TransGrid

Ausgrid

RIT-T: Project Assessment Conclusions Report

Powering Sydney's Future

November 2017

Executive Summary

This Project Assessment Conclusions Report (PACR) represents the third step in a formal Regulatory Investment Test for Transmission (RIT-T) process undertaken jointly by TransGrid and Ausgrid with a focus on alleviating the increasing risk to the supply of electricity to consumers from ageing electricity infrastructure in the Inner Sydney area.

The overall RIT-T process is designed to directly engage with parties on the problem and proposed options being considered, both network and non-network, to address it, test the market for alternate and more efficient solutions, and set out clearly the basis on which the preferred option has been selected.

Publication of the Project Specification Consultation Report (PSCR) in October 2016 marked the first stage of the consultation process. The PSCR set out in detail the need for TransGrid and Ausgrid to take action to ensure security of supply to Inner Sydney.

Release of the PSCR represented a formal recommencing of the Powering Sydney's Future project that TransGrid and Ausgrid consulted on extensively during 2014 and, ultimately, decided to defer in light of decreasing maximum demand forecasts at the time. A number of factors have contributed to this project being re-evaluated and this RIT-T commencing, including:

- fluid-filled cables in Inner Sydney will be nine years older, and consequently less reliable, when the project is delivered;
- derating of a major cable supplying Inner Sydney following a comprehensive testing program of the thermal resistivity of backfill and bedding materials;
- an observed rebound in summer peak demand for Inner Sydney, with near record demand in 2017 and a forecast increase in demand from heightened economic activity expected within Inner Sydney; and
- a change in the externally imposed transmission reliability standard – from 1 July 2018, away from the modified N-2 deterministic transmission reliability standard towards a reliability standard that explicitly undertakes a cost benefit assessment of network investments.

The Project Assessment Draft Report (PADR), released in May 2017, represented the second stage of the RIT-T process and identified the preferred option for investment by TransGrid and Ausgrid, taking into account feedback from stakeholders on the PSCR. The PADR presented the results of the RIT-T economic assessment, which demonstrated that the preferred option involved the following:

- the use of non-network solutions before a network project, as well as to defer network build by one year from when it would need to be commissioned without this support;
- installing two 330 kV cables at the same time with commissioning in time for the 2022/23 summer;
- operating Cable 41 at 330 kV with rating of 426 MVA; and
- decommissioning Ausgrid's cables in one stage.

This report, the PACR, discusses the issues raised by stakeholders in submissions to the PADR and how they have been incorporated in the final RIT-T assessment. Key issues raised and responded to include the range of demand forecasts considered, failure rates of existing fluid-filled cables and how non-network solutions can help manage the risk of supply outages to Inner Sydney. This PACR also responds to a range of points raised by the Australian Energy Regulator (AER) in relation to the Powering Sydney's Future project in its Draft Decision on TransGrid's regulatory proposal for the 2018-23 regulatory control period. While this is a separate process to the RIT-T, TransGrid and Ausgrid consider it useful to address points raised by the AER in this PACR to provide further insight into the robustness of the conclusions of the RIT-T process.

The PACR presents an assessment of the costs and benefits of a number of credible options in addressing the risk to supply in Sydney going forward, as well as the methodologies and assumptions underlying these results, and identifies the preferred way forward by TransGrid and Ausgrid. This assessment has been updated since the PADR in light of both submissions received and points raised by the AER.

Ten credible options have been assessed, covering a range of network and non-network technologies, including a new option introduced since the PADR

TransGrid and Ausgrid have considered a range of options and their ability to address the risk of supply disruption for consumers. Both network and non-network solutions have been considered as potential credible options for this RIT-T analysis – in particular:

- a range of **network options** has been included in the RIT-T assessment; and
- **non-network option components** have been incorporated into the assessment of all network options identified, to manage the supply risk prior to commissioning of the network component
  - in addition, two 'deferral' options (Option 7 and Option 8) have been included in the assessment to determine whether non-network components can efficiently defer the timing of network investment.

The credible network options considered differ principally based on:

- whether two new 330 kV cables are built together, or in stages;
- whether Cable 41 is remediated, operated without remediation (including at a lower voltage), or retired; and
- whether Ausgrid's existing fluid-filled cables are decommissioned in one stage, or two.

Option 8 has been introduced since release of the PADR and reflects feedback from customers, the AER and the Consumer Challenge Panel, as part of the separate regulatory review process for TransGrid, that supported a staged network option for the reasons that it reflects lower initial capital costs and provides 'optionality' (ie, the flexibility to defer the second cable if circumstances change).

The table below summarises the credible options identified and assessed as part of this RIT-T.

Table E-1 Summary of the credible options assessed as part of this RIT-T

Option & direct cost* ($m, NPV)	Use of non-network solutions before network commissioning	Use of non-network solutions to defer network build by one year	Two new 330 kV cables built		Cable 41				Decommissioning of Ausgrid fluid-filled cables	
			In stages	At once	Operate at 132 kV	Operate at 330 kV with rating of 426 MVA	Remediate to ~ 575 MVA	Retire	In stages	At once
1 – $224m	✓	-	✓	-	-	-	-	✓	✓	-
2A – $221m	✓	-	✓	-	✓	-	-	-	✓	-
2B – $250m	✓	-	✓	-	-	✓	-	-	-	✓
3A – $246m	✓	-	-	✓	-	-	-	✓	-	✓
3B – $247m	✓	-	-	✓	-	✓	-	-	-	✓
4 – $263m	✓	-	✓		-	-	✓	-	-	✓
5 – $273m	✓	-	-	✓	-	-	✓	-	✓	-
6 – $257m	✓	-	-	✓	-	-	✓	-	-	✓
7 – $234m	✓	✓	-	✓	-	✓	-	-	-	✓
8 – $212m	✓	✓	✓	-	✓	-	-	-	✓	-

** Note that the direct costs are shown for the 'central' scenario. The direct costs of each option are comprised of the network capital investment costs, non-network costs and cable decommissioning costs. Please also note that the timing of later investment stages (and hence the NPV of the cost) depends on the forecast demand scenario.*

All options will deliver significant net benefits due to their ability to avoid substantial unserved energy to Inner Sydney going forward

The RIT-T NPV assessment shows that all credible options can be expected to deliver significant net market benefits, when compared to the 'do nothing' option. The net benefits expected from each option have been tested over a range of different scenarios, which capture differences in key drivers of these benefits.

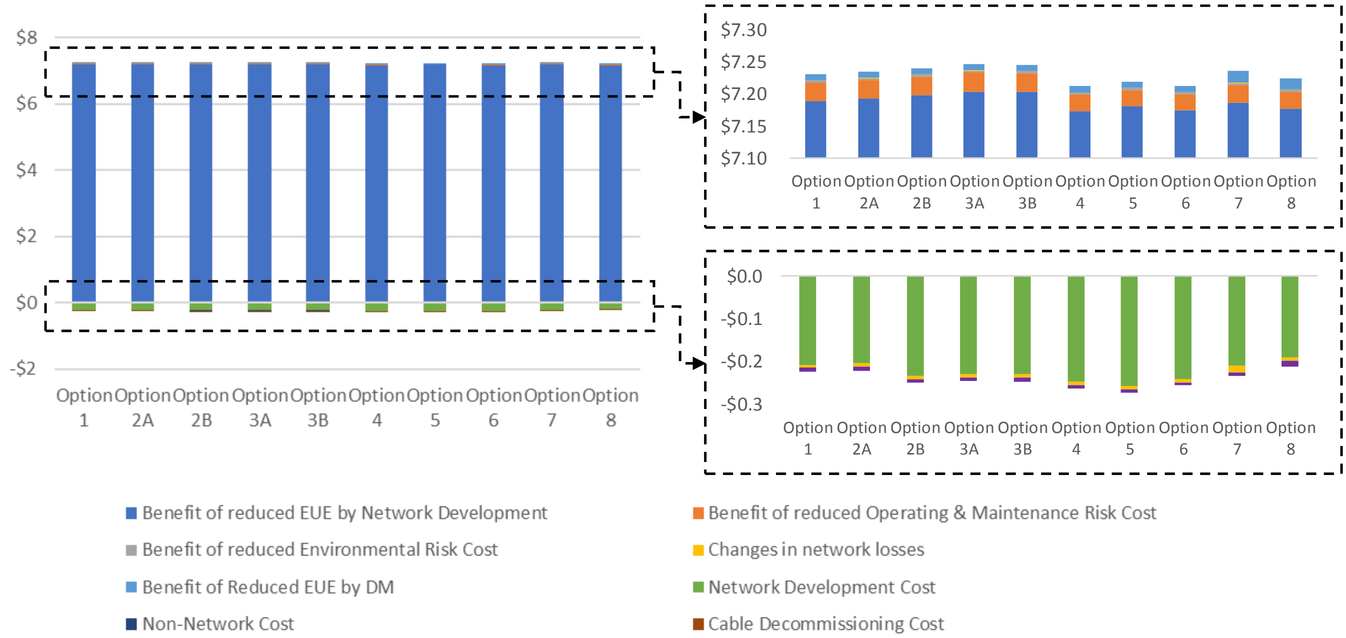
Table E-2 Reasonable scenarios assumed

Key variable/parameter	Scenario 1 – Low	Scenario 2 – Central	Scenario 3 – High
The value that customers place on reliable electricity supply (known as the Value of Customer Reliability – 'VCR)	AEMO VCR Value	The VCR used by IPART in its recent review of the NSW transmission reliability standards ($90/kWh)	$170/kWh for the Sydney CBD and $90/kWh for Inner Sydney (ie, the 'central' assumptions in the PADR)
Demand	Low	Medium	High
Discount rate	8.78%	6.13%	3.48%

Net benefits are greatest in the central and high scenarios, where options are estimated to deliver between $7 billion and $75 billion of net benefits, in PV terms, respectively. Under the low scenario, net benefits for all options are found to be marginally negative.[1] Overall, expected net benefits (ie, on a weighted-basis across all three scenario) are positive and estimated to be in the order of $27 billion for all options.

Benefits to the market arise primarily due to the fact that all credible options avoid substantial costs to consumers from disruption of electricity supply to Inner Sydney (ie, avoided expected unserved energy – or 'EUE'). Figure E.1 below shows the breakdown of costs and benefits estimated for the central scenario.

Figure E-1 Breakdown of benefits and costs estimated - Central scenario ($bn 2017/18)



[1] For clarity, the 'low scenario' has been constructed from a particularly adverse set of assumptions, which have all been selected to lower estimated market benefits, such as using the AEMO VCR value, low demand forecasts and a high discount rate.

TransGrid and Ausgrid have undertaken extensive sensitivity testing to test the robustness of the RIT-T assessment to assumptions about key variables.

In particular, we have undertaken two tranches of the sensitivity testing – namely:

- Stage 1 – testing the sensitivity of the optimal timing of the project ('trigger year') to different assumptions in relation to key variables; and
- Stage 2 – once a trigger year has been determined, testing the sensitivity of the total NPV benefit associated with the investment proceeding in that year, in the event that actual circumstances turn out to be different.

In Stage 1, TransGrid and Ausgrid have undertaken sensitivity analysis to first determine the optimal timing of the project, to conclude that a particular year represents the 'most likely' date at which the project will be needed.

In short, key takeaways from this first stage of sensitivity testing are as follows:

- the optimal timing of the project is found to be invariant to the following assumptions:
  > 25 per cent higher or lower capital costs for the network options;
  > an assumed 20-year life for Cable 41 (as opposed to 10-years);
  > adopting a higher VCR value of $170/kWh for customers in the Sydney CBD (consistent with the HoustonKemp report);
  > a higher assumed discount rate (8.78 per cent); and
  > shifting 60 per cent of the assumed corrective failure maintenance to shoulder periods.[2,3]
- the optimal timing of the project is brought forward under the assumption of a lower discount rate (3.48 per cent) and high load growth;[4]
- the optimal timing of the project is found to be delayed when a low load growth forecast is used in conjunction with a low VCR (ie, adopting AEMO's VCR values).

As outlined in this PACR, TransGrid and Ausgrid consider that the central Ausgrid demand forecasts are appropriate and reflect renewed economic activity in Inner Sydney, including of a number of significant infrastructure and redevelopment projects that are already effectively committed.[5] Moreover, TransGrid and Ausgrid note that the 2017 Ausgrid load forecasts for Inner Sydney continue to show a rebound in peak electricity demand for the area, consistent with the central forecasts used in this PACR.

In addition, TransGrid and Ausgrid note that assuming the standard AEMO VCR for the types of wide-spread and prolonged outages being considered for the PSF project are widely seen as inappropriate (including by AEMO).[6] A low VCR is also inconsistent with the basis on which IPART has recently determined the transmission reliability standard for the Inner Sydney area.

On balance, TransGrid and Ausgrid consider that the identification of the central trigger years for all options has been robustly determined and tested.

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2 As outlined in section 4.3, TransGrid and Ausgrid have investigated a lower assumed corrective failure rate in response to a query by the AER in its Draft Decision for TransGrid. The results of this investigation show that a shift of 60 per cent of corrective failures from summer to shoulder periods (shoulder period failure rate increase by 25 per cent) does not change 2021/22 as the practical need year for Options 1 to 6 and 2022/23 for Option 7 and Option 8.

