at the bulk supply point, the existing mix of assets serving that point, the cost of replacing those assets and the VCR at each bulk supply point, which depends on the mix of customers.

2 GreenSync submission to Supplementary Draft Report, 28 October 2016, p 1.

2.3 Overview of our recommended standards

We have recommended reliability standards to the Minister for each bulk supply point[3] across the transmission network to apply for the 2018 regulatory period. The recommended standard requires TransGrid to plan and develop the network's supply capability to meet the forecast demand at that bulk supply point so that it provides:

- the required level of redundancy (that is, it specifies the number of backup arrangements that must be in place to support continued supply of electricity in the event that part of the transmission network fails), and
- an allowance for TransGrid to plan for some expected unserved energy at each bulk supply point.

The existing standards provide the required level of redundancy only. Our recommendations do not result in changes to the redundancy standards. As a result, GreenSync questioned how our new standards differ from the existing standards.[4] We have changed the standards by introducing a new requirement – an allowance for a positive amount of expected unserved energy. This provides an additional constraint on TransGrid that avoids the need to be too prescriptive about the redundancy requirement.

The recommended standards provide for TransGrid to meet the requirements for redundancy and expected unserved energy using any combination of transmission network assets, non-network solutions (like backup power generation) or agreements with distribution network service providers (DNSPs) to use part of an attached distribution network.

2.3.1 Redundancy requirement

Our Terms of Reference require us to include a level of network capability informed by an economic assessment process to be expressed in terms of a network redundancy/N-x standard in our recommendations. Redundancy refers to the backup arrangements that are in place to allow supply to continue to be provided in the event that part of the transmission network fails.

The inclusion of a redundancy requirement is consistent with the current NSW transmission standards and with how transmission reliability standards are specified in other states of Australia. It is also consistent with the recommendations of the AEMC following its review of the transmission reliability standards.

3 We define a bulk supply point as a location where supply is provided to DNSPs or directly connected customers. Generally, the locations are the busbar(s) at TransGrid substations but sometimes the locations are where connections are made to TransGrid's transmission lines or cables (including "tee" connections). A more detailed definition is in the Glossary.

4 GreenSync submission to Supplementary Draft Report, 28 October 2016, p 1.

Moving away from a redundancy requirement would be a substantial departure from the standards that are currently in place and we do not consider that there is evidence to support such a move. Therefore, we have recommended standards that continue to specify the level of 'redundancy' at each bulk supply point. However, we have recommended complementary measures within the standards that provide greater flexibility around how the specified redundancy requirements can be met. For example, the standards we recommended explicitly provide that the specified level of redundancy can be met:

- even where the full load is not able to be supplied under all covered contingency circumstances, subject to the allowance for expected unserved energy being met
- by an arrangement that involves the use of non-network solutions and/or the distribution network (see discussion below), or
- by means of an alternative arrangement that does not provide the specified level of redundancy provided TransGrid can demonstrate that this would provide a better outcome for customers.

We intend the redundancy requirements to apply 'post-switching'. In other words, TransGrid may lose supply at a particular bulk supply point following the outage of a system element provided it has the capacity to put in place backup arrangements that are able to supply a non-zero amount of load. The time that TransGrid will have available to switch to backup arrangements would be limited by the expected unserved energy allowance. This approach ensures that the definition does not prevent non-network solutions from being implemented.

2.3.2 Allowance for expected unserved energy

We decided to include an allowance for expected unserved energy in the standard to give TransGrid some flexibility in terms of how it meets the specified level of redundancy. Including an allowance for a positive amount of expected unserved energy provides an additional constraint on TransGrid that avoids the need to be too prescriptive about the redundancy requirements (eg, we do not need to specify the capacity required for each level of redundancy, the time within which it needs to be activated or what type of assets need to be used).

Some flexibility in the redundancy requirements that are in place in other states of Australia exists. However, rather than considering expected unserved energy these standards tend to focus on the amount of demand (in MW) that may be put at risk. In Queensland and Tasmania this flexibility is in the form of provision for loss of load. In South Australia, an availability standard of 95% applies to network support arrangements.[5]

GreenSync questioned why we translated the amount of demand at risk to the time taken to restore an asset.[6] We consider that expected unserved energy is a superior indicator of the level of reliability of the network because it takes into account both the probability of outages occurring and the expected impact, including the duration of outages, whereas load at risk does not. In order to demonstrate compliance with this expected unserved energy allowance TransGrid would need to consider both the probability and impact, in terms of unserved energy, of different asset failures occurring. The impact will be affected by the backup and switching arrangements that are in place as well the time it would take to restore supply.

We consider that requiring TransGrid to have regard to the probability and impact of asset failures occurring would, over time, change TransGrid's planning philosophy. It should provide greater flexibility to TransGrid to find the optimum mix of firm network capacity, network backup (post-switching capacity), switching arrangements and network support in order to meet the expected unserved energy limit at the least cost. It also better reflects customers' willingness to pay for reliability.

We recommended an allowance for expected unserved energy at each bulk supply point as a maximum value that should be allowed to be planned for in any year, in minutes at average demand.

2.3.3 Implemented as planning standards

We have recommended standards that are specified as 'planning' standards rather than 'performance' standards.[7]

Performance standards have some advantages over planning standards: they are simpler to understand, the compliance process is likely to be less involved, and hence less costly, and they provide greater certainty to customers around what level of reliability they can expect to receive. However, for a performance standard to be appropriate there must be a sufficiently close relationship between

5 Essential Services Commission of South Australia (ESCOSA), *Electricity Transmission Code TC/08*, 29 October 2015, clause 2.12. ESCOSA notes that the current wording of the availability standard is ambiguous as it does not define the term 'availability'. ESCOSA is proposing changes that will clarify that the network support arrangement must have at least 95% availability on the occasions it is called upon. (ESCOSA, *Electricity Transmission Code Review - Draft Decision*, March 2016, p 11).

6 GreenSync submission to Supplementary Draft Report, 28 October 2016, p 1.

7 The difference between these two types of standards is at what point compliance with the standard is assessed. Planning standards require TransGrid to plan its network according to specified criteria. Compliance with the standard is assessed at the planning stage. On the other hand, performance standards would require TransGrid to deliver specified reliability outcomes. Compliance with the standard would be assessed by reviewing actual network performance.

planned outcomes and actual outcomes. Unlike distribution networks, transmission networks tend to have a low number of outages, which means that focusing on output measures may provide a false view of their reliability. There may be no outward signs that there is a major vulnerability in a transmission network until reliability is badly affected.

2.3.4 Compliance with the standards

IPART is responsible for assessing whether TransGrid has met its licence obligations, including the obligation to meet the reliability standard.[8]

To demonstrate compliance with the reliability standard, TransGrid would need to undertake probabilistic simulation modelling of the network taking into account system elements (including non-network elements), a defined set of combinations of asset failures, asset failure rates and assumed maximum demand/load profile at each bulk supply point. It would also need to report on the process, assumptions and outcomes it uses.

The Energy Users Association of Australia (EUAA) submitted that the new standards potentially mean more network investment that consumers have to pay for and bear the market risk for. It considers that the consumers should receive compensation if the reliability standards are not actually met.[9] However, in demonstrating compliance with the standards, TransGrid would be required to estimate an *expected value* of unserved energy at each bulk supply point, rather than be required to deliver specific performance outcomes.

Essential Energy submitted that it may be prudent to put in place a performance based review period, noting that the compliance is over the asset life and the review period would only be a small snapshot of the compliance period.[10] We consider that performance outcomes would be useful for informing future reviews of the standards as it would allow us to consider what impact the new planning standards will have had on the reliability experienced by customers. But, rather than include this in the standards as an additional compliance requirement, we consider that it would be sufficient to request this information as part of the next review process.

TransGrid submitted that the detailed process for compliance will need to be clarified around issues such as changes to maximum demand forecasts, and to cater for new bulk supply points.[11] We will undertake public consultation on our proposed approach to compliance in early 2017.

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8 *Electricity Network Assets (Authorised Transactions) Act 2015*.
9 EUAA submission to Supplementary Draft Report, 31 October 2016, p 3.
10 Essential Energy submission to Supplementary Draft Report, 28 October 2016, p 3.
11 TransGrid submission to Supplementary Draft Report, 26 October 2016, p 3.

2.4 How the recommended standards affect network investment

The reliability standards set by the Minister work as part of the regulatory framework governing transmission services. They do not replace the other parts of this regulatory framework, such as the RIT-T process.

Using the average life cycle failure rates as outlined above would mean that the reliability standards would not influence the timing of asset replacement decisions. However, we would expect them to influence the timing of investment for demand driven augmentations.

In general, a reduction in the reliability standards is likely to reduce costs to customers because the efficient cost of meeting them is lower, and an increase in reliability is likely to cost customers more. The efficient costs of meeting the standards are assessed by the AER. However, all else being equal, the new reliability standards are likely to put downward pressure on the cost of meeting them, because they explicitly facilitate the adoption of non-network solutions where they are the most efficient option.

2.4.1 The AER assesses if the standards are being met efficiently

GreenSync submitted that the proposed reliability standards do not protect consumers of regulated services from unreasonable price hikes and price gauging or encourage regulated service providers to improve their economic efficiency.[12] By themselves, the reliability standards set by the Minister do not ensure that the Transmission Network Service Provider (TNSP) only makes efficient investments. The incentives for TNSPs to make efficient investments also depend on the regulatory framework implemented by the AER.

Chapter 6A of the National Electricity Rules requires the AER to set allowable revenue for TNSPs.[13] The AER must consider any reliability standards set by jurisdictional legislation as an obligation on TNSPs.[14] The standards set by the Minister establish minimum standards for reliability, by prescribing both a redundancy level and average level of expected unserved energy at different bulk supply points. The AER's role is to assess the efficient level of capital and operating expenditure to meet these standards.

12 GreenSync submission to Supplementary Draft Report, 28 October 2016, p 1.

13 See National Electricity Rules, available at: http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Current-Rules, accessed 27 May 2016.

14 HoustonKemp, *Economic Regulation of NSW Electricity Network Businesses,* 7 May 2015, pp 4-5.

We also note that if a TNSP proposes an augmentation to the network of $6 million or more, it must undertake the Regulatory Investment Test for Transmission (RIT-T).[15] The RIT-T aims to identify the option that maximises the net present value to the market, given the reliability standards established by jurisdictional legislation (as well as the standards set under the National Electricity Rules to ensure system reliability, for example voltage requirements).[16] Changes to the Rules are also being considered to require replacement expenditure to be subject to the same regulatory process as augmentation expenditure.[17]

2.4.2 The standards promote the most efficient investment solution

We have recommended reliability standards that are framed to promote the most efficient network or non-network solution by using technology-neutral language, rather than promoting a specific type of network or non-network solution. Therefore we do not agree GreenSync's submission that the proposed reliability standards do not encourage competition where possible.[18] In particular, our recommended standards:

- Use terminology that focuses on the supply of electricity (the service output), rather than the specific technology used to meet this supply (the inputs). This provides scope for non-network options to be pursued and reduces the bias towards transmission network assets such as cables and transformers.
- Specify the 'supply capability' required at each bulk supply point but not how this supply capability is provided.
- Clarify the potential role of non-network solutions by noting that supply capability may be met by means of the transmission network, distribution network, network support arrangements, backup supply capability, or any combination of these.
- Allow for an exception to the required level of redundancy in certain circumstances.

The current standards, which specify reliability in terms of required redundancy (N-x), do not prescribe how that level of reliability would be met. For example, reliable electricity supply could be provided by a combination of cables, transformers, generators, demand-side management or battery storage. However, the way in which reliability standards are drafted can have a significant impact on the potential for non-network solutions to be a viable alternative to network investment. We consider that the existing reliability

15 AER, *Cost thresholds review for the regulatory investment test - Final determination*, November 2015, p 1.

16 System standards are set out in schedule 5.1a of the National Electricity Rules.

17 IPART, *Electricity transmission reliability standards – Final Report*, August 2016, pp 53-55.

18 GreenSync submission to Supplementary Draft Report, 28 October 2016, p 1.

standards may inadvertently limit the potential for some types of non-network alternatives, even if they are the most efficient option.

GreenSync notes that there seems to be a mixture of reliability measures with forecast solution costings, and that the model assumes that the only way to improve reliability is to duplicate transformers and lines.[19] For the purposes of modelling the optimal unserved energy at each supply point, we have focused on network costs, which is a simplifying assumption.

It is not possible to know in advance all of the potential solutions that will be available over the 2018 regulatory period. Some of the potential options for providing reliability, particularly non-network solutions, are not able to be considered in advance of when an investment decision is needed. Others depend on the forecast maximum demand and load profile at each bulk supply point, which changes over time. In addition, technological advances may also enable new options and/or reduce the cost of others. As a result, part of our aim in making recommendations on the standards is to ensure that they provide enough flexibility so as not to inhibit the uptake of new technologies.

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19 GreenSync submission to Supplementary Draft Report, 28 October 2016, pp 1-2.

3 Unserved energy allowance for Inner Sydney

TransGrid is proposing to undertake substantial additional investment in Inner Sydney in the 2018 regulatory period. The upcoming expenditure for the Inner Sydney is costly, long lasting and impacts a substantial number of customers. We have considered several ways of deriving an appropriate value for the expected unserved energy parameter in the reliability standard for Inner Sydney.

In our Draft Report released in May 2016, we proposed a separate process for determining the expected unserved energy allowance for Inner Sydney.[20] Broadly, the process we set out involved TransGrid and Ausgrid using their joint planning process to identify various reliability options in terms of the range of expected unserved energy values that could be delivered for this area and then providing a proposed unserved energy allowance for us to consider.

TransGrid has subsequently advised us that it is not in a position to propose an unserved energy allowance for Inner Sydney within the timeframe required. As a result, we have decided to adopt the results of our own modelling as the basis for our recommendations on the unserved energy allowance for Inner Sydney.

3.1 Recommended unserved energy allowance for Inner Sydney

We recommend that the unserved energy allowance included in the reliability standard for the Inner Sydney supply area is 0.6 minutes per year, at average demand. This is consistent with the recommendation in our Supplementary Draft Report.

This value would apply across the five Inner Sydney bulk supply points (Beaconsfield West, Haymarket, Rookwood Rd, Sydney North and Sydney South) as a single group. We have considered these bulk supply points as a single group for the purpose of setting an unserved energy allowance because they are so closely linked within the network that they are difficult to differentiate in terms of reliability.

Our recommendation for the unserved energy allowance is based on our own modelling of the optimal unserved energy for the Inner Sydney area, in line with our approach for the rest of the NSW transmission network.

20 IPART, *Electricity Transmission Reliability Standards - Draft Report*, May 2016, p 25.

Table 3.1 shows that TransGrid's estimate of the current expected unserved energy under the existing planning standards is around zero.[21] Therefore we expect that our recommendation would reflect a slight loosening of the reliability standard. This outcome was supported by TransGrid.[22] The EUAA agreed that it is not efficient for TransGrid to plan to have zero unserved energy.[23]

Table 3.1 Inner Sydney BSPs – annual USE in minutes at average demand

	IPART modelling	TransGrid estimate of current network
Inner Sydney	0.6	Around 0[a]

[a] Estimate based on the impact of both a single asset failure (n-1 contingency) and a simultaneous outage of a single 330kV cable and any 132kV feeder based on expected actual probabilities of outages and historical outage durations.

Source: IPART Draft Report, IPART calculations and TransGrid indicative compliance assessment.