3 Sensitivity analysis has also been undertaken to test the robustness of shifting more (or less) of corrective failure maintenance from summer to shoulder periods. The sensitivities undertaken were moving 70 per cent of corrective failure maintenance to shoulder periods and moving 50 per cent. Both sensitivities found minimal effect on the optimum investment timing, with no change for most options and only up to one year's difference for options 2B, 3A and 3B.

4 Although the evaluation shows some stages are needed as early as 2018/19, due to the complexity and scope of the project, the earliest practical completion year is 2021/22. It is therefore expected that non-network options will be used to manage the risk of unserved energy, where it is economic to do so, until a network option can be commissioned. All economic cost-benefit analysis presented in this report is based on the practical Stage 1 completion year of 2021/22 at the earliest (with the exception of Option 7 and Option 8, which assume a one year deferral of the costs of Option 3B and Option 2A, respectively, and apply a commissioning year of 2022/23).

5 These New South Wales government initiatives have now 'broken ground' and are now well underway. For more information on the progress of each project (and how these projects are all well-underway), can be accessed from their respective websites: https://westconnex.com.au/; and https://www.sydneymetro.info/images-and-video.

6 As outlined in section D.1 further.

Having assumed to have committed to the first stage of the project by this date, under Stage 2 of the sensitivity testing, TransGrid and Ausgrid have also looked at the consequences of 'getting it wrong'. This is consistent with how the RIT-T is designed to operate. That is, if demand turns out to be lower than expected, for example, what would be the impact on the net market benefit associated with the first stage of the project continuing to go ahead on that date. For options with two stages, this includes a deferral of the second stage of the project.

Specifically, TransGrid and Ausgrid have conducted extensive sensitivity analysis on the overall NPV of the net market benefit, based on the assumed option timing, including:

- a 25 per cent increase/decrease in the assumed network costs;
- alternate forecasts of maximum demand growth, based on POE10 (high) and POE90 (Low);
- both a lower and a higher VCR value;
- a lower discount rate of 3.48 per cent, as well as a higher rate of 8.78 per cent; and
- a longer service life for Cable 41.[7]

This second stage of the sensitivity analysis reaffirms the finding that all options are expected to have very high gross benefits, due to the significant unserved energy reduction when compared to the 'do-nothing' option for the next twenty years. For example, even assuming a low load growth forecast, which would effectively mean that major NSW government infrastructure developments in Sydney that have already commenced are abandoned, it is expected that all options will generate approximately $200-250 million in net market benefits.[8]

Overall, the range of assumptions embodied in these various scenarios and sensitivities ensures that the credible options are robustly tested across a reasonable number of future outcomes.

Submissions to the PADR queried a range of underlying assumptions, including demand forecasts and fluid-filled cable failure rates. TransGrid and Ausgrid have responded to each point raised in this PACR and included additional sensitivity tests, where relevant.

We continue to recommend that non-network solutions are used to defer network investment but now also recommend that network investment is staged over time

The analysis in this PACR continues to identify the prospect of deferring network expenditure, using non-network solutions, by one year as part of the preferred option. This was a key conclusion at the PADR stage of this RIT-T.

However, the ultimate *network* component of the preferred option has changed since release of the PADR. In particular, Option 8 in this PACR is now the preferred option for implementation by TransGrid and Ausgrid and involves:

- the use of non-network solutions before network commissioning;
- use of non-network solutions to defer network build by one year from when it would need to be commissioned without this support (ie, from 2021/22);
- installing two 330 kV cables in two stages, with commissioning of the first cable in time for the 2022/23 summer;
- operating Cable 41 at 132 kV; and
- decommissioning Ausgrid's cables in two stages.

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7 A major assumption in this PACR is that Cable 41 has a remaining service life of 10 years. However, TransGrid notes that there is a possibility that the service life of Cable 41 may extend to beyond 10 years provided that additional periodic maintenance works are carried out and the temperature of the hottest spots along the cable route are carefully monitored to avoid any over-temperature events. We have therefore also undertaken a sensitivity based on a service life of 20 years for Cable 41.

8 Please note that these estimates relate to the low demand sensitivity (shown in Table 5-4 below) and not the 'low scenario' – for clarity, the 'low scenario' has been constructed from a particularly adverse set of assumptions, which have all been selected to lower estimated market benefits, such as the low demand forecasts but also using the AEMO VCR value and a high discount rate.

The key difference between the conclusion in this PACR and that of the earlier PADR is the *network* component of the preferred option. In particular, the PADR recommended installing the two new 330 kV cables *in one stage* on account of minimising the inconvenience and disruption on the community and environment,[9] while this PACR recommends these cables are installed in two stages.

TransGrid and Ausgrid note that there is a balance between minimising wider community disruption[10] and having a lower initial capital cost as well as the 'optionality'/flexibility that comes with installing the two cables in two stages.

In addition, subsequent to the issue of the PADR, the AER and the Consumer Challenge Panel (CCP) expressed concern, through the separate regulatory review process relating to TransGrid, relating to a lack of flexibility with the preferred option at that stage. We therefore reviewed the options to consider the appropriate balance between retaining optionality, decreasing the initial capital cost and minimising community disruption and, consequently, developed Option 8. We also sought the views of customers and stakeholders in our TransGrid Advisory Council, who expressed support for a two-stage option.

Under Option 8, the installation of the second 330 kV cable could be delayed if demand growth is slower than forecast and/or a higher quantity of lower cost non-network options emerges as part of the formal RFT process TransGrid will shortly commence (outlined below). The opposite could also occur and this option would allow TransGrid to respond with a second cable earlier than planned should that become necessary.

Overall, the strength and quality of submissions and interest from non-network proponents to this RIT-T has driven this exciting result. There has been a very strong response from non-network proponents in response to the PSCR and PADR and TransGrid and Ausgrid have assessed proposals from these parties in detail and consider that there is scope for deferring the commissioning of network through the use of non-network solutions. As far as TransGrid and Ausgrid are aware, this is one of the largest capital expenditure deferrals by non-network solutions in Australia to-date.

Important information for non-network proponents looking to be a part of Powering Sydney's Future going forward

TransGrid and Ausgrid consider that there is a strong role for non-network solutions in reducing the risk of unserved energy to consumers in Sydney going forward – both through potentially deferring the commissioning of a network project, as well as in managing the risk of unserved energy between now and when these cables can be commissioned. Since release of the PADR, TransGrid and Ausgrid have had a number of meetings with non-network proponents to further discuss and clarify the role that such solutions can play.

TransGrid is currently in the process of preparing a formal two-stage RFT for non-network proponents to respond to for non-network solutions. The two-stage process allows TransGrid to flexibly procure more demand management should demand forecasts or cable conditions change, and to procure more efficient lower cost solutions should the demand management market further improve with more non-network

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9 In particular, the proposed cable route for all network options will pass through the highly developed Inner Sydney area and it is expected that the project construction works will have a significant impact to the community and environment, including the inconvenience caused by traffic disruption, increased noise due to excavation works etc. Installing the two 330 kV cables in one go minimises these impacts, compared to other network options that construct these two cables in two stages.

10 While TransGrid and Ausgrid note that the benefit to the wider community from avoiding this disruption and cost cannot be included in the RIT-T economic assessment, an indication of the number of parties that are likely to be affected by digging up the proposed cable route helps to illustrate the inconvenience and wider community costs from installing the two 330 kV cables in two stages (eg, under Option 2A). A current New South Wales government traffic counter that corresponds to one section of the proposed cable route records that approximately 27,000 vehicles of which 1,600 relate to 'heavy vehicles' (ie, trucks), pass that section on average each day – this implies that approximately 820,000 vehicles will be affected through traffic disruption and congestion for every month that particular section of road is under construction (sourced from the New South Wales government Roads and Maritime Services Georges River Road traffic station, which corresponds to one section of the proposed route –see Station ID 7275 at http://www.rms.nsw.gov.au/about/corporate-publications/statistics/traffic-volumes/aadt-map/index.html#/?z=13&lat=-33.90921191659774&lon=151.0794010162358&id=7275&tb=1&hv=1). We note that this is a very narrow estimate of the wider effects. eg, it only focuses on one particular section of the proposed route (ie, where there is a NSW government traffic counter currently located) and excludes additional inconvenience caused through noise due to excavation works and pollution. It has been included to help demonstrate the magnitude of this wider disruption on the community from installing the cables in two stages.

providers. In addition, the second stage would allow non-network proponents to learn from the first stage, and to refine their solutions to assist with deferral.

The first stage will seek approximately 40-60 MW of non-network capacity over a four-year program (based on the preferred Option 8) from 2018/19 summer to 2021/22 summer, and include binding contracts for the provision of non-network solutions that will be entered into. This RFT will be released after the AER provides certainty that funding is available to TransGrid to pursue non-network solutions, which is expected to align with the timing of its final determination on the revenue proposal in April 2018.

The second stage is a 'top-up' round (ie, in addition to the first stage) that will seek approximately 20-40 MW from 2020/21 summer to 2021/22 summer (a two-year program). A necessary precondition for any network deferral to occur is the procurement of appropriate non-network support from the market by TransGrid, sufficiently before the date at which the network component would otherwise need to be committed. To provide the necessary lead time, TransGrid anticipate that the second RFT will be released around September 2018.

TransGrid considers that the date of 31 January 2019 reflects the date at which TransGrid would need to enter into a contract for the cabling required *should a network project not be deferred using non-network solutions*. This effectively reflects the latest date that TransGrid can decide whether to commit to a network project for commissioning during 2021/22, or to commit to deferring the network project by a year using non-network solutions. Should sufficient non-network contracts *not be entered into* by this date, TransGrid may proceed with procuring the necessary cabling contracts and other arrangements in order to commission a network project before the summer of 2021/22.

Contents

1. Introduction

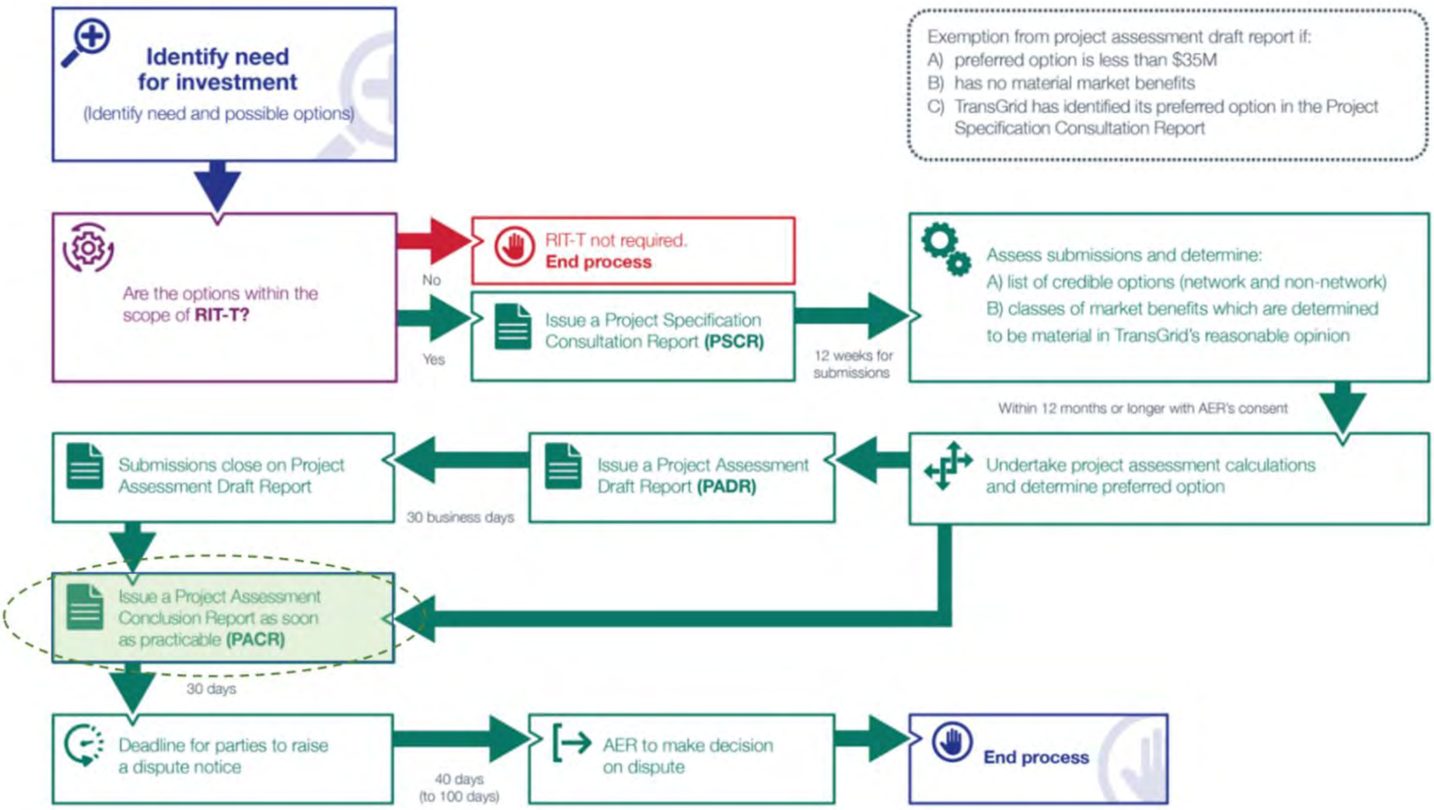
This Project Assessment Conclusions Report (PACR) represents the third step in a formal Regulatory Investment Test for Transmission (RIT-T) process undertaken jointly by TransGrid and Ausgrid with a focus on alleviating the increasing risk to the supply of electricity to consumers from ageing electricity infrastructure in the Inner Sydney area.