While our recommendations are likely to allow a small increase in the expected value of unserved energy in the Inner Sydney area, we do not consider that they would result in a significant change to the level of reliability experienced by customers. TransGrid has advised us that under current forecast demand and planned cable withdrawals by Ausgrid, it would continue to expect an annual unserved energy of zero for several years, even taking into account the current age and condition of the assets in service. Beyond this time, increases in maximum demand and the retirement of some of Ausgrid's older cables would lead to a positive value of expected unserved energy unless additional investment in the network is made.[24]

The new recommended standard should allow TransGrid to consider a broader range of investment options for the Inner Sydney area, including a greater ability to adopt new technologies, and result in investment decisions that better reflect the value that customers place on reliability. Through the regulatory revenue determination process with the AER, TransGrid would be required to demonstrate that any investments it proposes are efficient, and where relevant, necessary to meet the reliability standards that are in place. In our view, the recommendations we propose would provide additional flexibility to TransGrid in terms of expanding the number of investment options available to it.

21 This is based on the current standard requires TransGrid to plan its network so that the Inner Sydney metropolitan system is capable of meeting the peak load following the simultaneous outage of a single 330kV cable and any 132kV feeder or 330/132kV transformer, or an outage of any section of 132kV busbar. This is referred to as a modified N-2 obligation. In addition to this modified N-2 obligation, which applies to the combined TransGrid and Ausgrid system, an N-1 criterion also applies separately to TransGrid's Inner Sydney network. The load forecast to be considered is a 50% POE maximum demand forecast. NSW Department of Industry and Investment, Transmission network design and reliability standard for NSW, December 2010, p 10.

22 TransGrid submission to Supplementary Draft Report, 26 October 2016, p 1.

23 EUAA submission to Supplementary Draft Report, 31 October, p 2.

24 Email to IPART, TransGrid, 24 February 2016. Note that TransGrid has advised that it has not included the simultaneous outage of a single 330kV cable and any 330/132 kV transformer in this estimation and that to do so would require further assessment.

Recommendation

1 The allowance for expected unserved energy for Inner Sydney that should be included in the NSW transmission reliability standard is 0.6 minutes (maximum value per year in minutes at average demand).

3.2 Overview of electricity transmission in Inner Sydney

The Inner Sydney transmission system supplies most of the eastern Sydney metropolitan area, extending from the Pacific Ocean, west to Auburn, north to the Hawkesbury River and south to the Royal National Park. The network supplies electricity to over 500,000 customers including homes, businesses, hospitals and public transport as well as Australia's financial hub, Sydney Airport and Port Botany. The network is technically defined as TransGrid's 330kV cables 41 and 42, 330/132kV substations Beaconsfield, Haymarket, Rookwood Road, Sydney North and Sydney South and Ausgrid's 132kV transmission network that links to those TransGrid substations. A map of the Inner Sydney area is included in Appendix C.

3.2.1 What investment is TransGrid considering in this area?

The Inner Sydney transmission network represents an integrated supply arrangement between TransGrid and Ausgrid. A number of the underground cables supplying the Inner Sydney area were built more than 50 years ago. Due to deteriorating cable conditions, increasing environmental risks and growing maintenance concerns, some parts of the network are scheduled for retirement in the coming years.

TransGrid and Ausgrid are working together with the aim of achieving a coordinated and cost effective solution. This joint project is known as the 'Powering Sydney's Future' project. Powering Sydney's Future was initially being considered for the 2014-15 to 2017-18 regulatory period as a result of the combined impact of the proposed retirement of a number of Ausgrid's aged oil-filled cables and forecast demand growth in the area. The project did not proceed over this period as condition assessments determined that the cable retirements could be deferred and the load forecast was revised down.

The project has now recommenced and forecast investment is likely to be included in TransGrid's regulatory proposal to the Australian Energy Regulator for the 2018-19 to 2022-23 regulatory period.[25]

25 TransGrid, Fact Sheet – Powering Sydney's Future, May 2014, p 2, and additional information provided to IPART by TransGrid.

3.3 How we modelled the unserved energy allowance for Sydney

Our recommended standards would require TransGrid to plan its network to keep the expected value of unserved energy below 0.6 minutes per year at average demand following the simultaneous outage of a single 330 kV cable and any 132 kV feeder or 330/132 kV transformer.

Our modelling takes into account the probability and impact of the following situations, based on life-cycle average failure rates:

- system normal
- single transformer failure
- single line failure
- double transformer failure, and
- double line failure.

We have also included an allowance for non-catastrophic transformer failures (failures that can be repaired). To estimate the allowance for non-catastrophic transformer failures we used information on the rate of these failures (provided by TransGrid) as well as information on the average repair time (also from TransGrid) and the speed of switching available at the bulk supply point (based on our modelled optimum). Because backup capacity is available, a non-catastrophic failure would lead to an outage lasting only as long as it takes to switch to the backup capacity. We used TransGrid's historical rates of non-catastrophic failure and repair times to estimate this allowance.

For the Inner Sydney area, the allowance for these failures makes up a significant portion of the expected unserved energy allowance. Although TransGrid has not calculated the level of expected unserved energy in its network that is associated with non-catastrophic events, we consider that our allowance is likely to be consistent with the current level of expected unserved energy associated with these types of failures.

While TransGrid has not yet estimated the equivalent value for the Inner Sydney area, it would be required to do so in the future in order to assess compliance with the standards. It is important that the set of risks that TransGrid is asked to consider as part of the planning standards reflect the set of risks that were used to determine the allowance for expected unserved energy (the optimisation model).[26]

[26] If the definition in the standards is broader than was included in the optimisation model TransGrid may find it difficult to meet the standards without significant additional investment in reliability. This is not efficient and not driven by the value that customers place on reliability. On the other hand if the definition in the standards is narrower than what was included in the optimisation model TransGrid may find it too easy to meet the standards and not invest when there would be value in doing so.

3.3.1 Life-cycle approach

The recommended standards would require TransGrid to consider life-cycle average failure rates in estimating the expected value of unserved energy. Our model looks at single asset failures as well as the simultaneous failure of two transformers or two lines. In response to our Supplementary Draft Report, TransGrid submitted that the risks it considers for multiple outages do not match IPART's optimisation model (modified N-2) for Inner Sydney. It stated that the unserved energy due to the poor performance of the ageing cables supplying inner Sydney will be underestimated.[27]

While the model considers the life-cycle average failure rate of a typical asset of that type, the actual failure rate of each asset depends on a number of factors, such as the type of asset and its age. In reality the condition of a specific asset may be better or worse than average, and that will affect the likelihood of failure, but this is not taken into account in the model. This means that the expected unserved energy value in the standard will understate the actual probability of expected outages in years where assets are older than average, and hence more likely to fail, and overstate the actual probability of expected outages in years when assets are younger than average, and hence less likely to fail.

As a result, there may be times when the actual value of unserved energy for the network exceeds the value in the standard for that year. This is the same as under the current standard, which is also a planning standard. Even though TransGrid estimates an expected unserved energy of zero for the current network, supply outages still do occur from time to time.[28]

As provided for under the current standard, TransGrid would continue to decide at what point the age or condition related probability of asset failure is such that it warrants the replacement of assets. We are aware that for the Inner Sydney area, many of the assets that are currently in place are older than the life-cycle average. As a result, their actual probabilities of failure are likely to be higher than assumed in our modelling. This means that at this point in the life-cycle of the Inner Sydney network, the actual expected unserved energy may be higher than 0.6 minutes per year.

For Inner Sydney, we considered whether we should expand the number of simultaneous asset failures, for example, to consider the simultaneous failure of three or more assets. However, at the life-cycle failure rates included in our optimisation model, we expect that doing this would make very little, if any, difference to the optimal unserved energy estimated by the model.

27 TransGrid submission to Supplementary Draft Report, 26 October 2016, p 4.
28 Email to IPART, TransGrid, 20 September 2016.

3.3.2 Modelling Inner Sydney as a single group

Our unserved energy allowance is for the five Inner Sydney bulk supply points (Beaconsfield West, Haymarket, Rookwood Rd, Sydney North and Sydney South) as a single group. This is based on modelling each of the five Inner Sydney bulk supply points separately and using these to derive a group unserved energy allowance in the same way as we did for other grouped bulk supply points across the network:

- We added the unserved energy allowances in MWh for the individual bulk supply points within the group, then
- converted this value to minutes by dividing it by annual average demand at the combined individual bulk supply points.

Although we would have liked to jointly model these grouped supply points, this would introduce a significant additional level of complexity into the modelling.

3.3.3 Value of customer reliability (VCR)

Our Terms of Reference require us to have regard to the latest estimates of VCR published by AEMO. We have used these values to estimate a VCR for each bulk supply point across the network based on the different types of customers using electricity at each point and their consumption (Table 3.2). However, we have adopted a higher VCR value of $90/kWh for Inner Sydney ($2016), consistent with the Inner metropolitan value estimated by HoustonKemp for TransGrid for the Powering Sydney's Future project.

Table 3.2 AEMO VCR results ($2014-15)

Customer type	VCR ($/kWh)
Residential	26.53
Commercial	44.72
Industrial	44.06
Agricultural	47.67
Direct connect	6.05
Aggregate NSW, including direct connects	34.15

Note: Residential VCR results are for NSW (including the ACT); Commercial, Industrial, Agricultural and Direct connect results are across the National Electricity Market.

Source: AEMO, *Value of Customer Reliability Review - Final Report*, September 2014, pp 2, 18, 31.

Over the course of our review, we received feedback that the AEMO estimates are not an accurate representation of the value of customer reliability because they are calculated from a very small sample size,[29] are overly dependent on the

[29] Essential Energy submission to IPART Issues Paper, 28 January 2016, p 5.

methodology used,[30] and do not adequately capture low probability but high impact supply interruptions.[31] Ausgrid submitted that the AEMO estimates do not capture important customers such as the Australian Stock Exchange, NSW Parliament, and large financial institutions.[32]

TransGrid recommended that IPART use the VCR estimate for Inner Sydney of its consultant HoustonKemp (Table 3.3).[33] Essential Energy also supported this approach.[34] The HoustonKemp reports that the AEMO VCR values are understated, as:

- they do not differentiate between sub regions, and it is reasonable to expect higher VCR values for Inner Sydney compared to the state averages, and
- they do not consider prolonged outages, and these would be likely to increase the VCR because backup generation is often not designed for long periods.

The HoustonKemp analysis was completed as part of the Powering Sydney's Future project being undertaken by TransGrid and Ausgrid, and its report is available on our website. It sought to capture the differences in the VCR for Inner Sydney customers compared to the NSW average. Its estimates for Inner Sydney are based on earlier work by Oakley Greenwood for the Australian Energy Market Commission, which specifically focused on commercial customers in urban areas.

Table 3.3 Value of customer reliability ($/kWh)

Study	HoustonKemp ($2016)	AEMO NSW aggregate, inc direct connect ($2014)
Inner metropolitan	$90	$34.15
CBD	$150-$192 ($170)	$34.15

Source: HoustonKemp, *CBD and inner metro VCR estimates – A Final Report for TransGrid on research, methodology and results*, 28 July 2016. AEMO, *Value of customer reliability review – Final Report*, September 2014.

The EUAA notes that the HoustonKemp value is based on a desktop review commissioned by TransGrid, and is much higher than the NSW AEMO aggregate. While it agrees that the AEMO statewide VCR is likely to be an underestimate for Inner Sydney, it is concerned that adopting $90/kWh may result in over investment in network infrastructure. It submitted that the VCR used in IPART's analysis should have been based on customer input.[35]

The HoustonKemp report outlines a number of shortcomings with its estimates, including that long duration outages are not accounted for, small sample sizes,

30 ETSE Consulting submission to IPART Issues Paper, 27 January 2016, p 7.
31 Ausgrid submission to IPART Issues Paper, 22 January 2016, p 9.
32 Ausgrid submission to IPART Issues Paper, 22 January 2016, pp 7-8.
33 Letter to IPART, TransGrid, 9 September 2016.
34 Essential Energy submission to Supplementary Draft Report, 28 October 2016, p 3.
35 EUAA submission to Supplementary Report, 31 October 2016, pp 1-3.

and that respondents' VCRs are based on an outage time that is the worst for them. It noted that the only robust way to derive appropriate VCR estimates would be to conduct a new VCR study, focused on highlighting differences in VCRs between different geographic areas in NSW and different customer groups. However, overall it considers that its estimates are likely to be an underestimate of the true VCR value for the Inner City region.[36]

We agree with stakeholders that further work is needed to better understand the true value that different customers place on reliability. In our Final Report provided to the Minister in August 2016 we supported a nationally consistent approach to the VCR. We made a recommendation for the NSW Government to ask IPART to determine VCRs for NSW 12 months prior to the next review of reliability standards if updated nationally consistent VCRs are not available.[37] If this is the case, we expect that we would commence a review on determining NSW VCRs in 2019-20.

The EUAA submitted that if HoustonKemp's VCRs estimates are too high, customers would bear the costs of additional investment to meet the standards for their remaining life.[38] However, we are also mindful of the objectives of this review, which include our recommended standards not resulting in a significant change from the current level of reliability experienced by customers.

Table 3.4 shows the impact on the unserved energy allowance of using different VCRs. It shows that using the HoustonKemp value of $90/kWh in our modelling results in an unserved energy allowance which increases from around zero minutes per year currently, to around 0.6 minutes per year. This compares to an unserved energy allowance of 1.7 minutes per year if the Inner Sydney weighted AEMO value of around $38[39] is used. Other sensitivity analysis on the optimization results is contained in Box 3.1.

The EUAA posed the question:

> How many businesses in the inner metropolitan and CBD areas are prepared to pay for only 0.6min interruption per year? Or are they happy with 1.7 minutes per year using the AEMO VCR values?[40]

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36 HoustonKemp, *CBD and inner metro VCR estimates – A final report for TransGrid on research, methodology and results*, 28 July 2016, p 3.

37 IPART, *Electricity transmission reliability standards, an economic assessment – Final Report,* August 2016, p 39.

38 EUAA submission to Supplementary Draft Report, 31 October 2016, p 3.

39 WSP Parsons Brinkerhoff, *NSW Transmission Reliability Standards Review - Value of Customer Reliability*, May 2016, IPART calculation based on information in email to IPART, Ausgrid, 21 July 2016.

40 EUAA submission to Supplementary Draft Report, 31 October 2016, p 3.

Table 3.4 Impact on value of customer reliability ($/kWh) on unserved energy allowance

VCR ($/kWh)	Unserved Energy Allowance
HoustonKemp	
$90	0.6
Sensitivity: 90 x 70% - $63	1.5
Sensitivity: 90 x 130% - $117	0.6
Inner Sydney weighted AEMO VCR	
$38.08	1.7
Current level of expected unserved energy	Around 0

Source: HoustonKemp, *CBD and inner metro VCR estimates – A final report for TransGrid on research, methodology and results*, 28 July 2016. WSP Parsons Brinkerhoff, NSW Transmission Reliability Standards Review - Value of Customer Reliability, May 2016, IPART calculation based on information in email to IPART, Ausgrid, 21 July 2016.

On balance, we consider that where there is uncertainty around key inputs, we should be conservative in setting the allowances for expected unserved energy. We recognise that substantial reductions in transmission reliability have the potential to create widespread and costly outages so the implications of setting the allowances for expected unserved energy too high could be significant. There are a number of inputs to the economic analysis that require further work. Our conservative recommendations are designed to ensure that changes in the level of transmission reliability are limited.

Box 3.1 Sensitivity analysis on the optimisation model

At each bulk supply point, the model selects the unserved energy that is associated with the optimal combination of reliability settings it identifies based on the various inputs. An input change may result in a different value of unserved energy because it leads to a change in the optimal combination of reliability settings or it may result in the same unserved energy because it does not lead to a change in the optimal combination of reliability settings.

As well as conducting sensitivity analysis of the VCR on our unserved energy allowances, we also tested another of other input sensitivities, including:

- Maximum demand - up and down 30%.
- Cost co-efficient/exponent – up and down 30%.
- Asset lives – up and down 30%.
- Discount rate – 4.7% and 6.4% (compared to a base of 5.6%).
- Failure rate – up and down 10%.
- Line length – up and down 30%.

For the Inner Sydney area, the sensitivity analysis suggests that:

- The results are somewhat sensitive to changes in maximum demand – with a 30% lower maximum demand increasing the unserved energy to 1.3 minutes and a 30% higher maximum demand reducing it slightly to 0.5 minutes.
- Changes to the discount rate within the range we tested made only a very small difference (the low value did not result in any change; the high value raised the unserved energy from 0.6 minutes to 0.8 minutes).

4 Unserved energy allowance for other areas

Between our Draft and Final Reports for the review we made a number of changes to our optimisation modelling to ensure that it better took into account supply point specific information, such as load factors and the actual number of lines and transformers. This resulted in material differences in the optimal unserved energy allowance compared to our Draft Report for Munyang, Broken Hill, Wellington Town, Molong and Mudgee. As a result, we considered that an additional round of consultation was necessary for these bulk supply points.

This chapter presents our final recommendations on the unserved energy allowances for these locations.

4.1 Recommended unserved energy allowances

Table 4.1 presents our final recommendations on the annual unserved energy for each of the supply points. These values have been determined by the updated modelling estimates from our optimisation model.

Table 4.1 Final recommendations on annual USE in minutes at average demand

	IPART final recommendation	IPART Draft Report	IPART Supplementary Draft Report	TransGrid estimate of current network
Munyang	14	10	191	Less than 1
Broken Hill 22kV	10[a]	5	14	Around 5
Broken Hill 220kV		n/a[b]	5	Around 10
Wellington Town	21	10	21	Around 21[c]
Molong	46	16	46	Around 100
Mudgee	14	3	14	Around 30

[a] This is a 'group' standard across both supply points.

[b] Following release of the Draft Report we identified that our model did not correctly calculate the level of unserved energy in instances where a bulk supply point had no transformers. This resulted in a very high value of unserved energy at the Broken Hill 220kV bulk supply point. We have now corrected this.

[c] Revised following release of the Supplementary Draft Report.

Source: IPART calculations and TransGrid indicative compliance assessment (provided to IPART on a confidential basis), TransGrid submission to IPART Supplementary Draft Report, 26 October 2016, p 2.

Table 4.1 shows that we have revised some of our recommendations following the Supplementary Draft Report.

Our final recommendation for Munyang is an unserved energy allowance of 14 minutes, which is significantly lower than the recommendation of 191 minutes in our Supplementary Draft Report. The change is the result of using different inputs for the load factor and maximum demand at this bulk supply point. We have also updated our recommendation for Broken Hill to establish a group unserved energy allowance for both the Broken Hill 22 kV and 220 kV bulk supply points. This is because the two bulk supply points are related in terms of the available backup arrangements (backup generation).

Our recommendations for the other bulk supply points are the same as for our Supplementary Draft Report. The unserved energy allowance for Wellington Town is consistent with the current expected unserved energy, however the allowances are likely to be lower than the expected value of unserved energy currently associated with the transmission network at Molong and Mudgee. The implication of this recommendation for TransGrid is that it may need to undertake additional capital investment to improve the level of reliability at these bulk supply points.

Having reviewed our modelling for these bulk supply points and discussed each of them with TransGrid we consider that our modelling is appropriate.

Recommendation

2 The allowance for expected unserved energy for Munyang that should be included in the NSW transmission reliability standard is 14 minutes (maximum value per year in minutes at average demand).

3 The allowance for expected unserved energy for Broken Hill 22 kV and Broken Hill 220 kV should be set in NSW transmission reliability standard as a group at 10 minutes (maximum value per year in minutes at average demand).

4 The allowance for expected unserved energy for Wellington Town that should be included in the NSW transmission reliability standard is 21 minutes (maximum value per year in minutes at average demand).

5 The allowance for expected unserved energy for Molong that should be included in the NSW transmission reliability standard is 46 minutes (maximum value per year in minutes at average demand).

6 The allowance for expected unserved energy for Mudgee that should be included in the NSW transmission reliability standard is 14 minutes (maximum value per year in minutes at average demand).

4.2 Munyang

In our Supplementary Draft Report, we recommended an unserved energy allowance for 191 minutes for Munyang. Table 4.1 shows that this allowance is much higher than the current value of expected unserved energy at this bulk supply point, which is estimated at less than 1 minute. TransGrid submitted that as a result of this change, customers could experience a large deterioration in reliability.[41]

The load served by the Munyang bulk supply point is to the nearby ski fields. The high unserved energy allowance recommended in our Supplementary Draft Report was largely driven by the low load factor (0.18) at this bulk supply point resulting from the combination of a very pronounced winter peak, and low summer maximum demand. After considering submissions and further consultation, we have revised the load factor to reflect only the ski-season (0.36), rather than an annual load factor as we have done for the other bulk supply points.[42] We have also updated our input for maximum demand to reflect the ski-season maximum demand. As a result, our recommended unserved energy allowance has fallen from 191 minutes to 14 minutes per year at average demand (Table 4.2).

We also considered stakeholders' submissions relating to other characteristics particular to Munyang, including how seasonality may affect the VCR, its topography, and environmental requirements, but we have not made any further adjustments as a result of these issues.

Table 4.2 Updates to the Munyang Bulk Supply Point

	Final recommendation	IPART Supplementary Draft Report
Load factor	0.36	0.18
Maximum demand	27 MW	2 MW
Unserved Energy Allowance	14 minutes	191 minutes

Source: Information from email to IPART, TransGrid, 10 November 2016, IPART calculations.

4.2.1 Seasonality at Munyang

In response to our Supplementary Draft Report, Essential Energy submitted that TransGrid's forecasts of demand for Munyang underestimates the POE50 due to the lack of temperature correlation in the seasonal ski field are load. It stated that as a result, the load at risk has been underestimated by 10% relative to the actual and 26% relative to the POE10.[43]

41 TransGrid submission to Supplementary Draft Report, 26 October 2016, p 2.
42 The ski season load factors based on TransGrid data for the period 15 May to 1 October 2011.
43 Essential Energy submission to Supplementary Draft Report, 28 October 2016, p 1.

We further investigated our demand forecasts and we found that the maximum demand in our modelling was based on the summer maximum demand (1.9MW), instead of the winter maximum demand, which was significantly higher. We have updated our maximum demand forecast in line with TransGrid's winter maximum demand forecast of 27MW.[44]

Essential Energy submitted that businesses served by the Munyang bulk supply point have a variable VCR which is very low for the majority of the year, and extremely high for their peak period of economic production. It submitted that as a result, the VCR during peak periods has a four times multiplier (based on a 3-month peak season). Therefore it considered that we should use either an aggregate floor value load factor, or a seasonal load factor and VCR in order to adequately reflect the customers' real life situation.[45] TransGrid also submitted that IPART should take into account the potentially higher VCR during winter.[46]

While we agree that customers would value reliable energy supply more in the winter than summer, the VCR methodology does not take into account seasonality. Instead, the AEMO VCRs have been weighted by energy use by customer type - regardless of **when** the customers use the energy, and the absolute level of the energy used at each bulk supply point. Therefore there is no basis to adjust the VCRs for seasonality.

However, given the large seasonal variation in demand for Munyang, we consider that it is reasonable to set the standard based on the load factor at the time of the year when the bulk of the energy is being used. Therefore, we have decided to use the ski-season load factor (0.36) in our modelling.

4.2.2 Topography

TransGrid has indicated that Munyang has a low level of expected unserved energy currently because it has fast switching in place, whereas our model found manual switching to be optimal. Essential Energy suggested that manual switching may lead to greater expected unserved energy than our standard allows.

> Due to the likely severe prevailing weather conditions during the ski-season and the resultant increased risk of unplanned network outages coupled with the difficult terrain and ground-cover (access) conditions, the supply restorations times are likely to be much longer, and this warrants some readily available backup or redundancy in the interests of public safety and minimum amenity.[47]

The purpose of the new approach to setting reliability is to determine standards with reference to outcomes, rather than prescribe how the standards are met. We

44 Information provided in Email to IPART, TransGrid, 10 November 2016.

45 Essential Energy submission to Supplementary Draft Report, 28 October 2016, p 1.

46 TransGrid submission to Supplementary Draft Report, 26 October 2016, p 2.

47 Essential Energy submission to Supplementary Draft Report, 28 October 2016, p 2.

understand that in some cases automatic switching can be a relatively cost-effective option (due to the geography and proximity to other infrastructure at the bulk supply point). Munyang is relatively close to other infrastructure, including electricity generation in the Snowy area. For any new investment, the AER could consider whether automatic switching remains the most cost-effective way of meeting the standards.

4.2.3 Environmental requirements

TransGrid notes that there are environmental restrictions at Munyang that mean different technologies have been adopted at Munyang, such as gas insulated transformers, and these differences have not been factored into our cost estimates.[48] Differences in the cost relativities between the various supply, restoration and repair options available at a particular bulk supply point compared with the average might lead to a different unserved energy allowance than we have modelled. However, in relation to Munyang we note that the environmental restrictions referred to by TransGrid are likely to raise the cost of providing reliability. All else being equal, it is likely that this would lead to a higher unserved energy allowance rather than a lower one if factored into our modelling.

4.3 Broken Hill

There are two bulk supply points in Broken Hill – a 22kV bulk supply point for the township, and a 220kV bulk supply point for a mine. The recommendations in our Supplementary Draft Report would have meant that a new transmission line, battery storage, a new generator, or load curtailment would be required to meet the unserved energy allowances to supply the mine.[49]

The allowance for unserved energy is different for each supply point as a result of different inputs for maximum demand, load factor/load duration curves and network infrastructure. However, the two supply points are related in terms of the available backup arrangements.

TransGrid has access to backup generation at Broken Hill. We understand that TransGrid restores the township 22kV bulk supply point *first because it is closer to the gas turbines used for backup generation. However, our modelling suggests that the optimal value of unserved energy is higher at* the township 22kV bulk supply point and lower at the industrial 220kV bulk supply point (Table 4.3).

48 TransGrid submission to IPART Supplementary Draft Report, 26 October 2016, p 2.

49 TransGrid submission to Supplementary Draft Report, 26 October 2016, p 2.

Table 4.3 Broken Hill – Summary of USE for separate supply points (minutes)

	Customer	USE allowance - IPART Supplementary Draft Report	TransGrid estimate of current unserved energy	Current network restoration time
Broken Hill 22kV	Township	14	Around 5	30
Broken Hill 220kV	Mine	5	Around 10	60

Source: IPART, *Electricity transmission reliability standards – Supplementary Draft Report*, September 2016, p 28.

Because the two supply points share common backup arrangements, our final recommendation is to set a group standard for both Broken Hill bulk supply points. This is consistent with treatment of several other bulk supply points, including Canberra 132 kV and Williamsdale 132 kV, Macarthur 132 kV and 66kv, Orange North 132 kV and Orange 66 kV, and Taree 66 kV and 33 kV.[50] When the Broken Hill supply point is modelled as a group standard, the unserved energy allowance is 10 minutes at average demand. The current expected unserved energy is around 10 minutes, and so reliability should remain unchanged.

Essential Energy submitted that the access to backup generation at Broken Hill is currently provided by Essential Energy, but there are no formal arrangements in place for the operation of this this generation. It stated that without agreements in place it cannot be expected that DNSPs will maintain specific levels of redundancy, as often local growth or customer connections erode existing network capacity and hence redundancy. Therefore it proposed that it may be worth considering whether a requirement to supply backup capacity is included in the DNSPs' licence conditions.[51]

We do not consider that an obligation should be conferred on DNSPs to provide backup arrangements to TransGrid, as this may not be the most efficient option for meeting the reliability standards. Under the standards TransGrid is responsible for selecting the most efficient option to meet the standards, and negotiating with DNSPs to provide capacity where appropriate.

4.4 Wellington Town, Molong and Mudgee

Our recommendations for the other bulk supply points are the same as for our Supplementary Draft Report. The unserved energy allowance for Wellington Town is consistent with the current expected unserved energy, however information provided by TransGrid suggests that the unserved energy

50 IPART, *Electricity transmission reliability standards, an economic assessment – Final Report*, August 2016, p 22.

51 Essential Energy submission to Supplementary Draft Report, 28 October 2016, p 2.

allowances for Molong and Mudgee are likely to be below the expected value of unserved energy currently associated with the transmission network.[52]

Having reviewed our modelling and undertaken further consultation, we consider that our recommended allowances are appropriate.

4.4.1 Wellington Town

TransGrid submitted that our recommendation for Wellington Town of 21 minutes is only slightly lower than the current level of planned unserved energy. It states that this is reflective of the one hour time taken to manually switch to backup load served by Essential Energy's network, and that compliance with IPART's recommended allowance would require a non-network solution or a network investment.[53] However we note Essential Energy's submission which indicates that there may be low cost options to implement automated remote field switching.[54]

4.4.2 Molong

The expected unserved energy at Molong is currently around 100 minutes. We are recommending 46 minutes in our standards. TransGrid does not currently have available backup supply and therefore, should an outage occur, the estimated time to restore supply depends on how quickly the fault can be repaired (as opposed to how quickly the backup arrangements can be put in place). TransGrid submitted that the implementation of the recommended allowance would require a non-network solution or a network investment, at a cost of approximately $4 million.[55]

4.4.3 Mudgee

For Mudgee, TransGrid has informal arrangements in place with Essential Energy's distribution network to provide backup for the transmission system but it would take around one hour to switch between the two, resulting in a current expected unserved energy of around 30 minutes.[56] Essential Energy submitted that reducing this time to 15 minutes in line with our recommendations may be possible at low cost by implementing an automated change-over scheme subject to further and detailed investigation. However, it notes that local growth or customer connections erode network capacity, making it comparatively less economic to upgrade to maintain the desired level of reliability.[57]

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52 TransGrid submission to Supplementary Draft Report, p 2.
53 TransGrid submission to Supplementary Draft Report, 26 October 2016, p 2.
54 Essential Energy submission to Supplementary Draft Report, 28 October 2016, p 2.
55 TransGrid submission to Supplementary Draft Report, 26 October 2016, pp 2-3.
56 *Ibid.*
57 Essential Energy submission to Supplementary Draft Report, 28 October 2016, p 3.

Appendices

A Terms of Reference for the review

Premier of New South Wales

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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~~ Peter

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

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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:

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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 Recommended reliability standards

1. Status of this standard

(a) This standard is a reliability and performance standard issued by the *Minister* for the purposes of clause 3(a) of the *Licence*.

(b) This standard may be cited as the *Transmission Reliability and Performance Standard 2016 No. 1*.

2. Interpretation

(a) In this standard, where the terms below are italicised they have the corresponding meanings set out below.