The primary purpose of this report is to:

- set out the options that TransGrid and Ausgrid consider will address the growing risk to supply for consumers;
- discuss the issues raised by stakeholders in submissions to the Project Assessment Draft Report (PADR) and how they have been incorporated in the RIT-T assessment;
- present the assessment of the costs and benefits of each option in addressing this risk (as well as the methodologies and assumptions underlying these results); and
- identify the option which satisfies the RIT-T, and which is therefore the preferred option for investment by TransGrid and Ausgrid.

This PACR follows both a PADR and Project Assessment Consultation Report (PSCR) released in May 2017 and October 2016, respectively. The PACR represents the third stage of the formal consultation process set out in the NER in relation to the application of the RIT-T, as outlined in the figure below.

Figure 1-1 This PACR is the third stage in the RIT-T process



This RIT-T follows from the Powering Sydney's Future project that TransGrid and Ausgrid consulted on extensively during 2014 and, ultimately, decided to defer in light of decreasing maximum demand forecasts at the time.

TransGrid Ausgrid

1.1 Drivers of this Regulatory Investment Test for Transmission

The identified need for this RIT-T is TransGrid and Ausgrid's assessment that the future value of unserved energy[11], and other costs to electricity consumers, associated with the increasing likelihood of failure of fluid-filled cables exceed the cost of investment to avoid these failures. The expected date of this occurring is 2021/22 (as identified in the PSCR).

In the absence of such investment, the following are expected to increase the amount of unserved energy in the future, as well as imposing a range of other costs on consumers:

1. The deteriorating condition of ageing fluid-filled cables in the existing network resulting in the derating of 330 kV Cable 41 by TransGrid and the derating of a number of 132 kV cables by Ausgrid.
2. Impending retirement of three 132kV fluid-filled cables in Inner Sydney.
3. The age-related deteriorating condition of a further eight 132 kV fluid-filled Ausgrid cables in the Inner Sydney area.
4. Forecast increases in customer demand due to renewed economic activity within Inner Sydney.

As part of this report, as well as the PADR released in May 2017, TransGrid and Ausgrid have valued reductions in expected unserved energy, network losses and repair/maintenance and environmental costs associated with each option, compared to the do nothing option.

This PACR continues the joint planning efforts of TransGrid and Ausgrid to identify the most efficient solution across their respective networks as a whole.

1.2 Ageing electricity infrastructure presents an increasing risk to consumers

A reliable electricity supply to the Inner Sydney area, which includes the Central Business District (CBD) and a number of inner suburbs, is of crucial importance to customers and businesses located in these areas, as well as more broadly to New South Wales. This is due to the importance of the area in contributing to the wider economy.

Key elements of the current electricity transmission network supplying the Inner Sydney area are ageing. In particular, there are a number of fluid-filled cables that have been in operation since the 1960s and 1970s. TransGrid and Ausgrid have identified issues with these assets that are compromising their operating performance. After testing the backfill, TransGrid and Ausgrid have both had to downgrade the capacity that these cables can provide.

These ageing fluid-filled cables are also at a stage in their service life where they have an increasing likelihood of failure. When a failure occurs the cable is required to be out of service for lengthy periods to enable repairs. This is generally up to two months, but can be longer in difficult locations. This increases the likelihood that these network elements are out of service when failure of another network element occurs, which may result in unserved energy to consumers. Electricity consumers in Inner Sydney are therefore becoming increasingly vulnerable in terms of the expected level of disruption to their electricity supply.

TransGrid and Ausgrid have undertaken analysis as part of this RIT-T that shows a significant forecast increase in unserved energy to the Inner Sydney area due to an increase in the probability of cable failure of the assets in question and the increasing customer demand. In particular, if a forced outage of two or more significant transmission elements occurred, the impact of load curtailment, particularly for Inner Sydney, would be significant. The figure below summarises the outcome of this analysis.[12]

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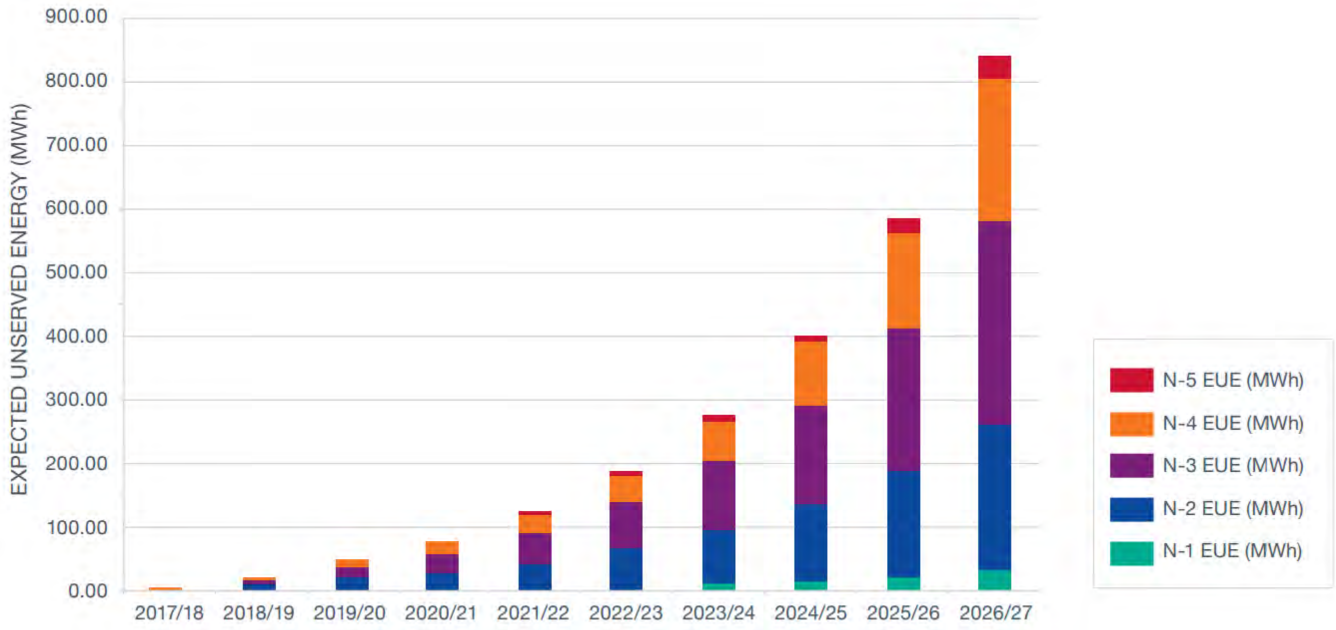
[11] Unserved energy is the electricity demanded by consumers but not able to be supplied.

[12] While this figure shows EUE for up to N-5, TransGrid and Ausgrid have only used EUE to N-4 in the PSF analysis (as outlined in section 4.11).

Figure 1-2 Forecast of expected unserved energy in Inner Sydney, 2017/18 to 2026/27



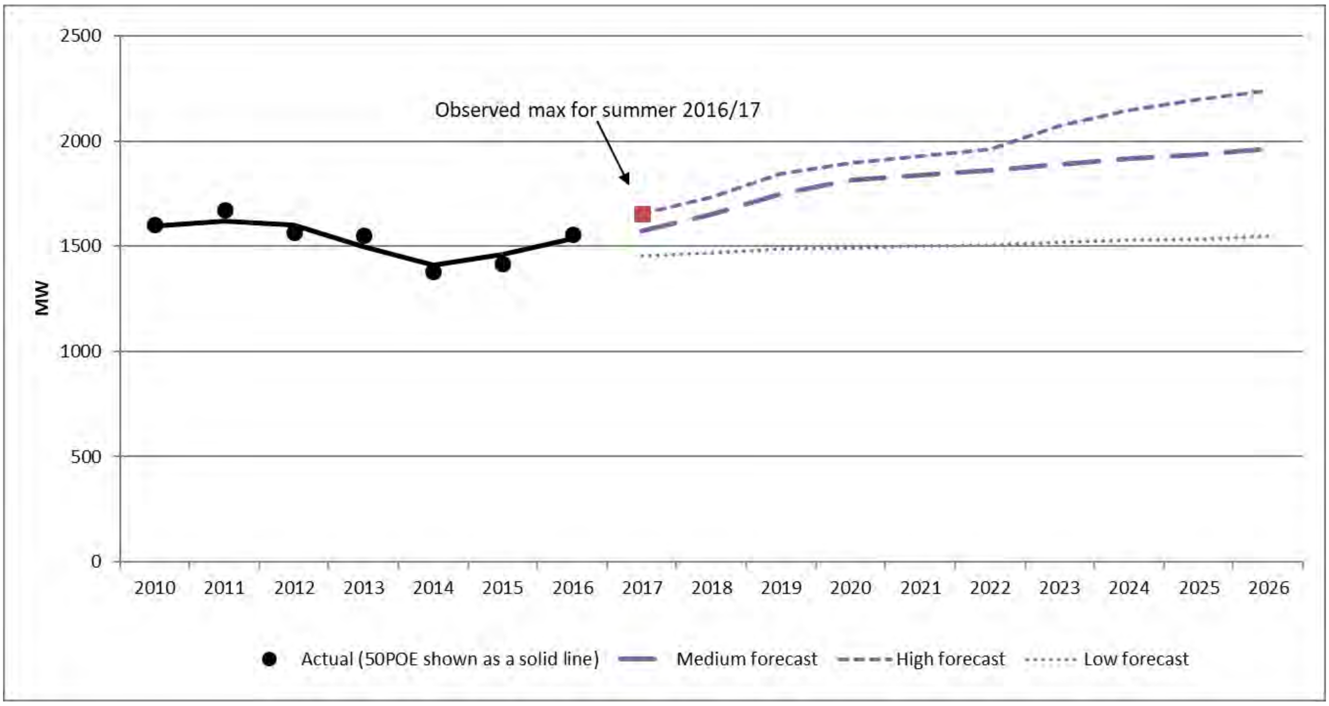
Source: TransGrid, 2017 Transmission Annual Planning Report, p. 27.

1.3 Customer demand is increasing due to renewed activity within Inner Sydney

Customer demand in the Inner Sydney area continues to increase due to renewed economic activity. This is evident in the observed summer 2016/17 peak demand, committed new customer connections and anticipated customer connections.

Figure 1-3 shows the historical peak demand for Inner Sydney and the forecast for the next 10 years. Of particular note is the actual maximum demand that occurred on 10 February 2017, which was in line with the high forecast.

Figure 1-3 Historical and forecast Inner Sydney peak demand growth



TransGrid and Ausgrid note that bespoke Inner Sydney demand forecasts have been used for this RIT-T, as AEMO does not currently estimate demand at this level. While this broad approach was not raised in submissions, we provide further detail regarding the individual spot loads assumed and our wider approach to forecasting demand in Section 4.2 below.

1.4 New transmission reliability standard applying in New South Wales

The reliability standards applying to electricity transmission in New South Wales were reviewed by the Independent Pricing and Regulatory Tribunal (IPART) at the end of 2016.[13] The result is a new reliability standard that will apply from 1 July 2018.

IPART recommended a new reliability standard for Inner Sydney which is expressed in two parts:

- Level of redundancy:

  For Inner Sydney, the required level of redundancy remains unchanged at modified N-2, i.e. a non-zero amount of load must be supplied following the simultaneous outage of a single 330kV cable and any 132kV feeder or 330/132 kV transformer.

- Unserved energy allowance:

  This requires the transmission system to be designed such that the annual expected unserved energy in respect to a bulk supply point[14] does not exceed the allowance for expected unserved energy specified for that bulk supply point. The reliability standard requires that the bulk supply points within the Inner Sydney transmission system be treated as one group and be designed so that there is a maximum of 0.6 minutes of unserved energy per year.

TransGrid and Ausgrid consider the approach in this RIT-T to valuing reductions in the expected unserved energy associated with each credible option to be consistent with IPART's approach to derive the new standard (that is, using an economic assessment to estimate the level of reliability that provides the most value to customers). For avoidance of doubt, the assessment in this RIT-T has been based on economic benefit analysis.

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[13] IPART published a Supplementary Final Report on 22 December 2016, which recommended unserved energy allowances for Inner Sydney as well as Broken Hill, Molong, Mudgee, Munyang and Wellington Town. IPART now needs to determine whether TransGrid will be compliant with the standard from 1 July 2018 and in, early 2018, IPART will begin a consultative process on their proposed approach to compliance.

[14] A bulk supply point is a location within the transmission network where electricity supply is provided to the distribution network or a directly connected customer.

2. Identified need

In the absence of undertaking any network or non-network investment, the following are expected to increase the amount of unserved energy in the Inner Sydney area, as well as a range of other costs borne by consumers, in the future:[15]

1. The deteriorating condition of ageing fluid-filled cables in the existing network, the derating of the 330 kV Cable 41 by TransGrid and the derating of a number of 132 kV cables by Ausgrid.
2. Impending retirement of three 132kV fluid-filled cables in Inner Sydney.
3. The age-related deteriorating condition of a further eight 132 kV fluid-filled Ausgrid cables in the Inner Sydney area.
4. Forecast increases in customer demand due to renewed economic activity within Inner Sydney.