Expected unserved energy means the expected amount of energy that cannot be supplied, taking into account the probability and expected impact (including expected outage duration and forecast load) of the following:

(i) failure of a single *system element*;

(ii) double transformer failure, or failure of equivalent *system elements*; and

(iii) double line failure, or failure of equivalent *system elements*.

Inner Sydney means the inner metropolitan transmission system, which is that part of the *transmission system* constituted by:

(i) cables 41 and 42;

(ii) the 330/132kV substations at Rookwood Road, Beaconsfield, Haymarket, Sydney North and Sydney South;

(iii) any future associated 330kV cables and 330/132kV substations; and

(iv) any of Ausgrid's 132k transmission network that links any of the above.

Level of redundancy means:

(i) for category 1 bulk supply points, a supply interruption may occur following the outage of a single *system element*;

(ii) for category 2 bulk supply points, a non-zero amount of load must be supplied following the outage of a single *system element*; and

(iii) for category 3 bulk supply points, a non-zero amount of load must be supplied following the outage of a single *system element*. In addition, for *Inner Sydney*, a non-zero amount of load must be supplied following the simultaneous outage of a single 330 kV cable and any 132 kV feeder or 330/132 kV transformer.

Licence means the Transmission Operator's Licence under the *Electricity Supply Act 1995* granted to NSW Electricity Networks Operations Pty Limited (ACN 609 169 959) as trustee for the NSW Electricity Networks Operations Trust dated 7 December 2015, or a licence that replaces it.

Licence Holder has the same meaning as under the *Licence*.

Minister has the same meaning as under the *Licence*.

RIT-T means the *Regulatory investment test for transmission and application guidelines 2010* published by the Australian Energy Regulator, or any replacement of that document from time to time.

System element means:

(i) a transmission circuit (a line or a cable);

(ii) a transformer;

(iii) a component of physical infrastructure other than a transmission circuit or transformer; or

(iv) network support arrangements, backup supply capability, or other measure that provides supply capacity.

Transmission system has the same meaning as under the *Licence*.

Tribunal has the same meaning as under the *Electricity Supply Act 1995*.

(b) Headings and notes which appear in this standard are intend as an aide to usage only, and do not form part of this standard.

(c) References to clauses in this standard are references to clauses of this standard, unless this standard expressly provides otherwise.

3. Requirement to design for a specified *level of redundancy* for each bulk supply point

Subject to clause 5(a) below, the *Licence Holder* must ensure that the *transmission system* is designed such that, for each bulk supply point listed in the table in clause 8, the *transmission system* achieves the *level of redundancy* category specified for that bulk supply point in the table in clause 8.

4. Requirement to design for a level of *expected unserved energy* for each bulk supply point

Subject to clause 6(a) below, the *Licence Holder* must ensure that the *transmission system* is designed such that the annual *expected unserved energy* in respect of a bulk supply point listed in the table in clause 8 does not exceed the allowance for *expected unserved energy* specified for that bulk supply point in the table in clause 8.

5. Flexibility in planning for the level of redundancy

(a) The *Licence Holder* is not required to comply with clause 3 above in respect of a bulk supply point listed in the table in clause 8 provided that:

(i) the *Licence Holder* has developed and submitted to the *Tribunal* a plan regarding measures for altering the reliability of the supply capacity of the bulk supply point;

(ii) that plan provides a greater net-benefit, using the cost-benefit methodology defined in the *RIT-T*, than the net-benefit of complying with clause 3 above; and

(iii) the *Tribunal* has advised the *Licence Holder* in writing that it is satisfied that the plan submitted under clause 5(a)(i) above would, if implemented, be likely to provide a greater net-benefit than would be provided by the *Licence Holder* complying with clause 3 above in relation to the bulk supply point.

(b) The *Licence Holder* must implement the plan within a time specified by the *Tribunal* to the *Licence Holder*, and such implementation must be to the reasonable satisfaction of the *Tribunal*.

(c) For the avoidance of any doubt:

(i) the *Licence Holder* may submit, from time to time, a proposed replacement for a plan referred to in clause 5(a); and

(ii) clause 5(a) applies to such a plan in the same way that it would apply to the first plan submitted under that clause in relation to a bulk supply point.

(d) Where the *Tribunal* has expressed satisfaction in writing under clause 5(a)(iii) about a plan that relates to a bulk supply point or bulk supply points listed in the table in clause 8, the *Licence Holder* may advise the *Tribunal* in writing that it has elected not to implement the plan. If the *Licence Holder* so advises the *Tribunal* of such an election:

(i) the *Licence Holder* is not required to implement the plan in question, despite clause 5(b);

(ii) despite clause 5(a), the *Licence Holder* must comply with clause 3 in respect of the bulk supply point or bulk supply points to which the plan in question relates; and

(iii) the *Licence Holder's* election not to implement the plan may not be reversed, unless the *Tribunal* provides its written consent for the reversal.

6. Flexibility in planning for the level of *expected unserved energy*

(a) The *Licence Holder* is not required to comply with clause 4 above in respect of a bulk supply point listed in the table in clause 8 provided that:

(i) the *Licence Holder* has developed and submitted to the *Tribunal* a plan regarding measures for altering the reliability of the supply capacity of the bulk supply point;

(ii) that plan provides a greater net-benefit, using the cost-benefit methodology defined in the *RIT-T*, than the net-benefit of complying with clause 4 above; and

(iii) the *Tribunal* has advised the *Licence Holder* in writing that it is satisfied that the plan submitted under clause 6(a)(i) above would, if implemented:

(A) be likely to provide a greater net-benefit than would be provided by the *Licence Holder* complying with clause 4 above in relation to the bulk supply point; and

(B) not result in a material reduction in the level of *expected unserved energy* at any bulk supply point.

(b) The *Licence Holder* must implement the plan within a time specified by the *Tribunal* to the *Licence Holder*, and such implementation must be to the reasonable satisfaction of the *Tribunal*.

(c) For the avoidance of any doubt:

(i) the *Licence Holder* may submit, from time to time, a proposed replacement for a plan referred to in clause 6(a); and

(ii) clause 6(a) applies to such a plan in the same way that it would apply to the first plan submitted under that clause in relation to a bulk supply point.

(d) Where the *Tribunal* has expressed satisfaction in writing under clause 6(a)(iii) about a plan that relates to a bulk supply point or bulk supply points listed in the table in clause 8, the *Licence Holder* may advise the *Tribunal* in writing that it has elected not to implement the plan. If the *Licence Holder* so advises the *Tribunal* of such an election:

(i) the *Licence Holder* is not required to implement the plan in question, despite clause 6(b);

(ii) despite clause 6(a), the *Licence Holder* must comply with clause 4 in respect of the bulk supply point or bulk supply points to which the plan in question relates; and

(iii) the *Licence Holder's* election not to implement the plan may not be reversed, unless the *Tribunal* provides its written consent for the reversal.

7. Requirement to provide information to the *Tribunal*

(a) The *Licence Holder* must comply with any request notified to the *Licence Holder* by the *Tribunal* for information that the *Tribunal* reasonably considers to be necessary or convenient for the *Tribunal* in monitoring the *Licence Holder's* compliance with this standard.

(b) The *Licence Holder* must comply with a request under clause 7(a) within a reasonable timeframe notified to the *Licence Holder* by the *Tribunal*.

(c) If reasonably requested to do so by the *Tribunal*, the *Licence Holder* must commission an audit of its compliance with this standard (or specified aspects of this standard). Such an audit must be conducted:

(i) by an auditor approved by the *Tribunal* in writing;

(ii) at the expense of the *Licence Holder*; and

(iii) such that a report on the audit by the auditor is provided to the *Tribunal* within a reasonable timeframe notified to the *Licence Holder* by the *Tribunal*.

(d) At least 90 days before entering into any contract for the construction of a new bulk supply point intended to form part of the *transmission* system (or within a different timeframe proposed by the *Licence Holder* and agreed to in writing by the *Tribunal*), the *Licence Holder* must submit a proposal regarding the new bulk supply point to the *Tribunal*. The proposal must:

(i) propose a *level of redundancy* category that this standard should specify for the new bulk supply point;

(ii) propose a level of *expected unserved energy* that this standard should specify for the new bulk supply point; and

(iii) set out reasons justifying the *level of redundancy* category and level of *expected unserved energy* proposed.

8. Table of values

	Redundancy category	Unserved energy allowance, maximum minutes per year at average demand
1. Inner Sydney		
Beaconsfield West 132 kV	3	0.6[a]
Haymarket 132 kV	3	
Rookwood Road 132 kV	3	
Sydney North 132 kV	3	
Sydney South 132 kV	3	
2.Other bulk supply points		
Albury 132 kV	2	14
ANM 132 kV	2	6
Armidale 66 kV	2	7
Beryl 66 kV	2	5
Boambee South 132 kV	2	18
Canberra 132 kV and Williamsdale 132 kV	2	3
Coffs Harbour 66 kV	2	10
Coleambally 132 kV	2	32
Cooma 66 kV	2	28
Cooma 132 kV	2	11
Cowra 66 kV	2	25
Dapto 132 kV	2	4
Darlington Point 132 kV	2	4
Deniliquin 66 kV	2	19
Finley 66 kV	2	12
Forbes 66 kV	2	19
Gadara (132 kV & 11 kV)	2	13
Glen Innes 66 kV	2	43
Griffith 33 kV	2	12
Gunnedah 66 kV	2	19
Holroyd 132 kV	2	24
Ingleburn 66 kV	2	5
Inverell 66 kV	2	40
Kempsey 33 kV	2	24
Koolkhan 66 kV	2	19
Liddell 330 kV	2	2
Lismore 132 kV	2	4

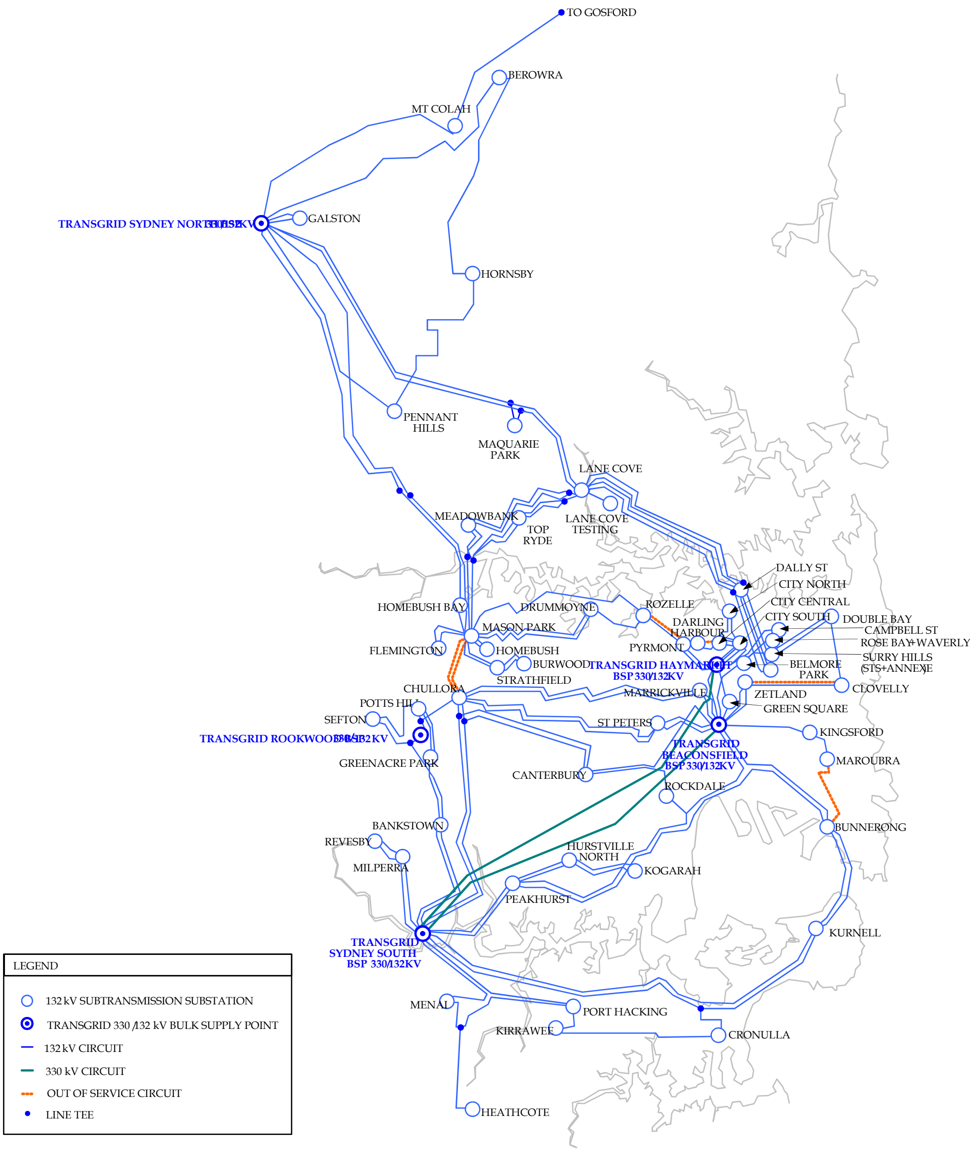
	Redundancy category	Unserved energy allowance, maximum minutes per year at average demand
Liverpool 132 kV	2	5
Macarthur 132 kV and 66 kV	2	3
Macksville 132 kV	2	23
Manildra 132 kV	2	6
Moree 66 kV	2	5
Mount Piper 66 kV	2	19
Munmorah 132 kV	2	20
Murrumburrah 66 kV	2	19
Muswellbrook 132 kV	2	3
Nambucca 66 kV	2	65
Narrabri 66 kV	2	5
Newcastle 132 kV	2	2
Orange North 132 kV / Orange 132 kV and 66 kV	2	7
Panorama 66 kV	2	5
Parkes 132 kV	2	9
Parkes 66 kV	2	51
Port Macquarie 33 kV	2	14
Queanbeyan 66 kV	2	4
Raleigh 132 kV	2	32
Regentville 132 kV	2	13
Stroud 132 kV	2	21
Sydney East 132 kV	2	2
Sydney West 132 kV	2	1
Tamworth 66 kV	2	4
Taree 66 kV and 33 kV	2	15
Tenterfield 22 kV	2	79
Tomago 132 Note 3	2	13
Tomago 330 kV	2	14
Tuggerah 132 kV	2	13
Tumut 66 kV	2	13
Vales Pt 132 kV	2	3
Vineyard 132 kV	2	1
Wagga 66 kV	2	33
Wagga North 132 kV	2	5
Wallerawang 132 kV	2	26
Wallerawang 66 kV	2	31

	Redundancy category	Unserved energy allowance, maximum minutes per year at average demand
Waratah West 132 kV	2	3
Wellington 132 kV	2	6
Yanco 33 kV	2	41
Balranald 22 kV	1	115
Broken Hill 22 kV and Broken Hill 220 kV	1	10
Casino 132 kV	1	7
Dorrigo 132 kV	1	41
Hawks Nest 132 kV	1	42
Herons Creek	1	17
Ilford 132 kV	1	14
Marulan 132 kV	1	10
Molong 66 kV	1	46
Morven 132 kV	1	33
Mudgee 132 kV	1	14
Munyang 33 kV	1	14
Murrumbateman 132 kV	1	49
Snowy Adit 132 kV	1	52
Wagga North 66 kV	1	42
Wellington Town	1	21
Yass 66 kV	1	22

a Applies across all the Inner Sydney bulk supply points listed.

C Map of the Inner Sydney area

Figure C.1 TransGrid and Ausgrid Inner Sydney network



Data source: TransGrid, 26 July 2016.

D IPART modelling inputs and assumptions

This appendix describes the inputs and assumptions used in the optimisation model.

The model finds the 'least total cost' set of planning criteria (see D.1) for each BSP, where *total cost* = *cost of supply arrangements* + *cost of expected unserved energy.*

Where two or more sets of planning criteria produce the same total cost, the model selects the set which involves the least load at risk and the quickest restoration time.

In calculating total costs, the model includes the following scenarios:

- system normal
- a single transformer failure
- a single line failure
- a double transformer failure, and
- a double line failure.

D.1 Planning criteria

The model uses **planning criteria** to inform both the cost of expected unserved energy and the cost of supply arrangements.

The planning criteria include the required level of redundancy at each BSP. The model is able to find the optimal level of redundancy at each BSP. However, we have recommended that the level of redundancy at each BSP remains the same as that which is required by the current electricity transmission reliability standard.

The values for other planning criteria are determined through the optimisation process. For each of these criteria, the model defines a range of discrete options. The criteria cover:

- **Load at risk** - load supplied from the BSP which is at risk of being interrupted, **after** allowing for any available backup capacity but **before** repair of the asset/s.

- **Restoration strategy** - the strategy to bring any available backup capacity into service following an asset failure or failures. An integer parameter from 0 to 5 is defined to select different forms and timescales of switching to the backup supply capacity, from no switching allowed (ie, no backup capacity), to automatic switching, remote switching and manual switching. This criterion imposes design requirements on switching arrangements.
- **Repair strategy** - the strategy to repair the failed asset(s) to their normal service levels (or to replace failed asset(s)). An integer parameter from 1 to 4 is defined to reflect the length of repair time, with longer repair times requiring less costly actions to achieve. This criterion imposes requirements on the management of spares, asset procurement and repair and replacement protocols.

The model assumes an upper bound for repair of transformers of 15,351 hours, repair of overhead lines of 120 hours, and repair of underground cables of 2,016 hours. These values were based on consultant advice to IPART, and correspond to the least-cost repair options.

Table D.1 Planning criteria (0 level of redundancy required, ie, N standard)

Planning criteria	Range of possible values		
	System normal (no failures)	Single failure	Double failure[a]
Load at risk for transformers	0%, 10%, 20%, …, 80% 90%	n/a	n/a
Load at risk for lines	0%, 10%, 20%, …, 80% 90%	n/a	n/a
Restoration strategy (same for transformers, lines and cables)	n/a	n/a	n/a
Repair strategy for transformers[b]	n/a	1 = 24 hrs 2 = 720 hrs 3 = 6,579 hrs 4 = 8,772 hrs	Equal to repair strategy for single failure
Repair strategy for overhead lines	n/a	1 = 8 hrs 2 = 24 hrs 3 = 48 hrs 4 = 120 hrs	Equal to repair strategy for single failure
Repair strategy for underground cables	n/a	1 = 168 hrs 2 = 672 hrs 3 = 1,344 hrs 4 = 2,016 hrs	Equal to repair strategy for single failure

a Many BSPs with 0 level of required redundancy (N standard) may only have one transformer or line. For these BSPs the planning criteria for a double failure are not relevant. However, some BSPs with 0 level of required redundancy (N standard) may have multiple transformers or lines. For example, three transformers might supply a load and a failure of any one of the three transformers would mean that the required supply cannot be met. In this situation, the repair strategy for transformers becomes relevant.
b The repair times for transformers have been updated since IPART's Draft Report, based on advice from TransGrid.
Data source: IPART based on consultant advice and advice by TransGrid.

Table D.2 Planning criteria (1 level of redundancy required, ie, N-1 standard)

Planning criteria	Range of possible values		
	System normal (no failures)	**Single failure**	**Double failure**
Load at risk for transformers	0%	0%, 10%, 20%, …, 80% 90%	n/a
Load at risk for lines	0%	0%, 10%, 20%, …, 80% 90%	n/a
Restoration strategy (same for transformers, lines and cables)[a]	n/a	0 = 0 1 = 0-5 mins 2 = 5 to 30 mins 3 = 0.5 to 1 hr 4 = 1 to 4 hrs 5 > 4 hrs	n/a
Repair strategy for transformers[b]	n/a	1 = 24 hrs 2 = 720 hrs 3 = 6,579 hrs 4 = 8,772 hrs	Equal to repair strategy for single failure
Repair strategy for overhead lines	n/a	1 = 8 hrs 2 = 24 hrs 3 = 48 hrs 4 = 120 hrs	Equal to repair strategy for single failure
Repair strategy for underground cables	n/a	1 = 168 hrs 2 = 672 hrs 3 = 1,344 hrs 4 = 2,016 hrs	Equal to repair strategy for single failure

[a] A restoration time of 0 means that no backup is available. The model assumes a restoration time of 8 hours for strategy option 5.

[b] The repair times for transformers have been updated since IPART's Draft Report, based on advice from TransGrid.

Data source: IPART based on consultant advice, and advice from TransGrid.

Table D.3 Planning criteria (2 levels of redundancy required, ie, N-2 standard)

Planning criteria	Range of possible values		
	System normal (no failures)	**Single failure**	**Double failure**
Load at risk for transformers	0%	0%	0%, 10%, 20%, …, 80% 90%
Load at risk for lines	0%	0%	0%, 10%, 20%, …, 80% 90%
Restoration strategy (same for transformers, lines and cables)[a]	n/a	0 = 0 1 = 0-5 mins 2 = 5 to 30 mins 3 = 0.5 to 1 hr 4 = 1 to 4 hrs 5 > 4 hrs	0 = 0 1 = 0-5 mins 2 = 5 to 30 mins 3 = 0.5 to 1 hr 4 = 1 to 4 hrs 5 > 4 hrs But such that it is longer than or the restoration time for a single failure.
Repair strategy for transformers[b]	n/a	1 = 24 hrs 2 = 720 hrs 3 = 6,579 hrs 4 = 8,772 hrs	1 = 24 hrs 2 = 168 hrs 3 = 2,190 hrs 4 = 4,380 hrs But such that it is longer than or equal to the repair time for a single failure.
Repair strategy for overhead lines	n/a	1 = 8 hrs 2 = 24 hrs 3 = 48 hrs 4 = 120 hrs	1 = 8 hrs 2 = 24 hrs 3 = 48 hrs 4 = 120 hrs But such that it is longer than or equal to the repair time for a single failure.
Repair strategy for underground cables	n/a	1 = 168 hrs 2 = 672 hrs 3 = 1,344 hrs 4 = 2,016 hrs	1 = 168 hrs 2 = 672 hrs 3 = 1,344 hrs 4 = 2,016 hrs But such that it is longer than or equal to the repair time for a single failure.

a A restoration time of 0 means that no backup is available. The model assumes a restoration time of 8 hours for strategy option 5.

b The repair times for transformers have been updated since IPART's Draft Report, based on advice from TransGrid.

Data source: IPART based on consultant advice, and advice from TransGrid.

D.2 Existing network inputs and assumptions

The model also uses input data and assumptions about the existing network and demand for electricity to inform both the cost of expected unserved energy and the cost of supply arrangements.

It uses the following input data, supplied by TransGrid, which is specific to each BSP:

- estimated maximum demand for 2018-19 (50% Probability of Exceedance (POE) forecast)[58]
- actual number of transformers, and
- actual number of lines.

For simplicity it assumes that:

- each transformer at each BSP is of equivalent capacity
- each line at each BSP is of equivalent capacity, and
- lines at each BSP are all either overhead or underground.

Where necessary to meet required level of redundancy, the model will increase the number of transformers or lines at a BSP. For example, if an N-2 BSP has only two transformers and no ability to switch to backup capacity, the model will add one transformer to allow the N-2 requirement to be met.

While the number of transformers and lines is based on the actual configuration at the BSP (subject to the caveat in the prior paragraph), the sizing of these assets is done dynamically by the model. Normally the assets are sized so that the maximum demand can just be met. For example, at a BSP with four transformers and a maximum load of 100 MW, each transformer would be sized to 25 MW capacity. However, if the transformer load at risk criterion is set to 40%, then the model will "shrink" the transformers so that each would be sized to 15 MW capacity.

IPART estimated line lengths based upon the location type for each BSP (ie, whether it is CBD, suburban, regional, or remote).

58 Probability of Exceedance (POE) refers to the likelihood that a maximum demand forecast will be met or exceeded. A 50% POE maximum demand projection is expected to be exceeded, on average, five years in 10.

Table D.4 Estimated line lengths

Location type	Estimated line length (km)
CBD	15
Suburban	30
Regional	150
Remote	300

Data source: IPART estimates.

D.3 Cost of supply arrangements

The supply arrangement costs cover the capital and operating costs for the following elements:

- transformer and line capacity
- backup capacity and restoration obligations, and
- repair obligations.

Transformer and line capacity costs provide the cost of system capacity in its normal state, ie, no asset failures. The cost of backup capacity, restoration obligations and repair obligations drive the cost of system capacity to deal with a single or double asset failure.

The model only includes costs that vary when the planning criteria change. This means, for example, that it excludes the cost of substation land, fencing and other site costs as they are the same across all the possible planning criteria.

D.3.1 Capital cost of transformer and line capacity

Life time capital costs

The model uses a power law to calculate the capacity cost of transformers and lines of a given MW rating.[59] It then multiplies the cost per transformer/ line circuit for each BSP by the number of transformers/ lines at each BSP.

Transformer unit costs are calculated using the following equation:

Cost = c.MW^b

where:

c = 0.094214

b = 0.640401

59 It assumes that transformers (and circuits) of any capacity can be purchased at a price given by the power law function. In practice, organisations like TransGrid tend to buy transformers of standard types and sizes to minimise purchase prices and inventory costs.

IPART derived the values for 'c' and 'b' by fitting a power law function to transformer purchase price data provided by TransGrid.

For **lines**, the capacity cost is multiplied by the line length to give a per circuit cost. An underground scaling factor is applied if the circuit is defined as an underground (UG) cable. Line circuit costs are calculated using the following equation:

Cost =(UG scaling factor if UG cable).km.c.MW^b

where:

c = 0.024784

b = 0.640401

UG scaling factor = 15

IPART assumed the value for 'b' in the line equation is the same that is used in the transformer equation. The value for 'c' and the underground scaling factor were based on consultant advice to IPART. The assumed line lengths are shown in Table D.4.

Cost multipliers are applied to the unit costs for transformers and circuit costs for lines to allow for installation. The multipliers vary by location type and the values used are shown in Table D.5.

Table D.5 Transformer and line cost multipliers

Location type	Transformer cost multipliers	Overhead line cost multipliers	Underground cable cost multipliers
CBD	2	2	1
Suburban	1.5	1.5	1
Regional	1	1	1
Remote	1.5	1.5	1

Data source: IPART based on consultant advice.

Annualising capital costs

Transformer and line capacity capital costs are transformed to an average annual basis using the following formula:

Annualised capital cost = d . capital cost / [(1-(1+d)$^{-L}$) . (1+d)];

where d = discount rate

L = life of asset

Discount rate

The model assumes a discount rate of 5.6% (real pre-tax).[60]

Life of asset

The model assumes the following asset lives, based on TransGrid's Regulatory Information Notice submitted to the AER:

- Transformer average life = 40 years.
- Overhead line average life = 50 years.
- Underground cable average life = 45 years.[61]

D.3.2 Backup capacity and restoration obligation costs

The total cost per MW of transformer and line capacity at each BSP is used as a proxy to cost backup capacity.[62] There are two further assumptions that scale these costs down:

- it is assumed backup capacity is shared between two BSPs, and therefore, only 50% of the cost is assigned to the BSP being assessed, and
- an additional efficiency factor of 50% is included to allow for backup capacity primarily being installed to service other requirements (for example, backup capacity may be provided by the distribution network, but it is likely that this distribution capability will also be being used for its own supply purposes. Therefore, only part of the distribution network costs are assigned to backup for the transmission system).

The costs of equipment or labour associated with having and using backup capacity include:

- the capital costs associated with any facilities or services necessary to achieve the required restoration times (eg, automatic control schemes), and
- the operating costs associated with using these facilities or services, when an asset failure occurs.

60 Using IPART's WACC methodology sampled to 22 July 2016 for inflation and interest rates, and to the end of June 2016 for market risk premium and debt margin.

61 The asset lives have been updated since the Draft Report.

62 Note: backup capacity could be provided by various forms that are not explicitly modelled.

Table D.6 Backup capacity and restoration strategy costs

Restoration time	Form of switching	Fixed capital cost ($m)	per MW capital costs ($m)	Fixed operating cost (per use) ($m)	per MW operating cost (per use) ($m)
0	firm - no requirement for switching	-	-	-	-
0 to 5 mins	fast-automatic	1.000	0.002	-	-
5 to 30 mins	slow-automatic	0.500	0.001	-	-
0.5 to 1 hr	fast-remote	0.100	0.0002	-	-
1 to 4 hrs	slow-remote / manual	-	-	0.050	0.0002
> 4 hrs	manual	-	-	0.100	0.0004

Data source: IPART based on consultant advice.

D.3.3 Repair obligation costs

The costs of equipment or labour associated with repairing (or replacing) assets include:

- the capital costs associated with any facilities or services necessary to achieve the required repair times (eg, spares, network arrangements, etc), and
- the operating costs associated with implementing the repair (or replacement), when an asset failure occurs.

Table D.7 Transformer repair strategy costs

Repair time[a]	Comment	Fixed capital cost ($m)	per MW capital costs ($m)	Fixed operating cost (per repair) ($m)	per MW operating cost (per repair) ($m)
24 hours	Requires on-site bay spare and fast change over	-	0.0144	0.050	0.001
720 hours	Requires spares and fast installation	-	0.0036	0.100	0.003
6,579hours	Fast procurement, delivery and normal installation	-	-	-	0.0018
8,772 hours	Normal procurement, delivery and installation	-	-	-	-

a The repair times for transformers have been updated since IPART's Draft Report, based on advice from TransGrid.

Data source: IPART based on consultant advice and advice from TransGrid.

Table D.8 Overhead line repair strategy costs

Repair time	Comment	Fixed capital cost ($m)	per MW capital costs ($m)	Fixed operating cost (per repair) ($m)	per MW operating cost (per repair) ($m)
8 hours	Requires special equipment and fast response	0.100	0.001	0.050	0.002
24 hours	Requires fast response	-	-	0.050	0.002
48 hours	Enhanced response	-	-	0.050	0.0015
120 hours	Normal response	-	-	0.050	0.0005

Data source: IPART based on consultant advice.

Table D.9 Underground cable repair strategy costs

Repair time	Comment	Fixed capital cost ($m)	per MW capital costs ($m)	Fixed operating cost (per repair) ($m)	per MW operating cost (per repair) ($m)
168	requires special equipment, spares and fast response	0.2000	0.0020	0.1000	0.0070
672	requires spares and fast response	-	0.0020	0.1000	0.0070
1,344	enhanced response and repair	-	-	0.0500	0.0025
2,016	normal response and repair	-	-	0.0500	0.0010

Data source: IPART based on consultant advice.