Since commencement of this RIT-T, Ausgrid has updated its customer demand forecast used in the economic assessment following a review of customer connections in progress, future load transfers and new spot load connections. The updated forecast is modestly higher than the demand forecast used in the PSCR,[16] with the most significant difference being due to the inclusion of a number of significant infrastructure and redevelopment projects (these projects include further stages of 'WestConnex' and Sydney Metro – both of which are now under construction[17]). The modestly higher demand forecasts in the PADR, compared to the PSCR, were raised in submissions and we have addressed these queries in section 4.2 below.

Since future demand patterns are inherently uncertain, TransGrid and Ausgrid have investigated a range of different demand forecasts as part of the 'reasonable scenarios' constructed for this RIT-T.[18] While net benefits are particularly expected for the central and high demand forecasts (where options are estimated to deliver between $7 billion and $43 billion of net benefits, in PV terms, respectively), there are also strong net benefits expected under the low demand forecasts (in the order of $200-250 million, in PV terms).[19]

Ausgrid also reviewed the methodology underpinning the forecast of future repair costs for aged cables following release of the PSCR, which resulted in a slight increase for the majority of assessed cables.[20] TransGrid and Ausgrid note that any assumed failure rates affect the market benefits of the credible options equally, since all options avoid the operating and maintenance costs due to cables failing – the estimated benefits from such costs due to cable failing are consequently similar for each credible option (as shown in Figure 6 of this PACR) and are overshadowed by the expected unserved energy. Assumptions regarding these repair costs were raised in submissions to the PADR and are discussed in more detail in section 4.3 below.

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15 Section 3 of the PSCR discussed in detail the emerging limitations in relation to the existing network in Inner Sydney. The PSCR not only outlined the identified need for this RIT-T but also detailed the key assumptions made in relation to the identified need, including the forecast of escalating unserved energy.

16 The reasons why are discussed in section 6.4.2 of the PADR. Appendix B to the PADR also provided the actual maximum demand forecasts assumed for each year of the assessment period.

17 These New South Wales government initiatives have now 'broken ground' and are now well underway. For more information on the progress of each project (and how these projects are all well-underway), can be accessed from their respective websites: https://westconnex.com.au/; and https://www.sydneymetro.info/images-and-video.

18 The construction of reasonable scenarios is discussed in detail in section 5.1 below.

19 Please note that these estimates relate to the low demand sensitivity (shown in Table 5-4 below) and not the 'low scenario' – for clarity, the 'low scenario' has been constructed from a particularly adverse set of assumptions, which have all been selected to lower estimated market benefits, such as the low demand forecasts but also using the AEMO VCR value and a high discount rate.

20 The updated cable repair costs are provided in Appendix E to the PADR.

3. Credible options assessed in this Regulatory Investment Test

This section summarises the credible network options considered as part of this RIT-T. In particular, it first summarises all credible options assessed, before presenting the next steps TransGrid and Ausgrid are taking to ensure sufficient non-network support is committed in time to both defer network expenditure as well as to manage the risk of supply interruption between now and when these cables are commissioned.

3.1 Summary of credible options assessed as part of this RIT-T

TransGrid and Ausgrid have considered a range of options and their ability to address the risk of supply disruption for consumers. Both network and non-network solutions have been considered as potential credible options for this RIT-T analysis – in particular:

- a range of **network options** has been included in the RIT-T assessment; and
- **non-network option components** have been incorporated into the assessment of all network options identified to manage the supply risk prior to commissioning of the network component
  - in addition, two ‘deferral’ options (Option 7 and Option 8) have been included in the assessment to determine whether non-network components can efficiently defer the timing of network investment.

The credible network components considered differ principally based on:

- whether two new 330 kV cables are built together, or in stages;
- whether Cable 41 is remediated, operated without remediation (including at a lower voltage), or retired; and
- whether Ausgrid’s existing fluid-filled cables are decommissioned in one stage, or two.

The table below summarises the credible options identified and assessed as part of this RIT-T.

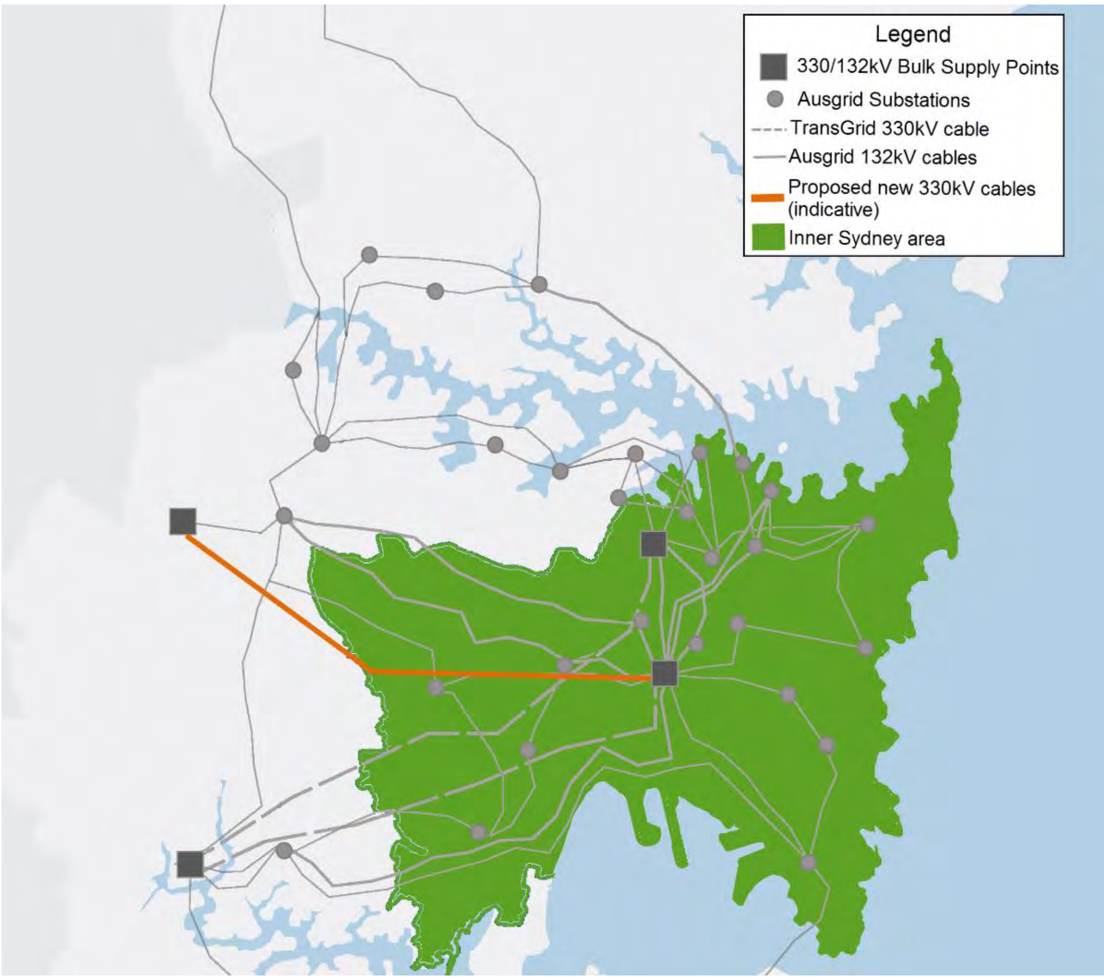
Table 3-1 Summary of credible options assessed as part of this RIT-T

Option	Use of non-network solutions before network commissioning	Use of non-network solutions to defer network build by one year	Two new 330 kV cables built		Cable 41				Decommissioning of Ausgrid fluid-filled cables	
			In stages	At once	Operate at 132 kV	Operate at 330 kV with rating of 426 MVA	Remediate to ~ 575 MVA	Retire	In stages	At once
1	✓	-	✓	-	-	-	-	✓	✓	-
2A	✓	-	✓	-	✓	-	-	-	✓	-
2B	✓	-	✓	-	-	✓	-	-	-	✓
3A	✓	-	-	✓	-	-	-	✓	-	✓
3B	✓	-	-	✓	-	✓	-	-	-	✓
4	✓	-	✓		-	-	✓	-	-	✓
5	✓	-	-	✓	-	-	✓	-	✓	-
6	✓	-	-	✓	-	-	✓	-	-	✓
7	✓	✓	-	✓	-	✓	-	-	-	✓
8	✓	✓	✓	-	✓	-	-	-	✓	-

Appendix B presents additional detail on the credible options assessed in this RIT-T (including detailed cost breakdowns), much of which was presented in section 3 of the PADR.

As outlined in the PSCR and PADR, any new cables to be installed are assumed to follow the same general route (Rookwood Road to Beaconsfield).[21] A network diagram illustrating this general route selection (orange line) is provided in the figure below.

Figure 3-1 Network diagram illustrating general route selection for the new cables



3.2 Important information for non-network proponents looking to be a part of Powering Sydney's Future going forward

TransGrid and Ausgrid consider that there is a strong role for non-network solutions in reducing the risk of unserved energy to consumers in Sydney going forward – both through potentially deferring the commissioning of a network project, as well as in managing the risk of unserved energy between now and when these cables can be commissioned. Since release of the PADR, TransGrid and Ausgrid have had a number of meetings with non-network proponents to further discuss and clarify the role that such solutions can play.

While contracts with non-network providers have not been entered into as part of this RIT-T process, this is consistent with the way a preferred network option would be treated under the RIT-T. In particular, it reflects the fact that a RIT-T is required to be undertaken sufficiently in-advance of the 'identified need' and when the network service provider(s) need to contract suppliers (of either network or non-network services).

TransGrid is currently in the process of preparing a formal two-stage RFT for non-network proponents to respond to for non-network solutions. The two-stage process allows TransGrid to flexibly procure more demand management should demand forecasts or cable conditions change, and to procure more efficient lower cost solutions should the demand management market continue to develop, with more non-network

[21] TransGrid and Ausgrid have investigated the costs and risks of alternate routes and consider that there is no other preferable route.

providers. In addition, the second stage will allow non-network proponents to learn from the first stage, and to refine their solutions to assist with deferral.

The first stage will seek approximately 40-60 MW of non-network capacity over a four-year program (based on the preferred Option 2A) from 2018/19 summer to 2021/22 summer, and include binding contracts for the provision of non-network solutions that will be entered into. This RFT will be released after the AER provides certainty that funding is available to TransGrid to pursue non-network solutions, which is expected to align with the timing of its final determination on the revenue proposal in April 2018.

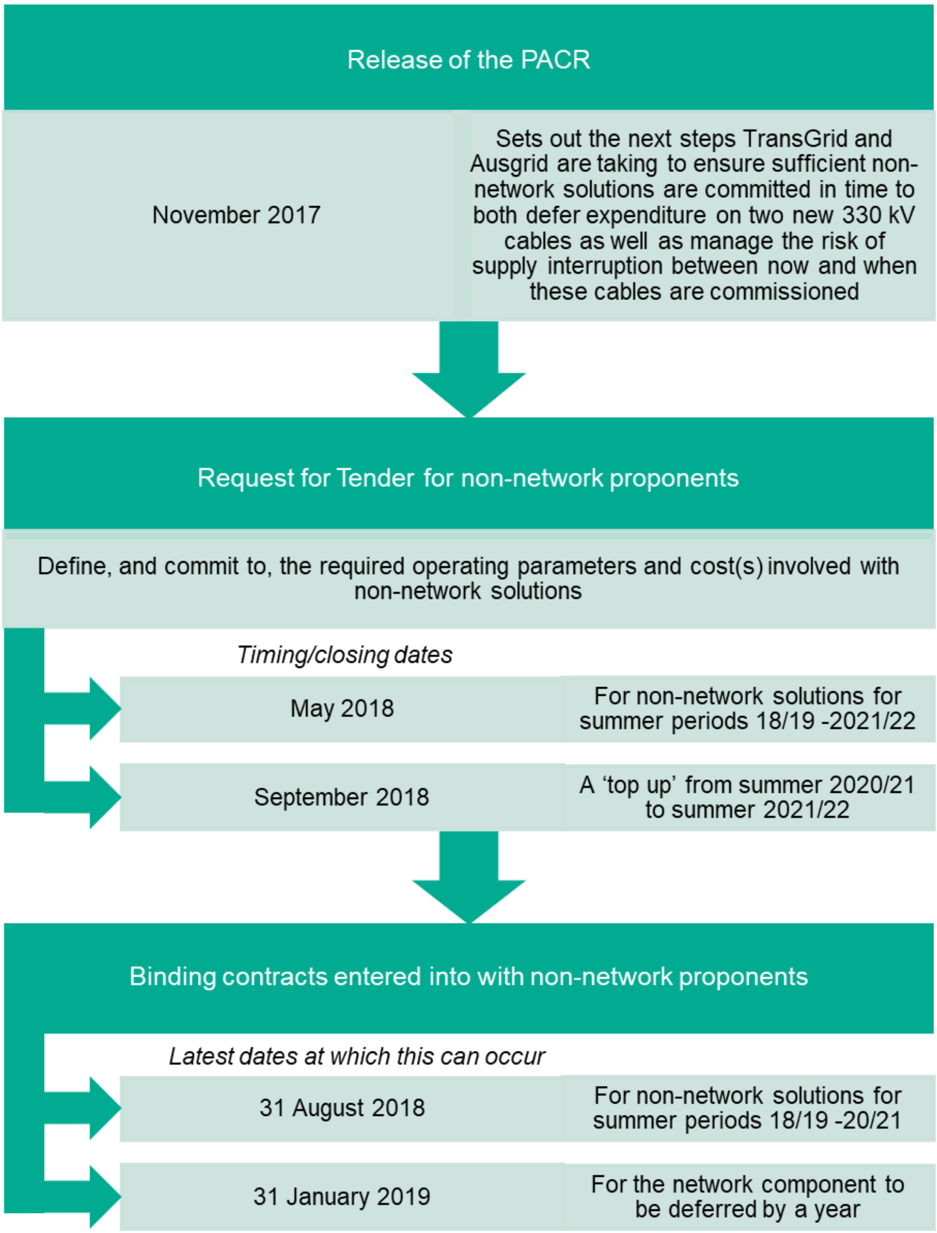
The second stage is a 'top-up' round (ie, in addition to the first stage) that will seek approximately 20-40 MW from 2020/21 summer to 2021/22 summer (a two-year program). A necessary precondition for any network deferral to occur is the procurement of appropriate non-network support from the market by TransGrid, sufficiently before the date at which the network component would otherwise need to be committed. TransGrid anticipate that the second RFT will be released around September 2018.

The figure on the next page summarises the process and key dates going forward for non-network proponents. In particular, it shows the following:

- anticipated timings for the two-stage RFT processes TransGrid is going to run; and
- the effective 'cut-off' dates.

The date of 31 January 2019 reflects the date at which TransGrid would need to enter into a contract for the cabling required *should a network project not be deferred using non-network solutions*. This effectively reflects the latest date that TransGrid can decide whether to commit to a network project, for commissioning during 2021/22, or to commit to deferring a network project by a year using non-network solutions. Should sufficient non-network contracts *not be entered into* by this date, TransGrid may proceed with procuring the necessary cabling contracts and other arrangements in order to commission a network project before the summer of 2021/22.

Figure 3-2 Summary of important dates for non-network proponents going forward



4. Submissions received on the Project Assessment Draft Report

The PADR released in May 2017 called for submissions from interested parties regarding the credible options presented by TransGrid and Ausgrid, including for proponents of alternative potential credible options that met the technical characteristics to come forward, as well as any feedback on the estimation methodology/assumptions adopted and the draft conclusion regarding the preferred option.

TransGrid and Ausgrid received four submissions to the PADR, from the following parties:

- ERM Power Retail Pty Ltd;
- GreenSync;
- AGL Energy Ltd; and
- EnergyAustralia.

These parties also made submissions to the PSCR, with the exception of GreenSync.[22]

All submissions received were complimentary of the PADR process generally, as well as the draft outcomes presented. No submissions were received that questioned the need to ultimately bolster the network in order to ensure reliable supply of electricity to consumers in Inner Sydney.

A few parties requested further detail regarding operational parameters required of non-network solutions. TransGrid and Ausgrid are continuing to work with those parties to define the required operating parameters and cost(s) involved.

This section addresses a number of specific issues raised in submissions, particularly in relation to the economic assessment undertaken in this RIT-T. These queries are targeted at gaining further insights into how non-network solutions have been treated in the analysis, and what their likely role will be going forward. As requested by submitters, we have anonymised the issues raised and kept submitting party names confidential.

TransGrid and Ausgrid would like to thank parties that have engaged with this RIT-T process, both through formal submissions to the PSCR and PADR as well as through interacting with the other various community and stakeholder engagement initiatives TransGrid and Ausgrid have undertaken. Overall, the process has been highly consultative and TransGrid and Ausgrid consider that this interaction has been crucial to achieving a well-balanced, considered and efficient assessment of the options aimed at addressing the risk of supply disruption for consumers in Inner Sydney.

TransGrid notes also that, separate to the PADR submissions process (and the RIT-T more generally), the AER raised a number of questions regarding the Powering Sydney's Future project in its September 2017 Draft Decision regarding TransGrid's regulatory proposal for the 2018-23 regulatory control period. We therefore also address the concerns raised by the AER in the sections below.[23] As part of this process, the Consumer Challenge Panel also reiterated a number of the points raised by the AER.[24]

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[22] In total, TransGrid and Ausgrid received eleven submissions to the PSCR, which are discussed in-detail in section 4 of the PADR (and reproduced as Appendix E to this PACR).

[23] The AER also submitted a formal Information Request (IR#041) to TransGrid as part of the separate regulatory review process, which requested additional information on how network support options have been assessed in the RIT-T. TransGrid responded with a direct response to each question raised by the AER in this request and provided a separate document providing more detail on the methodology used to assess proposed network support options.

[24] Consumer Challenge Panel, *TransGrid pre-determination conference presentation*,10 October 2017, slide 18.

4.1 Key drivers influencing the timing and scope of the network decision

Submitters inquired as to what key drivers are influencing the timing and scope of the network decision.

The key components determining the timing and scope of the network investment decision relate to the value of unserved energy from *not* investing. Put another way, the timing and scope of the network investment decision is determined by the value of unserved energy *avoided* by commissioning the network investment. Key factors that determine the value of the avoided unserved energy are the underlying demand forecasts, the load profile of demand that would likely be affected, the probabilities of asset failure, a proxy of the value that customers place on reliable electricity supply (the 'VCR') and the discount rate.[25]

A key point raised by the AER, in its Draft Decision, was that it does not consider that the scope and optimal timing of the project has been sufficiently established. In particular, the AER stated concern that the optimal timing of the project may differ from that estimated by TransGrid and Ausgrid, due to differences in the underlying assumptions.

TransGrid and Ausgrid have estimated the optimal timing for the project based on the year in which the annualised cost of the project falls below the assumed benefit (calculated on the basis of the expected USE in that year multiplied by the assumed VCR). TransGrid notes that the AER agrees that this is the appropriate approach. However, the AER contended that differences in the underlying assumptions would lead to differences in the identified trigger year, such that for many assumptions the optimal timing for the project would be deferred, with no expenditure required in the 2018-23 regulatory period.

To assist in responding to this point raised by the AER, we have drawn a distinction between two key stages of the assessment – namely:

- Stage 1 – the sensitivity of the optimal timing of the project ('trigger year') to different assumptions in relation to key variables; and
- Stage 2 – once a trigger year has been determined, the sensitivity of the total NPV benefit associated with the investment proceeding in that year, in the event that actual circumstances turn out to be different.

That is, TransGrid and Ausgrid have undertaken sensitivity analysis to first determine the optimal timing of the project, to conclude that a particular year represents the 'most likely' date at which the project will be needed.

Having assumed to have committed to the first stage of the project by this date, TransGrid and Ausgrid have then also looked at the consequences of 'getting it wrong'. That is, if demand turns out to be lower than expected, what would be the impact on the net market benefit associated with the first stage of the project continuing to go ahead on that date. For options which have two stages, this includes a deferral of the second stage of the project. This recognises the limited time available to commit to the first stage of the PSF project based on TransGrid and Ausgrid's view of the most likely trigger year, given the lead times involved for both the non-network (1-2 years) and network (5 years) elements.

We have provided additional insight into these two stages to the sensitivity testing of alternate assumptions in section 5.5 below.

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25 The approach to estimating the market benefit from avoided unserved energy is detailed further in section 7.1 of the PADR.

4.2 Range of underlying demand forecasts assumed

This section discusses three points relevant to the assumed demand forecasts. First, it describes the increase in demand forecast between the PSCR and the PADR/PACR. It then provides more detail on the assumed load profile. It also discusses points raised by the AER regarding the difference between the demand forecasts used and the broader AEMO Sydney Region connection point forecast.

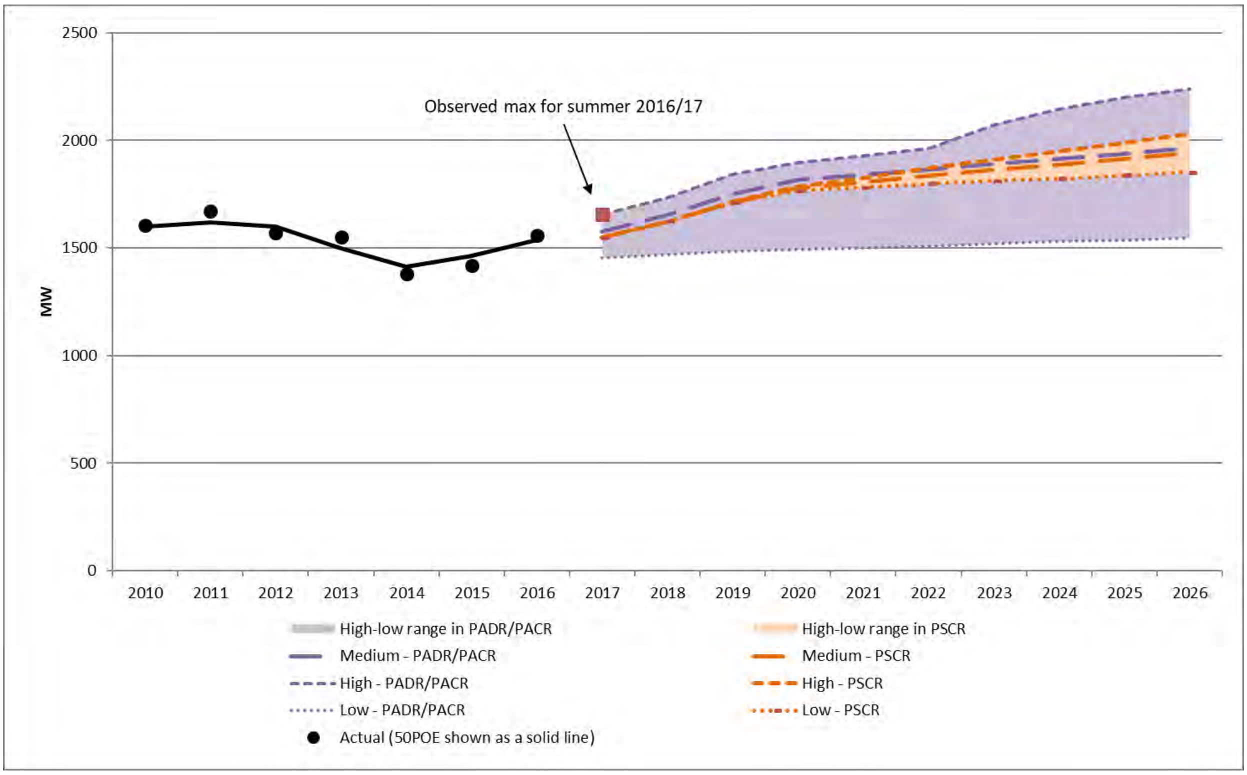
4.2.1 Increase in demand forecast between the PSCR and the PADR/PACR

One submission queried the moderate increase in the demand forecasts between the PSCR and the PADR. Parties were interested in understanding further the drivers of this, especially in the context of recent price movements and whether this is attributed to changes in energy efficiency or rooftop solar installation rates.

The figure below summarises the demand forecasts included in the PSCR, and shows the updated high and low range of the demand forecasts used for sensitivity analysis in the PADR. In addition, it shows the actual summer 2016/17 maximum demand for the Inner Sydney area of 1,654 MW, which occurred on Friday 10 February 2017 and is approximately 5% higher than the medium scenario forecast for summer 2016/17 and, as the chart shows, is in line with the high scenario forecast used in the PADR.

The figure below also shows that, while the base demand forecasts increased modestly between the PSCR and PADR/PACR, a greater range of future demand levels have been investigated in the PADR/PACR, including a lower 'low' demand.[26]

Figure 4-1 Historical and forecast Inner Sydney peak demand growth



The largest contribution to demand growth is from future spot loads, mainly composed of large transport, infrastructure and residential development projects currently underway. The figure below shows a breakdown of the components of the medium forecast to show the underlying contributions to demand.[27]

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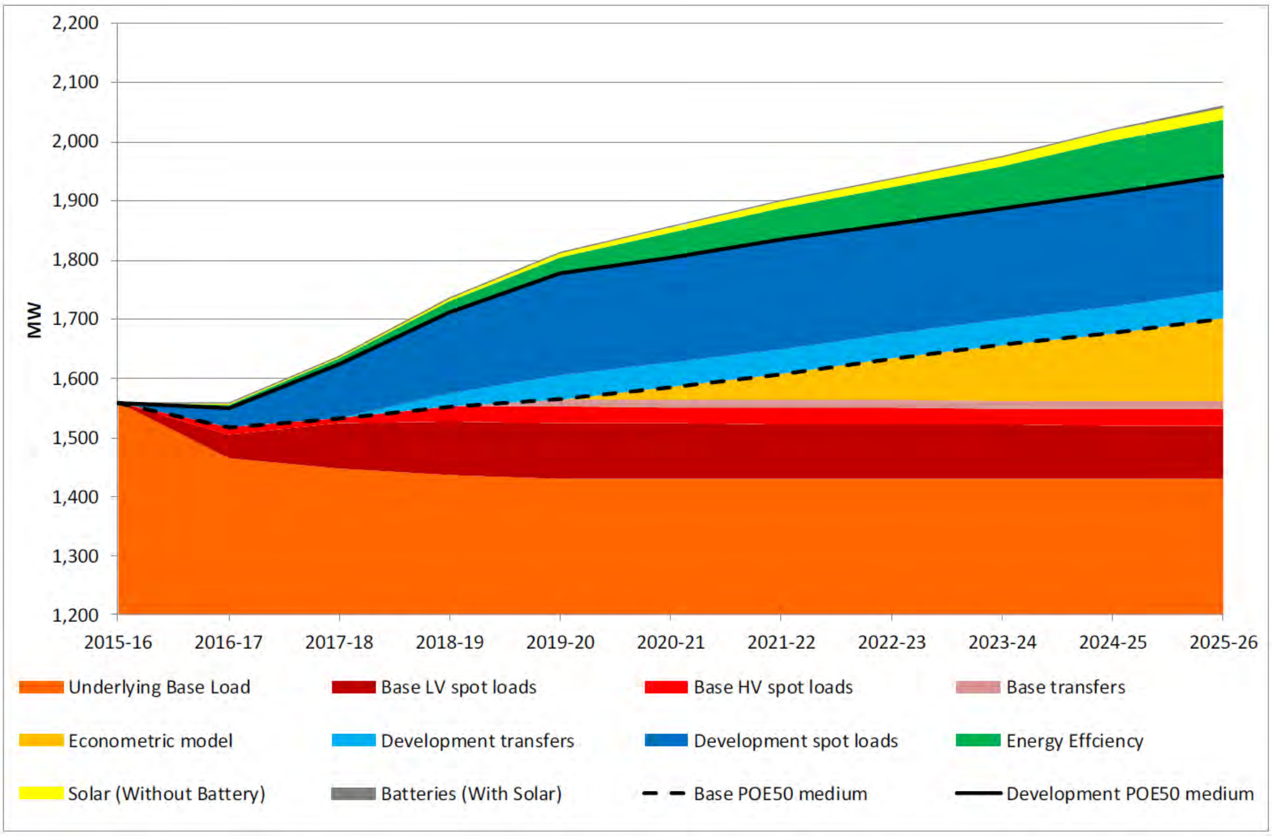
26 Between the PSCR and the PADR, the decision was made by TransGrid and Ausgrid to investigate a low demand forecast that stripped out most new block loads as an extreme low forecast. This resulted in the low forecast falling significantly between the PSCR and PADR, as illustrated in the figure above.