D.3.4 Operating costs

The long-term average annual operating costs associated with capital costs (eg, to cover maintenance activities)[63] are assumed to be linearly proportional to the calculated capital cost, with a single constant input in the model to define this relationship. The constant used in the model is 2%. That is, the annual operating cost of equipment is 2% of the annual capital cost of the equipment.

The average annual operating costs are separate to the operating costs associated with particular repair or restoration strategies which are only incurred when there is an asset failure.

D.4 Cost of expected unserved energy

D.4.1 Expected amount of unserved energy

The expected unserved energy at each BSP is the sum of the expected amount of unserved energy for each scenario[64] at that BSP.

The expected amount of unserved energy for each scenario=

expected number of asset failures (forced outages) per year *

duration of supply outage associated with the asset failure(s) *

proportion of annual energy required that cannot be supplied while the asset is in a failed state *

annual energy required (MWh)

Where backup capacity is available, the model calculates:

1) the expected unserved energy before switching has occurred, and

2) the expected unserved energy after switching has occurred but before repair of the asset.[65]

63 These are in addition to operating costs associated with the use of specific restoration or repair strategies as described in sections D.3.2 and D.3.3.

64 The scenarios are: system normal, a single transformer failure, a single line failure, a double transformer failure and a double line failure.

65 For double contingency events (double transformer failures of double line failures) the model performs an equivalent four-stage process as it steps through the two restorations and two repair stages.

Expected number of asset failures (forced outages)

The expected number of asset failures (forced outages) is the probability of asset failure multiplied by the number of assets, for each asset type at each BSP.

The probabilities of asset failure used in the model are summarised in Table D.10. They are reflective of the average life-cycle failure rates for each asset type. For transformers and overhead lines, IPART derived these values using TransGrid's historic failure data, weighted by asset subcategory. For underground cables, IPART derived the values from Ausgrid failure data for Inner Sydney, provided by TransGrid. TransGrid provided separate rates for catastrophic transformer failure (requiring replacement) and non-catastrophic transformer failure (not-requiring replacement).

Table D.10 Asset failure frequency

Asset type	Failure frequency
Transformers (catastrophic failures per year per transformer)	0. 557%
Transformers (non-catastrophic failures per year per transformer)	17.0%
Overhead lines (failures per year per 100km)	29.01%
Underground cables (failures per year per 100km)	5.95 %

Data source: IPART based on TransGrid historic performance data and Ausgrid underground failure rates provided by TransGrid.

The model assumes the primary and secondary buses of the transformers are effectively solid and fully switched (ie, a fault on any transformer or line will not automatically result in the outage of other transformers or lines).[66]

Duration of supply outage

The duration of supply outages associated with a particular scenario is determined by the restoration and repair strategies (see section D.1).

Proportion of annual energy required that cannot be supplied

The model uses a normalised integral of a load duration curve to determine the proportion of annual energy required that cannot be supplied while an asset remains in a failed state. The curve relates the proportion of annual energy required that cannot be served to the proportion of maximum demand that can still be served following a failure event.

The proportion of maximum demand that can be served following a failure event is equal to (1- %load at risk) for the relevant scenario (see section D.1).

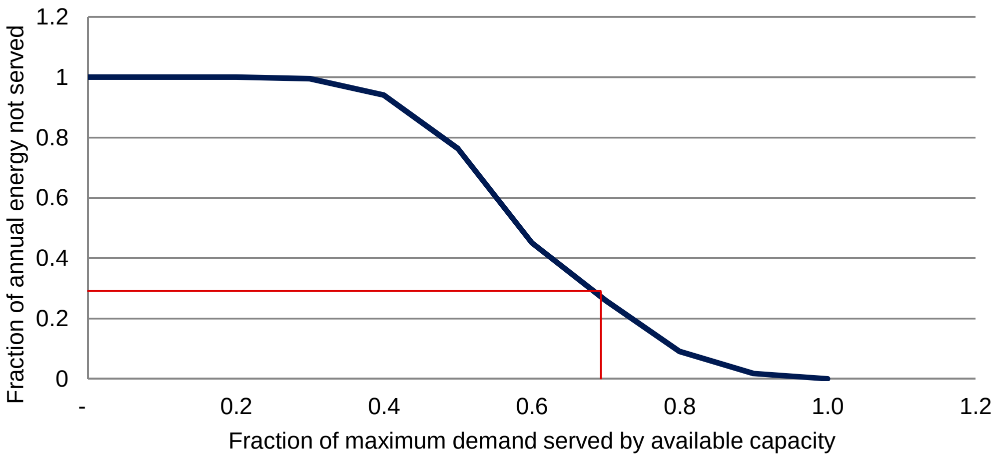
66 An underlying assumption is that for actual circumstances where this is not the case, operating arrangements would be such that any "good" assets would be rapidly switched back into service following the fault, such that the resulting actual reliability is approximately equal to these assumed arrangements.

A hypothetical example is provided in Box D.1.

The model uses curves which are specific to each BSP.[67] IPART derived the curves using TransGrid data (load at 15 minute intervals for the 2011 calendar year).

Box D.1 Proportion of annual energy required that cannot be supplied if a single transformer fails

Normalised integral of the load duration curve for a hypothetical BSP



In this example, the load at risk if a transformer fails is 30% of maximum demand at the BSP (as set by the planning criteria). Therefore 70% of maximum demand can be served following a transformer failure (ie, capacity is reduced to 70% of maximum demand).

If the transformer failure occurs during a period of low demand then it is likely that the required supply at that point in time could be met. However, if the failure occurs during a period of high demand, then it is possible that none of the required supply could be met.

Because we do not know when a transformer failure will occur, we consider what proportion of energy would be lost if the failure lasts for an entire year (which includes periods of low and high demand). The curve tells us that, on average across all possible moments of failure, around 30% of energy required at this BSP would not be served if capacity of the BSP was reduced to 70% of maximum demand.

Note: If there are load shedding protocols in place, some supply may still be met even if the failure occurs during a period of high demand.

67 The model used for IPART's Draft Report used TransGrid's state-wide load duration curve.

Annual energy required

The **annual energy required** (MWAh) at each BSP is the maximum demand (MW) multiplied by the load factor (%) multiplied by the number of hours in a year.

IPART estimated a load factor for each BSP using TransGrid data (load at 15 minute intervals for the 2011 calendar year).[68] Maximum demand assumptions are discussed in section D.2.

D.4.2 Cost of expected unserved energy

The cost of unserved energy (ie, annual reliability cost) is the total amount of expected unserved energy for each BSP multiplied by the value of customer reliability (VCR) for that BSP.

The model uses the most recent VCRs published by AEMO,[69] weighted by customer type at each bulk supply point.

IPART engaged WSP Parsons Brinckerhoff (PB) to recommend VCRs for each bulk supply point, based on the values published by AEMO, weighted by customer type. For bulk supply points that were based on Ausgrid data, PB developed a non-weighted VCR using the straight average of the customer type splits. This is because there was no consumption data provided to undertake a weighted average. Additionally, no weighting was required for direct connect customers as there is only one customer type at each bulk supply point.

Since publishing our Draft Report we have updated the VCRs for some BSPs based on advice from TransGrid, Ausgrid and Essential Energy.

D.5 Unserved energy allowance

The unserved energy allowance for each BSP that IPART has adopted for our recommended reliability standards takes the expected unserved energy associated with the 'least total cost' set of the following planning criteria, given the required level of redundancy:

- load at risk
- restoration strategy
- repair strategy.

68 The model used for IPART's Draft Report had an average load factor of 51% for all BSPs, based on TransGrid's state-wide load duration curve.

69 AEMO, *Value of Customer Reliability Review - Final Report*, September 2014, pp 2, 18.

To this value we add an allowance for non-catastrophic transformer failure. While the optimisation model only takes into account catastrophic failures (that is, where the transformer needs to be replaced following failure),[70] the rate of non-catastrophic transformer failure (failures that can be repaired) is significant and this adds to the expected unserved energy for the network.

To estimate the allowance for non-catastrophic transformer failures we used information on the rate of these failures (provided by TransGrid) as well as information on the average repair time (also from TransGrid) and the speed of switching available at the BSP (based on our modelled optimum). Where backup capacity is available, we assumed that a non-catastrophic failure would lead to an outage lasting only as long as it takes to switch to backup capacity. Where no backup capacity is available, then we assumed that the non-catastrophic outage would last for the repair time (TransGrid's average is approximately 35 hours).

While the model identifies the optimal level of redundancy, we have recommended that the level of redundancy at each BSP remains the same as that which is required by the current electricity transmission reliability standard.

The expected unserved energy in MWh is then used to calculate the allowance for expected unserved energy in minutes per annum by dividing it by estimated average annual demand at that BSP (in MW) and converting it to minutes (by multiplying it by 60).

We have estimated annual demand at each bulk supply point using forecast maximum demand (in MW) and the estimated load factor.

70 Because this rate and the cost of minor repairs are largely independent of the planning criteria adopted, the presence of non-catastrophic transformer failures would not affect the optimisation calculation.

D.6 Bulk Supply Point (BSP) data

Table D.11 BSP data

Bulk Supply Point/s	Level of redundancy (category)[a]	Maximum demand (MW)	Number of transformers	Number of lines/ cables	Location type	Line/ cable length (km)	Overhead line or underground cable	Load factor	VCR ($/MWh)
Albury 132 kV	2	112	0	3	Regional	150	o'head line-s	0.49	36,119
ANM 132 kV	2	100	0	3	Regional	150	o'head line-s	0.73	6,050
Armidale 66 kV	2	26	2	4	Regional	150	o'head line-s	0.57	34,827
Balranald 22 kV	1	4	1	1	Remote	300	o'head line-s	0.45	33,793
Beryl 66 kV	2	67	2	2	Regional	150	o'head line-s	0.55	34,024
Boambee South 132 kV	2	22	0	2	Regional	150	o'head line-s	0.54	33,835
Broken Hill 22 kV	1	38	2	1	Remote	300	o'head line-s	0.48	34,676
Broken Hill 220 kV	1	22	0	1	Remote	300	o'head line-s	0.75	34,150
Canberra 132 kV and Williamsdale 132 kV	2	Canberra 132 kV =435 Williamsdale 132 kV =180	Canberra 132 kV = 4 Williamsdale 132 kV = 2	Canberra 132 kV = 5 Williamsdale 132 kV = 4	Regional	150	o'head line-s	0.55	37,279
Coffs Harbour 66 kV	2	48	3	6	Regional	150	o'head line-s	0.54	36,373
Coleambally 132 kV	2	11	0	2	Regional	150	o'head line-s	0.38	38,166
Cooma 66 kV	2	17	3	3	Regional	150	o'head line-s	0.24	34,357
Cooma 132 kV	2	40	0	2	Regional	150	o'head line-s	0.52	34,357
Cowra 66 kV	2	30	2	3	Regional	150	o'head line-s	0.43	33,831
Dapto 132 kV	2	571	4	3	Regional	150	o'head line-s	0.65	39,575
Darlington Point 132 kV	2	18	2	1	Regional	150	o'head line-s	0.9	37,691
Deniliquin 66 kV	2	45	2	2	Regional	150	o'head line-s	0.53	35,547
Dorrigo 132 kV	1	2	0	1	Regional	150	o'head line-s	0.62	34,513

Bulk Supply Point/s	Level of redundancy (category)[a]	Maximum demand (MW)	Number of transformers	Number of lines/ cables	Location type	Line/ cable length (km)	Overhead line or underground cable	Load factor	VCR ($/MWh)
Finley 66 kV	2	18	2	2	Regional	150	o'head line-s	0.49	35,460
Forbes 66 kV	2	31	2	2	Regional	150	o'head line-s	0.54	34,721
Gadara 132 kV and 11 kV	2	60	2	2	Regional	150	o'head line-s	0.61	6,050
Glen Innes 66 kV	2	8	2	3	Regional	150	o'head line-s	0.54	34,432
Griffith 33 kV	2	80	3	2	Regional	150	o'head line-s	0.47	36,683
Gunnedah 66 kV	2	25	2	2	Regional	150	o'head line-s	0.52	36,353
Hawks Nest 132 kV	1	8	0	1	Regional	150	o'head line-s	0.37	32,849
Herons Creek	1	9	0	1	Regional	150	o'head line-s	0.53	38,350
Holroyd 132 kV	2	313	2	4	Suburban	30	u'ground cable-s	0.46	40,650
Ilford 132 kV	1	8	0	1	Regional	150	o'head line-s	0.47	38,350
Ingleburn 66 kV	2	142	2	2	Suburban	30	o'head line-s	0.47	39,149
Inner Sydney	3	Bea = 362 Hay = 446 Roo = 280 SydN = 835 SydS = 1033	Beaconsfield 3 Haymarket 3 Rookwood R 3 Sydney N 5 Sydney S 6	Beaconsf 1 Haymarket 1 Rookwood 2 Sydney N 6 Sydney S 6	CBD	15	u'ground cable-s	Bea = 0.55 Hay = 0.48 Roo = 0.48 SyN = 0.52 SyS = 0.53	90,000
Inverell 66 kV	2	35	2	3	Regional	150	o'head line-s	0.49	34,248
Kempsey 33 kV	2	24	2	5	Regional	150	o'head line-s	0.56	34,693
Koolkhan 66 kV	2	48	3	3	Regional	150	o'head line-s	0.5	35,143
Liddell 330 kV (33 kV supply via Mac Gen)	2	25	0	6	Regional	150	o'head line-s	0.65	40,211
Lismore 132 kV	2	116	2	2	Regional	150	o'head line-s	0.48	36,003
Liverpool 132 kV	2	373	3	2	Suburban	30	o'head line-s	0.42	36,330
Macksville 132 kV	2	8	0	2	Regional	150	o'head line-s	0.57	35,223

Bulk Supply Point/s	Level of redundancy (category)[a]	Maximum demand (MW)	Number of transformers	Number of lines/ cables	Location type	Line/ cable length (km)	Overhead line or underground cable	Load factor	VCR ($/MWh)
Macarthur 132 kV and 66 kV	2	Macarthur 132 kV =162 Macarthur 66 kV =162	Macarthur 132 kV = 1 Macarthur 66 kV = 1	Macarthur 132 kV = 2 Macarthur 66 kV = 1	Suburban	30	o'head line-s	0.47	37,364
Marulan 132 kV	1	104	1	6	Regional	150	o'head line-s	0.61	36,865
Molong 66 kV	1	4	1	3	Regional	150	o'head line-s	0.51	32,176
Moree 66 kV	2	27	2	2	Regional	150	o'head line-s	0.54	37,147
Morven 132 kV	1	7	0	1	Regional	150	o'head line-s	0.49	38,350
Mount Piper 66 kV	2	41	2	3	Regional	150	o'head line-s	0.5	38,401
Mudgee 132 kV	1	21	0	1	Regional	150	o'head line-s	0.48	34,311
Munmorah 33 kV and 132 kV	2	113	1	2	Regional	150	o'head line-s	0.41	35,530
Munyang 33 kV	1	27	2	1	Regional	150	o'head line-s	0.36	39,965
Murrumbateman 132 kV	1	5	0	1	Regional	150	o'head line-s	0.44	29,314
Murrumburrah 66 kV	2	36	2	2	Regional	150	o'head line-s	0.53	34,661
Muswellbrook 132 kV	2	227	2	2	Regional	150	o'head line-s	0.51	40,211
Nambucca 66 kV	2	6	2	2	Regional	150	o'head line-s	0.49	33,775
Narrabri 66 kV	2	44	2	3	Regional	150	o'head line-s	0.56	36,084
Newcastle 132 kV	2	425	3	6	Regional	150	o'head line-s	0.33	39,507
Orange North 132 kV/ Orange 132kV and 66kV	2	Orange North 132 kV/ Orange 132kV =144 Orange 66 kV =49	Orange North 132 kV/ Orange 132kV = 3 Orange 66 kV = 3	Orange North 132 kV/ Orange 132kV = 2 Orange 66 kV =5	Regional	150	o'head line-s	Orange North 132 kV/ Orange 132kV = 0.74 Orange 66 kV = 0.54	34,366