27 Appendix C of this PACR outlines the key contributions to the underlying demand forecasts.

Figure 4-2 Contributions to the POE 50 Medium Development forecast



TransGrid and Ausgrid have investigated high and low sensitivities to test the robustness of the RIT-T assessment to variations in the demand forecast. TransGrid and Ausgrid consider that the range investigated (and illustrated in the figure above) is sufficiently broad to capture all reasonable expectations regarding future demand. While net benefits are higher for the central and high demand forecasts (where options are estimated to deliver between $7 billion and $75 billion of net benefits, in PV terms, respectively), there are still strong net benefits expected under the low demand forecasts (in the order of $200-250 million, in PV terms).[28]

The most significant difference between the high demand forecasts in the PADR compared to the PSCR is due to the inclusion of a number of significant infrastructure and redevelopment projects (these projects include further stages of ‘WestConnex’ and Sydney Metro – both of which are now under construction[29]). A very moderate change to the medium scenario between the PSCR and the PADR occurred due to updated information relating to movement of loads in the underlying 11kV electricity network (these changes were not related to changes in energy efficiency or rooftop solar installation rates). None of the demand scenarios investigated between the PSCR and PADR differ in assumptions around energy efficiency and rooftop solar installation rates.

TransGrid and Ausgrid note that the 2017 Ausgrid load forecasts for Inner Sydney continue to show a rebound in peak electricity demand for the area, consistent with the medium forecasts illustrated above.

4.2.2 Assumed load profile

One submitter queried the sensitivity of the results to the assumed underlying load profile. Specifically, parties wished to know whether different annual load profiles have been used for the 10, 50 and 90% POE cases and whether the selection of 2013/14 as a reference year is significant or not.

The expected unserved energy calculation in the PADR has been undertaken for half hourly load intervals during a financial year. The historical half hourly load trace of financial year 2013/14 is used as the base load

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28 Please note that these estimates relate to the low demand sensitivity (shown in Table 5-4 below) and not the ‘low scenario’ – for clarity, the ‘low scenario’ has been constructed from a particularly adverse set of assumptions, which have all been selected to lower estimated market benefits, such as the low demand forecasts but also using the AEMO VCR value and a high discount rate.

29 These New South Wales government initiatives have now ‘broken ground’ and are now well underway.

profile then scaled up by the ratio of the forecasted maximum demand (ie, high, medium and low) to 2013/14 POE50 maximum load to evaluate future expected unserved energy.

TransGrid and Ausgrid consider that the selection of 2013/14 as a reference year is a reasonable approach to calculate the expected unserved energy, since 2013/14 was a mild year temperature/demand-wise. Specifically, the real maximum demand in 2013/14 was below the POE50 maximum demand (as shown in Figure 4 above). Therefore, by adopting the shape of the 2013/14 load trace the maximum demand - using the scaled load trace approach adopted by TransGrid and Ausgrid – will likely be below the load profile expected on a POE50 or higher POE demand day, which will underestimate the expected unserved energy.

For completeness, TransGrid and Ausgrid have investigated the use of 2015/16 as a reference year (as suggested by one submitter) and found that the expected unserved energy results are slightly higher than using 2013/14 as the reference year, but it does not affect the project need year.

4.2.3 Difference from AEMO's 'Sydney Region' forecast

The AER, in its Draft Decision, stated concern that the demand forecasts used are above those produced by AEMO. In particular, the AER makes reference in its Draft Decision to AEMO's 2016 Sydney Region connection point forecast and the BIS Shrapnel forecast[30] as comparisons with the Ausgrid forecast for the Sydney Inner Metro region, in reviewing the need and investment timing of the Powering Sydney's Future project. The Consumer Challenge Panel also raised a concern about the demand forecasts applied in the separate regulatory review process, stating that demand forecasts assumed were 'bullish'.[31]

TransGrid notes that, while the AEMO and BIS Shrapnel forecasts as referred to in AER's Draft Decision may provide an indicative trend based on past trend rate of economic growth, they do not adequately reflect a forecast of future demand in Sydney inner metro area due to significant out-of-trend economic activity in Sydney's inner metro region currently. In addition, it is highly relevant to note that:

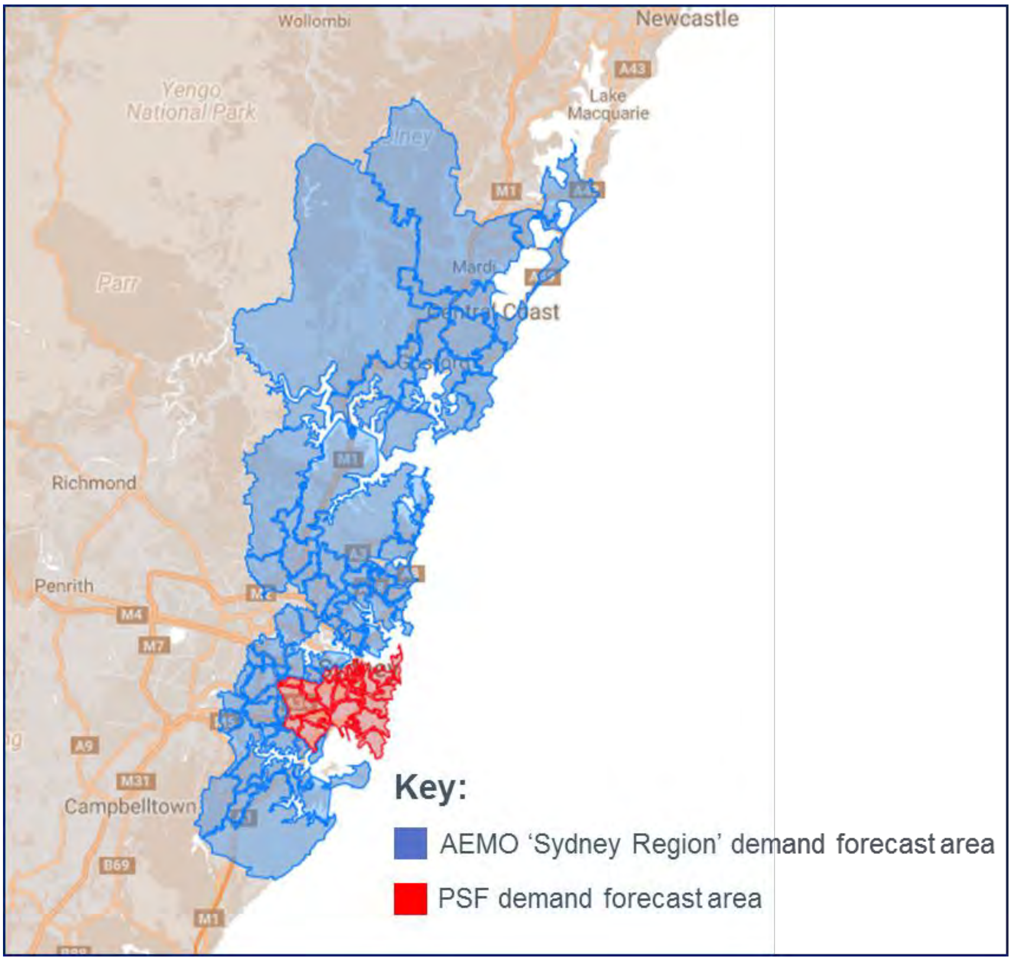
- AEMO does not produce a forecast for the Sydney inner metropolitan area (the area affected by the PSF project); and
- AEMO produces connection point forecasts, which predict the *aggregate* future demand for the broader Sydney Region, which is significantly larger and characteristically different to the Sydney inner metropolitan area.

The figure below illustrates the significant differences in geographical areas covered by the PSF and AEMO Sydney Region forecasts.

30 BIS Shrapnel were retained by Ausgrid at the PSCR stage to independently develop demand forecasts for Inner Sydney for this project (discussed further in the PSCR).

31 Consumer Challenge Panel, *TransGrid pre-determination conference presentation*,10 October 2017, slide 18.

Figure 4-3 Differences in demand forecast areas between what was used in the PSF assessment and the, wider, AEMO Sydney Region forecasts



Importantly, AEMO's 'Sydney Region' forecast (ie, the blue area) extends north across the Hawkesbury River into the Central Coast area and goes past Cronulla in the south. It is a much wider area which includes significantly different customer and demand profiles, including a higher proportion of residential and medium density load. In total, it includes eight TransGrid Connection Points.

In short, the wider AEMO forecasts do not provide a good comparison for the PSF forecast (ie, the red area), which includes two TransGrid Connection Points and where non-residential customers account for 85 per cent of summer peak. Differences in residential and non-residential customer demand include their respective load profiles (e.g. they peak at different times of day) and their different responses to price. The PSF demand forecast was developed to account for the specific characteristics of the underlying load, including the connection of large new spot loads, as outlined above, which the AEMO forecast does not include.

In order to provide further explanation on the suitability of a more localised 'bottom-up' demand forecast approach undertaken for the Powering Sydney's Future RIT-T TransGrid, Ausgrid and AEMO have met with the AER and provided a comprehensive explanation of the forecasting methodology that is appropriate for Inner Sydney.

In addition, TransGrid and Ausgrid note that AEMO has since released its 2017 Transmission Connection Point forecast, which is materially higher than its 2016 forecast.

4.3 Forced outage rates assumed and average time required to repair cables

This section discusses two points relevant to the assumed forced outage rates assumed and average time required to repair cables. First, it provides additional detail on the assumed cable failure rates and sensitivity tests on them. It then outlines the interaction between wider asset management practices and assumed failure rates.

4.3.1 Additional detail on the assumed cable failure rates and sensitivity tests on them

One submission questioned the cable failure rates assumed in the assessment and whether a sensitivity study has been undertaken on the assumed probability of failure for forced outages and repair times as part of the economic assessment. In particular, the party wished to understand how material the failure rate and mean time to repair assumptions are with regards to the preferred timing of investment, as well as how the Ausgrid oil filled cable failure model report translates to TransGrid's critical Cable 41.

Ausgrid's oil filled cable predictive failure model was created using historical failure and population information from both TransGrid fluid cables (ie, 41 and 42) and Ausgrid's entire oil cable population. Condition information, such as oil leaks and serving insulation resistance test results and failure data for TransGrid oil cables was included (in the information relating to all Ausgrid oil cables) to produce the population and individual feeder parameters that were reviewed in the report. In essence, TransGrid's oil cables were considered along with Ausgrid's oil feeder population for this modelling.

TransGrid and Ausgrid did not investigate a formal sensitivity regarding the assumed failure rates and the benefit of avoided operating and maintenance costs in the PADR since doing so would only alter the *magnitude* of the estimated net benefits across options and not the *ranking* of options relative to one-another. Specifically, the estimated benefits from avoided operating and maintenance costs are similar for each credible option (as shown in Figure 8.1 of the PADR and Figure 6 of this PACR) and are overshadowed by the expected unserved energy.

4.3.2 Interaction between wider asset management practices and assumed failure rates

The party also requested more information on how the operating and maintenance, as well as wider asset management, practices of TransGrid and Ausgrid affect the failure rates, and what actions are (or can be) being taken to minimise repair times.

Ausgrid undertakes a preventative maintenance program that governs the ongoing maintenance requirements through an asset's life and is a combination of condition based maintenance and preventative activities. Importantly, these maintenance practices do not improve the inherent performance of the cable system but, instead, restore it to a condition commensurate with its age and operating environment. This assists in reducing the rate of defects/failures (e.g. oil leaks) but does not prevent the general deterioration (wear-out) of the cable, which is the primary concern for Cable 41.

Corrective issues are identified during planned maintenance or by cable monitoring systems. These corrective issues may be repaired during the planned maintenance outages or through subsequent outages (semi-forced) determined by the defect severity and accessibility for repairs. Planned inspection and corrective maintenance will not prevent all failure modes occurring.

TransGrid and Ausgrid note that cable repair times are dependent on the component of the cable system that has failed and the extent of repair required (including secondary consequences). This can be further influenced by the failure location (e.g. failures in major roads will require traffic management and authority to work on the road, which is generally limited to short timeframes at night). The inherent design of the oil cables precludes shorter repair times in that the oil in the system must be drained prior to cable jointing or repair work as well as, generally, the requirement to establish new jointing bays (civil works required), re-pressurising and testing the cable following works.

In its Draft Decision for TransGrid, the AER expressed a view that the cable failure rates assumed by TransGrid would be likely to overstate the probability of cables being unavailable and therefore overestimate the expected amount of unserved energy. The AER reached this conclusion based mostly on historical corrective failure rates and the potential for some corrective failure maintenance to be shifted to off peak shoulder periods (March - May and September – November periods), thereby reducing the likelihood of unserved energy during corrective failure maintenance. The Consumer Challenge Panel also raised a concern about assumed cable availability in the separate regulatory review process, stating that the assumptions were 'bullish'.[32]

As noted in TransGrid's revenue proposal, failure frequency has been determined using historical outage information and the mean time to repair is determined using an assessment of the potential failure types. Since TransGrid submitted its revenue proposal to the AER in January 2017, and since the PADR was released, Ausgrid has further analysed the historical failure logs, failure modes and outage records, to refine the failure rates. The assessment has shown that it is theoretically possible to move approximately 60 per cent of corrective failure maintenance originally assumed to occur during summer to the off-peak shoulder period (however, the remaining 40 per cent of corrective failure maintenance required immediate attention and could not be postponed). There is a limit on how many outages can be planned for shoulder periods. Currently, it is the longer planned outages, such as those with longer recall times, which are scheduled for outside peak periods. Review of data from shoulder periods shows that there were at least two, and up to four planned outages at any one time across the group of cables in the PSF area. This outage congestion makes it impractical to move all nominally discretionary outages to the shoulder period.

The AER also noted an alternative view regarding calculation of the average mean time to repair (MTTR) cable faults using a weighted average. This alternative approach had not been applied due to data availability during the initial analysis. Further review and consolidation of data has allowed us to apply the alternative method.

The assessment shown in section 5.4 illustrates that shifting 60 per cent of corrective failure maintenance to shoulder periods with the alternatively derived MTTR values has no impact on the optimum investment timing.[33] TransGrid and Ausgrid have also tested further sensitivities to this assumption and found that the impact on the optimal timing of options is minimal, as outlined in section 5.4.

4.4 The reliability and availability of Ausgrid's cables

Similar to the points discussed above with respect to forced outage rates assumed and average time required to repair cables, another interested party requested justification of the use of pre-derating failure data for Ausgrid cables.

Ausgrid notes that the failure rate of fluid filled cables depends on several factors including:

- environmental degradation to outer sheath and serving, such as corrosion and serving degradation;
- metallurgical fatigue of aluminium fluid containment and sheath components, due to thermal cycling and expansion/contraction over many years; and
- overheating of conductors and insulation due to overloading.

In the case of Ausgrid's 132 kV fluid filled cables, the observed failure modes are in the first two categories, notwithstanding the recent need to derate a number of cables to avoid the risk of future damage in the event of cascading failures or under multiple contingencies (especially contingencies involving 330kV cables). The loading on the cables both before and after derating is not a factor that has contributed to historic or projected failure rates.

The cables under consideration have operated in a heavily meshed network, generally at N-2 levels of reliability as required by reliability standards for Inner Sydney. Under these circumstances, the risk of overloading is only during a network emergency caused by the failure of multiple network elements. At other times, cables operate at loading levels significantly below their ratings. Therefore, pre-derating loading has not been a contributor to 132 kV fluid filled cable failure rates. This is consistent with the observed failure modes TransGrid and Ausgrid have recorded over many years.

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32 Consumer Challenge Panel, *TransGrid pre-determination conference presentation*,10 October 2017, slide 18.

33 TransGrid and Ausgrid also adopted the AER's proposed approach to calculating average MTTR for this case and it is the combination of the two revised assumptions that results in no timing change.

TransGrid and Ausgrid have revised cable ratings based on cable condition and backfill test results, limiting the maximum flows below this rating, to manage the risk of operating cables outside their safe operating boundary.

Since the cables have been derated, the network has been planned and operated so that even under system emergencies the loading on the cables will not exceed the cable ratings. Therefore, it is reasonable to assume that the failure rate of the cables due to overheating has not changed to any significant extent.

The failure rate due to other causes remains unchanged. This is the basis of the justification to use pre-derating cable failure data.

The AER, in its Draft Decision, queried whether the assumptions made on cable capacity are consistent with industry practice, and suggested that emergency ratings may be more relevant. In particular, the AER has considered that TransGrid has relied on assumptions of cable capacity that are inconsistent with industry practice, which are likely to underestimate network capacity and so overstate the amount of expected unserved energy.[34]

TransGrid notes that cable emergency cyclic ratings have been used in the modelling in all circumstances, where appropriate to do so. In particular:

- for parallel cables, TransGrid's assessment of expected unserved energy (EUE) included use of emergency cyclic ratings for cables during the scenario where the other parallel cable was under outage; and
- for all other cables, TransGrid's assessment of EUE used the continuous cyclic rating for all scenarios, as it is the same as their emergency cyclic rating (since there is no parallel cable in close proximity). This is the highest rating advised by cable manufacturers for their continuous operation. Operation at higher ratings will reduce cable life and TransGrid considers it not prudent, especially during the summer period where one cable has failed, for another cable (or multiple cables) to be loaded above the emergency cyclic rating on a daily basis until the failed cable is repaired, as this will significantly degrade and reduce the overall life of the cable.[35]

Since release of the Draft Decision, TransGrid has been in discussion with the AER regarding the exact assumed used of emergency ratings and prepared a separate document clarifying TransGrid's use of cable ratings in calculating EUE.

4.5 The use of bespoke VCR estimates to value unserved energy

The AER, in its Draft Decision, queried the use of VCR estimates in the analysis that are above those used by IPART in reviewing the reliability standard for the Sydney CBD and Inner Suburbs. The Consumer Challenge Panel also stated that the assumed VCR values were 'bullish' as part of the separate regulatory review process.[36]

IPART used an estimate of \$90/kWh developed by HoustonKemp for the VCR over both Inner Suburbs and CBD customers. The PADR for this RIT-T used this figure for the Inner Suburbs as well as a, higher, value of \$170/kWh for the CBD customers, which was based on the value recommended in the HoustonKemp report.

While TransGrid and Ausgrid consider that there are good reasons to believe that the VCR value for customers in the CBD area would be higher than in the Inner Suburbs area, as set out in the HoustonKemp report, we note that using the \$170/kWh or \$90/kWh figure for CBD customers is not material for the identification of the optimal timing for the PSF project, or for the outcome under the RIT-T analysis.

To demonstrate this, TransGrid and Ausgrid have updated all the economic assessment in this PACR so that it assumes the \$90/kWh figure for all affected customers under the 'central' set of assumptions, ie, both Inner

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34 AER, *Draft Decision: TransGrid Transmission Determination: Attachment 6 – Capital Expenditure*, September 2017, p6-96

35 Emergency rating can only be used for a very short period of time on an infrequent basis . Therefore, cable emergency ratings were not used in the assessment of EUE for these cables.

36 Consumer Challenge Panel, *TransGrid pre-determination conference presentation*,10 October 2017, slide 18.

Suburbs and CBD customers. The original assumption of $170/kWh VCR value for the CBD has been included only in the 'high VCR' scenario.

4.6 Further detail on the avoided 'environmental' costs included

TransGrid and Ausgrid note that, while financial environmental costs and benefits have been modelled as part of this RIT-T, they are not a material driver in the economic evaluation for this project (as can be seen in section 5).

One party requested further information on the assumed New South Wales Environmental Protection Agency (EPA) obligations – including:

- details of the flexibility of Ausgrid's retirement plan; and
- details of the flexibility of Ausgrid to keep cables requiring corrective action (leaking fluid) in-service during peak load.

Both Ausgrid and the EPA are aware that many of Ausgrid's 132 kV fluid filled cables have deteriorated to the extent that fluid is leaking into the surrounding ground and, in some cases, into waterways.

In its Compliance Policy, the EPA states:[37]

> *"The NSW Government and community have an expectation that the EPA will actively promote compliance with relevant legislation and deliver improved environmental outcomes. This will be achieved by assisting those it regulates to understand and meet their legislative obligations and* ***driving compliance through transparent, consistent and accountable regulatory actions that target those who consciously choose not to comply with the law****" [emphasis added]*

In support of this objective, Ausgrid has developed a fluid filled cable retirement strategy, with input and feedback from the EPA, in order to minimise the risk of pollution and non-compliance with environmental legislation. The strategy involves the reduction of fluid leakage by at least 50 per cent of the starting level for each successive regulatory period (i.e. 100 per cent of the original leakage volume become 50 per cent in the next regulatory period, then 25 per cent in the following regulatory period etc). Ausgrid is required to report the leakage rates to the EPA on an ongoing basis, until all fluid filled cables are retired.

While Ausgrid's retirement strategy gives the ability to prepare different retirement schedules, the choices are still constrained by the need to select cables which contribute materially to the reduction in fluid leakage and by the economies of scale related to different options. The Ausgrid cables to be retired as a result of Powering Sydney's Future contribute over half of the reduction in fluid leakage required over the 2019-2024 regulatory control period, consistent with cables being among the higher priority remaining in service at that time. To substitute alternative cables would require a larger volume of lower priority cables, with a corresponding increase in cost to achieve the equivalent environmental outcome.

Neither the EPA's mandate, nor any plan submitted to the EPA by Ausgrid, give any overt flexibility, over and above that of the retirement plan noted above, for retaining cables requiring corrective action (leaking fluid) in-service during peak load. While Ausgrid would make short term operational decisions based on the relative risks at the time of identifying any required corrective action related to fluid leakage, Ausgrid has not received any exemptions from the EPA to retain cables with a known leak in service and would anticipate that it would not be feasible for these to be granted under operational circumstances.

Ausgrid also notes that continued operation with significant fluid leaks at times of peak loading poses not just a pollution risk, but an elevated risk of further and/or permanent damage to the cable, therefore extending repair times and potentially leading to the need for abandonment/replacement of the cable.

Notwithstanding the approach to operational decisions under contingency conditions, we note that Powering Sydney's Future is a jointly planned response under the National Electricity Rules, so is intended to develop plans to avoid these contingencies occurring where they are reasonably predictable. Planning works so as to

[37] http://www.epa.nsw.gov.au/resources/legislation/130251epacompol.pdf, p3

reduce or remove the risk of pollution from cables as a result of predictable defects is consistent with these objectives.

Further, as noted in other material, the planning underpinning the Powering Sydney's Future project clearly shows that this project provides the most efficient plan to facilitate the retirement of the leaking cables. This is due to the fact that one new 330kV cable allows the retirement of several 132kV cables, giving rise to significant economies of scale.

4.7 Cost of non-network solutions included in the PADR assessment

As part of the PSCR, TransGrid and Ausgrid invited public submissions on potential credible non-network options that could meet the required technical characteristics. TransGrid and Ausgrid received eleven submissions from non-network proponents, offering a range of different technologies.

The non-network proposals were assessed to determine whether they can economically assist in managing the risk of unserved energy prior to the commissioning of the preferred network option (Option 2A) at the time. Specifically, a package of non-network solutions totalling approximately $7-10 million (in aggregate) was calculated and included as part of the assessment for *each* of the network options prior to when the network option is commissioned.

One submitting party wished to understand further how the $7-10 million total cost for non-network support had been determined and what the likely impacts are of this cost being higher or lower.

Given the magnitude of responses to the PSCR from non-network proponents, TransGrid and Ausgrid took a 'merit order' type approach to determining which offers should be included in the solution. When assessing competing options, the options were selected in order of least cost until the requirement is met, in order to derive the preferred mix of non-network options and the estimated cost. Because the dispatch costs for the various non-network options vary significantly, a volume of dispatch must be chosen to derive the merit order – section 5.4 of the PADR outlines in more detail how these dispatch volumes were calculated.

The table below summarises the outworking of the approach taken, while keeping costs of various technologies confidential as was strictly requested by proponents.

Table 4-1 Summary of the 'merit order' from non-network solutions proposed

Merit Order	Solution Type
1	Existing diesel generation
2	Existing tri/cogeneration
3	Demand response
4	Solar generation
5	Grid-scale battery storage
6	Customer owned battery storage

TransGrid and Ausgrid note that the $7-10 million cost range has been derived using this approach and incorporates a probability based assessment of expected dispatch. Should an actual cable failure occur of the magnitudes being considered, the costs of the non-network solutions would be far greater due to the actual cost of dispatching these solutions.

Subsequent to the issue of the PADR, TransGrid received feedback from the AER and the Consumer Challenge Panel (CCP), as part of the separate regulatory review process, supporting a two-stage network option (Option 2A) for the reasons that it reflected lower initial capital costs and provided 'optionality' (ie, the flexibility to further defer the second cable if circumstances change).