Bulk Supply Point/s	Level of redundancy (category)[a]	Maximum demand (MW)	Number of transformers	Number of lines/ cables	Location type	Line/ cable length (km)	Overhead line or underground cable	Load factor	VCR ($/MWh)
Parkes 132 kV	2	29	0	3	Regional	150	o'head line-s	0.83	6,050
Parkes 66 kV	2	25	2	3	Regional	150	o'head line-s	0.46	34,215
Port Macquarie 33 kV	2	55	3	3	Regional	150	o'head line-s	0.53	35,051
Queanbeyan 66 kV	2	63	2	1	Regional	150	o'head line-s	0.52	32,756
Raleigh 132 kV	2	7	0	2	Regional	150	o'head line-s	0.52	33,951
Regentville 132 kV	2	264	2	2	Regional	150	o'head line-s	0.37	36,346
Snowy Adit 132 kV	1	10	0	1	Regional	150	o'head line-s	0.31	44,549
Stroud 132 kV	2	34	0	3	Regional	150	o'head line-s	0.37	32,960
Sydney East 132 kV	2	533	4	2	Suburban	30	o'head line-s	0.52	36,952
Sydney West 132 kV	2	1,107	5	9	Suburban	30	o'head line-s	0.46	38,534
Taree 66 kV and 33 kV	2	Taree 33 kV =24 Taree 66 kV =47	Taree 33 kV = 2 Taree 66 kV = 2	Taree 33 kV = 3 Taree 66 kV = 3	Regional	150	o'head line-s	Taree 33 kV = 0.47 Taree 66 kV = 0.53	34,906
Tamworth 66 kV	2	101	2	2	Regional	150	o'head line-s	0.52	36,250
Tenterfield 22 kV	2	5	2	2	Regional	150	o'head line-s	0.57	33,891
Tomago 132 kV	2	210	3	4	Regional	150	o'head line-s	0.97	39,507
Tomago 330 kV	2	965	4	4	Regional	150	o'head line-s	0.97	6,050
Tuggerah 132 kV	2	182	2	2	Regional	150	o'head line-s	0.43	35,530
Tumut 66 kV	2	32	2	2	Regional	150	o'head line-s	0.59	33,997
Vales Pt 132 kV	2	99	2	4	Regional	150	o'head line-s	0.37	35,530
Vineyard 132 kV	2	474	3	2	Regional	150	o'head line-s	0.32	35,546
Wagga 66 kV	2	73	3	4	Regional	150	o'head line-s	0.38	34,842
Wagga North 132 kV	2	54	0	2	Regional	150	o'head line-s	0.73	34,842
Wagga North 66 kV	1	20	1	3	Regional	150	o'head line-s	0.38	34,842

Bulk Supply Point/s	Level of redundancy (category)[a]	Maximum demand (MW)	Number of transformers	Number of lines/ cables	Location type	Line/ cable length (km)	Overhead line or underground cable	Load factor	VCR ($/MWh)
Wallerawang 132 kV	2	79	2	4	Regional	150	o'head line-s	0.35	34,085
Wallerawang 66 kV	2	4	2	4	Regional	150	o'head line-s	0.47	34,085
Waratah West 132 kV	2	204	2	2	Regional	150	o'head line-s	0.38	39,507
Wellington 132 kV	2	164	2	2	Regional	150	o'head line-s	0.57	34,747
Wellington Town	1	10	0	1	Regional	150	o'head line-s	0.55	34,747
Williamsdale 132 kV	2	180	2	4	Regional	150	o'head line-s	0.55	37,279
Yanco 33 kV	2	38	2	4	Regional	150	o'head line-s	0.53	35,914
Yass 66 kV	1	12	2	6	Regional	150	o'head line-s	0.51	32,581

a This is the level of redundancy required by the current electricity transmission reliability standard. It is not used an input to the model.

Source: TransGrid; IPART based on TransGrid data; IPART assumptions, WSP Parsons Brinkerhoff, *NSW Transmission Reliability Standards Review - Value of Customer Reliability*, May 2016.

E Response to submissions

We received five submissions to our Supplementary Draft Report on Electricity Transmission Reliability Standards. This Appendix responds to the issues raised.

Issue	Submitter	Response
Reliability standard		
The report should be very clear on the intended application of the standard and its limited direct interaction with replacement projects as a result of the life-cycle approach.	Ausgrid, pp 1-2.	Using the average life cycle failure rates would mean that the reliability standards would not influence the timing of asset replacement decisions. However, we would expect them to influence the timing of investment for demand driven augmentations.
Clarify definition of 'average demand' for defining USE in minutes.	TransGrid, p 4.	We calculated the average demand by applying a load factor to the maximum demand. Load factors were calculated for each BSP based on actual 2011 demand time series. We did not use 50% of maximum demand.
Any changes to reliability standards must serve the goal of ensuring that NSW consumers are provided a low cost secure electricity supply. The proposed reliability standards do not protect consumers of regulated services from unreasonable price hikes and price gouging. The proposed changes are not costed, and there is no clarity as to why the standards should change. The proposed reliability standards do not have regard to the impact on customers – the reliability/cost trade-off is not explicit and power to make this choice is not put in the hands of customers, in fact the opposite is promoted.	GreenSync, p1.	The purpose of the optimisation modelling is to assess the reliability/cost trade-off for customers. The impact on customers is directly incorporated in our analysis through the VCR. The model finds the level of USE where customers would be indifferent to paying to have energy supplied or incurring the energy loss (experiencing a black out). By themselves, the reliability standards set by the Minister do not ensure that the TNSP only makes efficient investments. The incentives for TNSPs to make efficient investments also depend on the regulatory framework implemented by the AER. However, all else being equal, the new reliability standards are likely to put downward pressure on the cost of meeting them, because they explicitly facilitate the adoption of non-network solutions where they are the most efficient option.
The proposed reliability standards do not encourage regulated service providers to improve their economic efficiency – if it is true that the average utilisation of NSW transmission networks is just over 50% then this is clearly not an efficient service now, let alone under an expanded asset base.	GreenSync, p 1.	Average load factors for transmission networks of around 50% do not represent inefficiency. Rather, they reflect the load profile of end customers – that is, customers use a different level of energy at different times of the day and year. Where the reliability standards require TransGrid to increase its reliability, the standards facilitate the adoption of non-network options, and the AER will review whether the appropriate options have been considered and the expenditure proposed is efficient.

Issue	Submitter	Response
The proposed reliability standards do not encourage competition where possible.	GreenSync, p 1.	We have recommended reliability standards that are framed to promote the most efficient network or non-network solution by using technology-neutral language, rather than promoting a specific type of network or non-network solution. Part of our aim in making recommendations on the standards is to ensure that they provide enough flexibility so as not to inhibit the uptake of new technologies.
Why is this methodology superior to AEMO's methodology?	GreenSync, p 1.	Our methodology optimises the USE allowance to minimise the sum of the costs to customers of USE, and the costs of the infrastructure to avoid USE.
Is the proposal for a reliability standard, or a replacement for the RIT process? There seems to be a mixture of reliability measures with forecast solution costings.	GreenSync, p 1.	The reliability standard is set in advance and does not replace any part of the RIT-T process. For the purposes of modelling the optimal USE at each supply point, we have focused on network costs, which is a simplifying assumption.
The review states that the recommended redundancy is to remain the same – so what is the new recommendation regarding reliability?	GreenSync, p 1.	We are recommending that the standards are changed to introduce a positive allowance for USE.
Why is the amount of time taken to restore an asset part of a reliability standard, when it should be VCR x probability of outage?	GreenSync, p 2.	We consider that expected USE is a superior indicator of the level of reliability of the network because it takes into account both the probability of outages occurring and the expected impact, including the duration of outages, whereas load at risk does not.
Supports the life-cycle approach.	TransGrid, p 1.	
Supports the draft recommendation to allow for flexibility in how TransGrid meets its reliability requirements – including non-network options.	TransGrid, p 3.	

Issue	Submitter	Response
Compliance		
TransGrid may not have the network augmentations in place to satisfy the new reliability standard until 2022. Confirm that the standards will not have to be met operationally by 1 July 2018.	TransGrid, p 4.	We have not yet finalised the requirements for demonstrating compliance with the standards. We will undertake public consultation in regards the compliance process, which we will begin early 2017. Consultation will cover when compliance reporting should commence, and the frequency of compliance reporting. Part of this process could include sharing an unpopulated version of the compliance model with DNSPs.
Clarify how the compliance process will work. TransGrid will undertake simulation modelling as part of the planning process, which IPART would assess. However the detailed process will need to be clarified to manage changes to maximum demand forecast and to cater for new BSPs.	TransGrid, p 4.	
IPART should provide a description and example of the application of the standard.	Ausgrid, p 1.	
IPART should provide clarification on how the flexibility provisions in clause 5 should be applied.	Ausgrid, p 1.	See page 50 of IPART's Final Report released in August 2016.
Although the approach is a planning standard, it would be prudent to put in place a performance based review period, to assist in providing confidence that the methodology is delivering on the outcomes. It is understood that compliance is over the life of the asset, and a review period would only be small snapshot of the compliance period.	Essential Energy, p 3.	We consider that performance outcomes would be useful for informing future reviews of the standards as it would allow us to consider what impact the new planning standards have had on the reliability experienced by customers. But, rather than include this in the standards as an additional compliance requirement, we consider that it would be sufficient to request this information as part of the next review process.
Supports the TNSP reporting on how changes to asset conditions may impact reliability, as average asset failure rates are not a good predictor of future performance for an aged network – the standard cannot be used as a risk assessment of the probability of failure at a point in time.	Ausgrid, p 2.	See Box 5.1 in IPART's Final Report released in August 2016.
Responsibility for meeting standard		
There are no formal arrangements in place between the TNSP and DNSPs where a distribution network provides the required redundancy. It may be worth considering whether conditions need to be added into the DNSP licences so that TransGrid can meets its requirements.	Essential Energy, p 2.	We do not consider that an obligation should be conferred on DNSPs to provide backup arrangements to TransGrid, as this may not be the most efficient option for meeting the reliability standards. Under the standards TransGrid is responsible for selecting the most efficient option to meet the standards, and negotiating with DNSPs to provide capacity where appropriate.

Issue	Submitter	Response
Sydney		
Confirm the grouping of the supply points for Inner Sydney – the grouping could halve the USE allowance depending on how it is calculated.	TransGrid, p 4.	0.6 minutes refers to the Inner Sydney loads. Our unserved energy allowance is for the five Inner Sydney bulk supply points (Beaconsfield West, Haymarket, Rookwood Rd, Sydney North and Sydney South) as a single group. This is based on modelling each of the five Inner Sydney bulk supply points separately and using these to derive a group unserved energy allowance in the same way as we did for other grouped bulk supply points across the network.
IPART should clarify that all potential failure modes which materially contribute to USE may be considered. The risks considered by TransGrid for multiple outages do not match IPART's optimisation model (modified N-2) for inner Sydney. The USE due to the poor performance of the ageing cables supplying inner Sydney will be underestimated.	TransGrid, p 4.	We considered whether we should expand the number of simultaneous asset failures, for example, to consider the simultaneous failure of three or more assets. However, at the life-cycle failure rates included in our optimisation model, we expect that doing this would make very little, if any, difference to the optimal USE estimated by the model.
More justification of a VCR of $90 is required – this is based on a desktop review from TransGrid, and is much higher than the AEMO NSW aggregate of $34.15 (2014). IPART should have sought at least some direct consumer input on the values that might apply in inner metropolitan and CBD of Sydney. If IPART adopts the $90, it may be applied more broadly. The HoustonKemp study states that "…both TransGrid and Ausgrid are seeking VCR estimates that would be suitable for use in other network planning assessments (including RIT-T and RIT-D) relating to augmentation to supply to the Sydney CBD. It may also impact on reliability standards developed in other States and Territories under the COAG Energy Council response.	EUAA, pp 1-3.	We agree with stakeholders that further work is needed to better understand the true value that different customers place on reliability. In our Final Report provided to the Minister in August 2016 we supported a nationally consistent approach to the VCR. We made a recommendation for the NSW Government to ask IPART to determine VCRs for NSW 12 months prior to the next review of reliability standards if updated nationally consistent VCRs are not available. If this is the case, we expect that we would commence a review on determining NSW VCRs in 2019-20. For the purposes of our review, on balance we consider that where there is uncertainty around key inputs, we should be conservative in setting the allowances for expected USE. Our conservative recommendations are designed to ensure that changes in the level of transmission reliability are limited.

Issue	Submitter	Response
Concern that higher VCRs and lower USE will result in significant investment and higher costs. How would different values of VCR impact on costs and the network investment plans. What would or would not be built with the AEMO vs IPART vs HoustonKemp values? What does this mean for customers?	EUAA, p 3.	Currently the USE in Sydney is around zero – and our standards increase this to 0.6 minute. We have included a sensitivity study using the AEMO weighted VCR for Inner Sydney which results in an USE allowance of 1.7 minutes. We have used an approach based on generalised costs that apply to all BSPs – this approach does not consider specific investment plans for each BSP. The site specific costs for meeting the standards will be considered through AER regulatory revenue determination process.
Supports 0.6 minutes at average demand for grouping of five Inner Sydney BSPs.	TransGrid, p 1.	
Supports the methodology used to develop an applicable VCR for the Sydney CBD.	Essential Energy, p 3.	
Munyang		
The low load factor at this BSP reflects high seasonal loads - the VCR is very low for most of the year, and very high for the peak. In these cases, the VCR: - should have an aggregate floor value load fact OR - have a seasonal load factor and location specific VCR, for example, the peak season should have a 4x multiplier (based on 3 months of the year).	Essential Energy, pp 1-2; TransGrid, p 2.	We agree that customers would value reliable energy supply more in the winter than summer, however the VCR methodology does not take into account seasonality. Instead, the AEMO VCRs have been weighted by energy use by customer type - regardless of when the electricity is used, and the absolute level of the energy used at each BSP. Therefore there is no basis to adjust the VCRs for seasonality. However, given the large seasonal variation in demand for Munyang, we consider that it is reasonable to set the standard based on the load factor at the time of the year when the bulk of the energy is being used. Therefore, we have decided to use the ski-season load factor (0.36) in our modelling, which effectively assumes that that winter demand is carried all through the year.
TransGrid's forecasts underestimate the POE50 due to the lack of temperature correlation in the seasonal ski field area load. As a result, the load at risk has been underestimated by 10% relative to the actual and 29% relative to the POE10.	Essential Energy, 1.	We further investigated our demand forecasts and we found that the maximum demand in our modelling for our Draft Supplementary Report was based on the summer maximum demand (1.9MW), instead of the winter maximum demand, which was significantly higher. We have updated our maximum demand forecast in line with TransGrid's winter maximum demand forecast of 27MW.

Issue	Submitter	Response
Munyang is likely to be a high cost supply point, as it requires special environmental impact mitigation measures because it is close to the Murray river, such as usual gas filled transformers.	TransGrid, p 2.	Differences in the cost relativities between the various supply, restoration, and repair options available at a particular BSP compared with the average, might lead to a different USE allowance than we have modelled. The environmental restrictions referred to are likely to raise the cost of providing reliability. All else being equal, it is likely that this would lead to a higher USE allowance if factored into our modelling.
The likely severe prevailing weather conditions during the ski-season and the resultant increased risk of unplanned network outages coupled with the difficult terrain and ground-cover (access) conditions mean that the supply restorations times are likely to be much longer, and this warrants some readily available backup or redundancy in the interests of public safety and minimum amenity.	Essential Energy, p 2.	The purpose of the new approach to setting reliability is to determine standards with reference to outcomes, rather than prescribe how the standards are met. We understand that in some cases automatic switching can be a relatively cost-effective option (due to the geography and proximity to other infrastructure at the BSP. Munyang is relatively close to other infrastructure, including electricity generation in the Snowy area. For any new investment, the AER could consider whether automatic switching remains the most cost-effective way of meeting the standards.
The change in the USE from 1 minute to 191 minutes could result in a large deterioration of reliability, which is unlikely to meet expectations of seasonal (winter) customers.	TransGrid, p 2.	Our final recommendation is for a USE of 14 minutes, based on the load factor at the time of the year when the bulk of the energy is being used (ski-season load factor of 0.36).
Broken Hill		
The load served is for a single mine customer. IPART's recommended allowance will require a new transmission line, battery storage, a new generator, or load curtailment.	TransGrid, p 2.	We are recommending setting the USE allowance for the Broken Hill supply points as a group. As a result, we are recommending an USE allowance of 10 minutes, which is consistent with the current expected USE.
There are no formal arrangements in place for operation of back up generation, in terms of availability and financial responsibility. Without t agreements in place it cannot be expected that DNSP's will maintain specific levels of redundancy, as often local growth or customer connections erode existing network capacity and hence redundancy.	Essential Energy, p 2.	Under the recommended standards TransGrid is responsible for selecting the most efficient option to meet the standards, and negotiating with DNSPs to provide capacity where appropriate.

Issue	Submitter	Response
Wellington Town		
Supports the standard, but recommends that IPART reviews the standard. The USE allowance is currently slightly over 21 minutes and is reflective of switching load via essential Energy's network, which takes an hour. Meeting the standard would require additional investment.	TransGrid, p 2.	
Supports 21 minutes.	Essential Energy, p 2.	No additional evidence has been received to suggest that 21 minutes is incorrect. We note Essential Energy's submission that reducing the USE may be possible at low cost.
Currently it takes around an hour to restore supply to around 90% of existing peak load using manual switching to the Essential Energy Distribution network. Reducing this time to 30 minutes may be possible at low cost by implementing automated remote field switch subject to further and detailed investigation.	Essential Energy, p 2.	
Molong		
IPART should review this standard - it will cost around $4 million to achieve the standard (currently at 100 minutes).	TransGrid, p 3.	
Informal backup is available via Essential Energy's distribution network, but it cannot be permanently relied upon for an extended duration (catastrophic single transformer outage).	Essential Energy, p 3.	No additional evidence has been received to suggest that 46 minutes is incorrect.
Supports 46 minutes.	Essential Energy, p 2.	
Mudgee		
The USE will need to fall from around 30 minutes to 14 minutes, requiring increased investment. TransGrid recommends that IPART review the USE allowance for Mudgee.	TransGrid, p 3.	
Supports 14 minutes.	Essential Energy, p 3.	
Informal backup is available via Essential Energy's distribution network taking around an hour. Reducing this time to 15 minutes may be possible at low cost by implementing automated change-over scheme subject to further and detailed investigation. However, local growth or customer connections erode network capacity, making it comparatively less economic to upgrade to maintain the desired level of reliability.	Essential Energy, p 3.	No additional evidence has been received to suggest that 14 minutes is incorrect.

Issue	Submitter	Response
VCRs outside of Sydney		
The NSW AEMO national planning VCR should be used until a more accurate data source for developing granular VCRs can be determined.	Essential Energy, p 3.	We have used AEMO weighted VCR values for all BSP points except Sydney. We have used the HoustonKemp estimates for the Inner Sydney BSPs because the AEMO estimates do not capture differences between metro and other customers, and metro customers are likely to have a higher value of reliability. Given the uncertainty around the VCRs, using the HoustonKemp value for Sydney is a conservative assumption to ensure that changes in the level of transmission reliability are limited.
It is unclear why a hybrid use of VCRs is applicable outside the CBD. ▾ Why is the Oakley Greenwood Business <160MWh Urban Feeder VCR used for the Inner metro, but the 2014 AEMO number used for urban commercial customers? ▾ Why isn't the Oakley Greenwood Business <160MWh Rural Feeder VCR not used for rural customers?	Essential Energy, p 3.	
Large customer connections at both the TNSP and DNSP level should be determined using direct VCR values.	Essential Energy, p 3.	We support a nationally consistent approach to the VCR. We made a recommendation that the NSW Government asks IPART to determine VCRs for NSW 12 months prior to the next review of reliability standards if updated nationally consistent VCRs are not available. This could be considered in a comprehensive VCR study.
The most efficient outcome might be for a few high VCR consumers to install their own reliability mechanisms eg, distributed generation and/or battery systems.	EUAA, p 3.	This could be the case. We note that the higher VCR for inner city is driven by the VCRs of small and medium commercial customers, rather than large customers (this is likely to reflect the fact that large customers have backup supply arrangements).
An alternative to network investment is the City of Sydney's renewable energy master plan where new generation can offset the need for network augmentation or replacement.	EUAA, p 3.	This option could be considered as part of the RIT-T process.
If customers are paying for more network investment based on a higher VCR, then they should receive compensation if higher standards are not met.	EUAA, p 3.	The standards are planning standards and not performance standards.
Modelling		
The model appears to assume that the only way to improve reliability is to duplicate transformers and lines.	GreenSync, p 2.	The model is based on network elements - this is a simplifying assumption. It is not possible for us to pre-empt available technologies and their associated costs in advance. We consider that this simplification delivers a reasonable estimate of reliability costs, and we have included sensitivity results. The AER process will require TransGrid to consider the alternatives and use the most efficient option for meeting the standards.

Issue	Submitter	Response
The model also models distribution costs under the backup capacity calculations. Have the relevant DNSPs provided data and input into the model? If not, on what basis were these costs calculated?	GreenSync, p 2.	Backup capacity was costed as if it was provided by network elements operated by TransGrid. The DNSPs did not provide data for the model, although our Inner Sydney calculations had regard to some data jointly prepared by TransGrid and Ausgrid.
The original dataset is not available in the spreadsheet displaying sensitivity analysis results.	GreenSync, p 2.	The original dataset is provided in the workbook showing sensitivity analysis results. Tab 'oq25basecase', rows 1 to 147 provides a complete tabulation of the input data used for the base case. The same rows in each of the other sensitivity case tabs show the input data used for each.
In 1.3 – cost of supply arrangements – why are there estimates of costs when this is purporting to be a reliability calculation?	GreenSync, p 2.	Cost estimates are needed for the optimisation, which establishes reliability standards based on what would minimise the costs.
Model has created a function for the cost of transformers. This is based on a best fit curve of historic transformer purchase. Why would this be used rather than a RIT-T process?	GreenSync, p 2.	For computational purposes, it was more tractable to model transformer costs using a continuous cost function.
What is the consultant advice used in the repair strategy costs?	GreenSync, p 2.	Dr Brian Nuttall provided the parameters we used for repair strategy costs based on his professional judgement and experience.
2% of annual capital cost is far too high as a calculation of annual operating costs.	GreenSync, p 2.	This figure was recommended to us by Dr Brian Nuttall, based on his professional experience.
1.10 – assumption 17% of transformers have a non-catastrophic failure each year. What is a 'non-catastrophic failure'? and is it really 1 in 6 transformers each year?	GreenSync, p 2.	A non-catastrophic transformer failure is one that does not require replacement of the transformer. In many cases, these failures are relatively minor and quickly repaired at low cost. The 17% figure (1 in 6 transformers each year) was provided by TransGrid based on their actual experience.
Underground is assumed to be 15x more expensive than overhead – why? What data is used to derive this?	GreenSync, p 2.	That figure was recommended to us by Dr Brian Nuttall, based on his professional experience.
Line failures seem way too high – please provide the historic data, how far does it go back? Recent gold plating should have resolved this.	GreenSync, p 2.	TransGrid provided the line failure data, based on their records.
Average asset lives are applied to new and end of life assets, rather than taking asset age into account.	GreenSync, p 2.	This is consistent with life-cycle approach to standards.
The restoration strategy is a basic index from 0-5 – this is not granular enough for an important model that involves hundreds of millions of dollars of expenditure. A better, more sophisticated measure should be used.	GreenSync, p 2.	Simplifying assumption for modelling purposes, recommended to us by Dr Brian Nuttall. This approach is well suited to a planning standard.

Issue	Submitter	Response
Repair times are represented as a number from 1-4, again not nuanced or sophisticated enough to be a satisfactory representation of the system. Minutes of outage is an industry standard.	GreenSync, p 2.	Simplifying assumption for modelling purposes, recommended to us by Dr Brian Nuttall.
Why is the upper bound for transformer repair 15,351 hours? What drives this? At 640 days, is it reasonable? Should it be based on working days or 8 hour days?	GreenSync, p 2.	Simplifying assumption for modelling purposes, recommended to us by Dr Brian Nuttall. It represents the time taken to replace two transformers when they must be built sequentially.
The assumption that each transformer at each BSP is of equivalent capacity is wrong, and a gross simplification that should be addressed.	GreenSync, p 2.	Simplifying assumption for modelling purposes. We tested this assumption in workshops with TransGrid, Ausgrid, AEMO and AEMC engineering staff, who told us it was reasonable in the circumstances.
Assumption that each line at each BSP is the same length is facile. Recent historic outage data for each line would be a more accurate measure.	GreenSync, p 2.	Simplifying assumption for modelling purposes. We tested this assumption in workshops with TransGrid, Ausgrid, AEMO and AEMC engineering staff, who told us it was reasonable in the circumstances. We also conducted sensitivity testing on changed line lengths. The results were very insensitive to assumed line lengths.
It is stated that the model artificially "dynamically increases or shrinks the number of transformers and lines to meet a required n state". This seems extraordinary – how can this be reconciled with real-world situations?	GreenSync, p 2.	The modification to the number and capacity of transformers and lines should be thought of something that happens in the planning stage. We do not propose that an actual substation would have this ability to dynamically change its capacity.
Table 1.4 has coarse and unrealistic estimates of line length.	GreenSync, p 2.	Simplifying assumption for modelling purposes. We tested these assumptions in workshops with TransGrid, Ausgrid, AEMO and AEMC engineering staff, who told us they were reasonable. We also conducted sensitivity testing on changed line lengths. The results were very insensitive to assumed line lengths.
In 1.3, it is assumed that there is space at existing BSPs to add transformers. This assumption is compounded by the dynamic nature of the model, which 'shrinks' and 'expands' the number of transformers according to n requirements.	GreenSync, p 2.	Simplifying assumption for modelling purposes. Note that the alterations to a BSP would only happen at the planning stage. We are not proposing modifications to a BSP as built.

Issue	Submitter	Response
‘b’ in the cost equation is assumed to be the same between transformers and lines. Why?	GreenSync, p 2.	Simplifying assumption for modelling purposes. The b parameter was statistically estimated for transformers based on TransGrid purchasing data. We had no comparable purchasing data for lines. We understand that, based on engineering principles, the cost exponent for lines would be between 0 and 1. We adopted the same b for lines as for transformers. We undertook sensitivity analysis using 0.45 and 0.83 as alternative line cost exponents. Approximately half the BSP had the same expected USE with varied exponents. For the other BSPs, the result was sensitive to this parameter. When better cost data for lines becomes available we would incorporate that in any future reviews of the standards.
Arbitrary load duration for calculating load at risk at time of failure. This should be calculated on a per asset basis with actual load curves.	GreenSync, p 2.	We calculated the actual load duration curve for each BSP, using 15 minute demand data for the 2011 year. This actual data was used in the model.
Modelling inputs are simply not granular or sophisticated enough to provide useful outputs.	GreenSync, p 2.	Simplifying assumption for modelling purposes. We tested these assumptions in workshops with TransGrid, Ausgrid, AEMO and AEMC engineering staff, who told us they were reasonable in the circumstances. We also conducted extensive sensitivity testing on alternative inputs within a range of +/-30%. The results were in general not highly sensitive to these alternative inputs.
Table 1.5 – arbitrary multipliers, and if aggregated historic data is used, why is it again multiplied? Input is a weighted average already.	GreenSync, p 3.	The multipliers were recommended to us by Dr Brian Nuttall, based on his professional experience and judgement.
Check maths in 1.5 – dividing by 60 may not be correct.	GreenSync, p 3.	Our modelling has been peer reviewed by external consultants and subjected to internal QA.
Review process		
The IPART review was not sufficiently publicised - EUAA has only just become aware of the review.	EUAA, p 1.	We have undertaken extensive consultation including holding public hearings, and advertising the review.

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. The AEMO publishes electricity demand forecasts and VCR values.
Average demand	Total energy supplied during the year (MWh) divided by the number of hours in the year.
Bulk supply point (BSP)	A location where supply is provided to Distribution Network Service Provider(s) (DNSP) or directly connected customer(s) at a particular voltage. For the avoidance of doubt: ▾ Generally the locations are the busbar(s) at TransGrid substations (where there can be multiple individual connections to the DNSP's or directly connected customer's network). Sometimes the locations are where connections are made to TransGrid's transmission lines (or cables). These can be at "tee" connections or at busbars or substations owned by the DNSP or directly connected customer; ▾ Where there are multiple connections at the same voltage at a particular location, such as the connection of several DNSP lines to the busbar(s) at a TransGrid substation, that constitutes a single bulk supply point; ▾ Where there are supplies provided at different voltages at a particular location, such as from the higher voltage busbar(s) as well as the lower voltage busbar(s) of a TransGrid substation, each voltage level constitutes a separate bulk supply point.

Direct connect customers	Customers that connect directly to the transmission network, excluding DNSPs.
Distribution Network Service Provider (DNSP)	A business in the NEM that operates an electricity distribution network system.
Expected unserved energy	The expected amount of energy that cannot be supplied, taking into account the probability of supply outages attributable to credible contingency events, expected outage duration, and forecast load.
Inner Sydney	Refers to the Inner Metropolitan Transmission System which is constituted by cables 41 and 42, the 330/132kV substations at Rookwood Road, Beaconsfield, Haymarket, Sydney North and Sydney South and future associated 330kV cables and 330/132kV substations, as well as Ausgrid's 132k transmission network that links those supply points.
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 solutions.
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	The National Electricity Rules govern the operation of the NEM.

Non-network solutions	Non-network solutions are alternatives to traditional transmission assets, such as lines and transformers, which can be used to address supply constraints. They include demand-side management (eg, load curtailment arrangements) or local generation.
Regulatory Investment Test for Transmission (RIT-T)	As defined in the *National Electricity Rules*. The test is developed and published by the AER. It prescribes how costs and market benefits of transmission investment options should be assessed.
Transmission Network Service Provider (TNSP)	A business in the NEM that operates an electricity transmission network system.
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.