A key consequence of pursuing a lower capital cost option is that it lowers the annualised cost of the network option (referred to as the 'Annual Delay Value' or 'ADV'). The ADV is the expected value of benefits attributable to delaying a network option by a year and can be thought of as the economic threshold that the expected cost to consumers must be lower than before network investment is triggered (ie, where the annualised cost of the network option is lower than the net cost of non-network option, then it is preferable to deliver the network solution). Consequently, by undertaking the lower cost Option 2A (instead of, say, Option 3B as was recommended in the PADR), the investment is economically triggered a year earlier in 2020/21, and the potential length of the non-network program is forecast to be truncated from four to three years.

Notwithstanding this economic assessment, TransGrid will pursue a two-stage demand management program over four years as it provides more flexibility to Option 2A should demand forecasts or cable conditions change going forward. Longer programs also provide non-network proponents greater certainty, and allow proponents' investment to be amortised over longer periods, including the opportunity for provide more refined products and relationships.

Another submission noted that cost sensitivities were not run on assumed non-network costs, and questioned whether this affects the outcomes.

Sensitivities were not run on non-network costs at the PADR stage as the cost provided by submitters were treated as firm and reflective of competitive costs *for the purposes of the NPV assessment*. No further information has been received regarding the magnitude of these initial costs proposed by submitters. Notwithstanding this, we have calculated the budget ceiling for various levels of demand management to manage risk where it is economic to do so.

To reduce the EUE risk in the interim, in the years up to and including 2019/20, we have determined the budget ceiling for various DM capacities. We have applied a Benefit-to-Cost Ratio (BCR > 1.0) criterion to calculate these budget ceiling values. That is, the value of EUE reductions (the DM benefit) must provide a net benefit (DM benefit – DM cost > 0). In other words, these DM capacities must be cheaper than these values to provide any additional net benefits to the 'do nothing' option.

We have calculated the budget ceiling for various levels of demand management in the table below.

Table 4-2 Summary of 'interim' network support requirements and available budget for each

MW	MWh	$m	$/MWh	$/kW
2018/19 Network support requirements and available budget				
10	1,310	$0.5	$390	$51
20	2,620	$1.0	$390	$51
40	5,240	$1.9	$355	$47
2019/20 Network support requirements and available budget				
20	4,760	$1.9	$405	$97
40	9,520	$3.6	$375	$89
60	14,280	$5.0	$349	$83

For project deferral, we similarly calculated the budget ceiling to defer the project by one to two years, but with a slightly different criterion. The difference is the value of EUE reductions (the DM benefit) must provide a net benefit to a level ('Do Nothing EUE' – (DM benefit – DM cost) <= ADV) that is competitive with the annualised cost of the network option (ADV or Annual Delay Value); otherwise it is not economically feasible to defer the network option any further. The BCR>1 criterion still applies for project deferral, with the ADV treated as a benefit of deferring by one year, and the residual EUE (less DM net benefits) as a cost. It is important to note that these levels of DM do not completely remove the risk of EUE, and the residual EUE must be taken into account.

The budget ceiling results for project deferral is shown in Table 4.3. Negative budgets mean the residual EUE is higher than the ADV – despite the use of those levels of DM – and the network option cannot be deferred any further with this level of DM.

Appendix I of the PADR provides additional analysis of using non-network technologies to defer network investment. Specifically, it compares the cost of using various increments of non-network technologies

(20MW, 40MW, 60MW, 80MW and 100MW) to defer network investment (Option 2A) and illustrates that, for all increments investigated, deferral beyond 2021/22 involves substantial costs. The table below summarises the network support required and the budget ceiling for each for deferral beyond 2020/21.

Table 4-3 Summary of 'deferral of Option 2A' network support requirements and available budget for each

MW	MWh	$m	$/MWh	$/kW
2020/21 Network support requirements and available budget				
20	5,380	$0.3	$63	$17
40	10,760	$2.6	$242	$65
60	16,140	$4.6	$282	$76
80	21,520	$6.2	$289	$78
2021/22 Network support requirements and available budget				
20	6,000	-$5.5	-	-
40	12,000	-$2.4	-	-
60	18,000	$0.3	$15	$5
80	24,000	$2.6	$108	$32
2022/23 Network support requirements and available budget				
60	19,680	-6.3	-	-
80	26,240	-3.1	-	-
100	32,800	-0.3	-	-

4.8 Installation of the two 330 kV cables in stages, as opposed to at once

Options 2A and 3B differ principally due to how the new 330 kV cables are installed – specifically, Option 2A assumes these cables are installed in stages, while Option 3B assumes they are installed at once.

Under the RIT-T framework, these two options were found to have essentially the same net market benefits (as outlined in section 5 below). Option 3B was selected as the preferred option at the draft/PADR stage due to the fact that it minimises the already significant impact to the community and environment (i.e. the inconvenience caused by traffic disruption, increased noise due to excavation works, etc), compared to any credible option that constructs these cables in two stages (e.g. Option 2A). Moreover, while the staged credible options (such as 2A) have a lower initial capital investment requirement than Option 3B, there is a relatively short interval between when the two stages are expected to be required under the central demand forecasts, and so results in only a minimal capital deferral benefit.

One submitter enquired as to whether there is any scope for the Stage 1 cost to be reconfigured, at a lower cost, by removing the allowance for providing the second cable at a later date.

The option of removing the provision for Stage 2 at the time of the installation of the first cable was considered by TransGrid and Ausgrid at the time of undertaking the PADR assessment and it was considered commercially infeasible. Without the provision in Stage 1 to install a Stage 2 cable a separate cable route needs to be identified in a highly developed inner metro area of Sydney, which will lead to a significant cost increase and community impact without providing a commensurate increase in market benefits.

In its Draft Decision, the AER considers there is real options value in the ability to stage the project given demand uncertainty, and the possibility that non-network options may become more prevalent over time.[38] In short, the AER states concern that insufficient consideration has been given to 'option value' and the benefit

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[38] AER, *Draft Decision: TransGrid Transmission Determination: Attachment 6 – Capital Expenditure*, September 2017, p. 105

of staging projects in order to enable a subsequent decision to defer or cancel later stages in the light of updated demand expectations, or to adopt future non-network alternatives (whose cost may have fallen).

TransGrid and Ausgrid note that options that involve staging have been considered in this RIT-T (ie, options 1, 2A, 2B, 4 and 8 all involve staging). Moreover, counter to the AER's description, for these options in scenarios in which demand turns out to be low, the assumed timing of the second stage *has* been deferred. Therefore these options have already captured 'option value' of being able to delay future elements of capex, if it turns out that future demand is lower than the current central scenario.[39]

TransGrid and Ausgrid have run a range of studies (as detailed in section 5 and Appendix I of the PADR) and do not consider, based on costs provided by proponents, that non-network solutions can be drawn upon to defer the network option beyond commissioning in 2022/23. This is driven largely by the fact that forecast expected unserved energy increases markedly from 2022/23, principally due to changes in the likely equipment failure rates, thus requiring higher levels of non-network solutions. Sensitivity analysis undertaken by TransGrid and Ausgrid, and presented in Appendix I to the PADR, confirms that no additional deferment is possible and the appropriate year to which the network option can be deferred is 2022/23 – that is, the net benefits delivered by the respective levels of non-network support are unable to reduce the net cost to below the deferral value threshold.

This should not take away from the fact that deferral of this magnitude by non-network solutions would be a huge achievement and, as far as TransGrid and Ausgrid are aware, one of the largest in Australia to-date.

4.9 The approach taken to weighting the reasonable scenarios investigated

One submission to the PADR questioned why an equal weighting has been applied to all three reasonable scenarios investigated.

The RIT-T requires that the market benefits of credible options for each scenario (relative to the base case) are weighted by the probability of each relevant reasonable scenario occurring. The AER states in its RIT-T guideline that, where a TNSP has no material evidence for assigning a higher probability for one reasonable scenario over another, a TNSP may weight all reasonable scenarios equally.[40] TransGrid and Ausgrid do not consider there is material evidence for assigning a higher probability for one reasonable scenario over another. Each of the three scenarios have therefore been assigned equal weights.

TransGrid and Ausgrid note that while the gross benefits vary in magnitude across the three scenarios investigated, the identification of the preferred option does not. In fact, all options are effectively ranked equally *within* a scenario. The conclusion from this is that the weightings assumed have no impact in determining the preferred option as part of this RIT-T.

4.10 Interaction between the project 'trigger year' and key underlying assumptions

One submitter expressed an interest to understand further how the Stage 1 project trigger timing is influenced under each of the sensitivity studies. Section 5.5.1 outlines the project trigger year for a range of sensitivity tests undertaken on the trigger year.

4.11 Effect of various contingency states assumed

One submitter stated it understands that a range of coincident, non-credible events up to N-5 has been included in the analysis. They requested to further understand the materiality of the assumption to include these cases and, in particular, if the analysis was constrained to the modified N-2 standard only, whether this would influence the outcomes.

TransGrid and Ausgrid did calculate expected unserved energy using a range of contingency states but note that only up to N-4 was considered in the RIT-T assessment.[41] In total, approximately 1600 contingency

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39 This approach to capturing 'option value' is consistent with AER guidance. See: AER, *Regulatory investment test for transmission application guidelines*,18 September 2017, pp. 35-38.

40 AER, *Final Regulatory investment test for transmission application guidelines*, June 2010, p. 33.

41 In the earlier PSCR analysis up to N-5 was reported but this was revised down to N-4 in the PADR.

states were calculated, which were selected on the basis of network impact and likelihood of occurring and included contingencies up to N-4. For N-3 and N-4 contingencies, only contingencies with either high probability or high network impact were considered, such as one or two 330kV cables plus one or two aged oil-filled 132kV cables.

Examples of contingency events assumed include:

- Cable 42 failing at a time when Cable 41 is unavailable due to repairs or vice versa; and
- Cable 41 and/or Cable 42 failing when portions of the 132 kV network are out of service for maintenance.

While instances of coincident failures are considered rare in transmission networks generally, the age and condition of the oil-filled cables that make up the majority of the Inner Sydney transmission network means that these cables fail more frequently than cables employing modern cable technology and take longer to repair. As a consequence, these cables are often out of service for both planned maintenance and due to unplanned events, which is expected to worsen as these cables age further. This means that at any time the likelihood of one or more elements already being out of service increases, with the result that multiple contingency events can eventuate.

The table below shows the expected unserved energy (EUE) distribution of the states covered in the analysis up to N-4 for the 'do nothing' base case.

Table 4-4 EUE under various contingency states

	EUE Up to N-2		EUE Up to N-3		EUE Up to N-4	
Year	Total (MWh)	Total ($M)	Total (MWh)	Total ($M)	Total (MWh)	Total ($M)
2017/2018	1.46	0.13	10.02	0.90	14.56	1.31
2018/2019	12.88	1.16	41.15	3.71	53.18	4.81
2019/2020	36.74	3.31	94.11	8.52	117.59	10.71
2020/2021	53.44	4.81	134.25	12.19	169.16	15.47
2021/2022	75.62	6.81	188.30	17.15	239.81	22.04
2022/2023	108.51	9.77	268.11	24.54	345.18	31.96
2023/2024	150.10	13.54	372.09	34.27	485.97	45.36
2024/2025	196.38	17.76	493.93	45.77	657.28	61.83
2025/2026	263.99	23.97	670.93	62.70	909.31	86.43
2026/2027	353.76	32.30	909.99	85.99	1257.00	120.98

TransGrid and Ausgrid consider that if the analysis is constrained to modified N-2 only, the result will underestimate the real risk to consumers in Inner Sydney. The aging state of the oil-filled cables in the network and anticipated load growth render the consequence of excluding N-3 and N-4 significant (even though they have a low probability of occurring).

TransGrid and Ausgrid estimate that the need year of the project and the non-network solution will be deferred about two to three years if the analysis is constrained to modified N-2, but the risk of load shedding will be very high during the period.

The submitter was also interested in understanding the unserved energy distribution across the variety of contingency states investigated.

The table below shows the distribution of the EUE in each contingency category. Within the 1600 contingency states up to N-4, the major contributions to the unserved energy are contingencies involving the 330kV cable 42 or 41.

Table 4-5 Distribution of the USE in each contingency category (MWh)

	N-2		N-3		N-4	
Year	42+41 (1 State)	42+One 132kV (20 States)	41+42+ One 132kV (20 States)	42+two 132kV (190 States)	41+42+two 132kV (190 States)	42+Three aged 132KV (35 States)
2017/2018	0.02	1.44	0.82	7.74	0.77	3.77
2018/2019	0.30	12.58	2.61	25.66	2.08	9.94
2019/2020	1.07	35.66	5.65	51.73	4.23	19.24
2020/2021	1.65	51.79	8.23	72.58	6.38	28.53
2021/2022	2.43	73.19	11.84	100.84	9.56	41.95
2022/2023	3.62	104.89	17.26	142.35	14.55	62.51
2023/2024	5.17	144.93	24.56	197.42	21.85	92.03
2024/2025	6.94	189.44	33.53	264.02	31.69	131.66
2025/2026	9.57	254.42	46.69	360.24	46.72	191.66
2026/2027	13.18	340.54	64.84	491.38	68.49	278.52

4.12 'Double-counting' adjustment for non-network solutions

TransGrid and Ausgrid have applied a 20 per cent adjustment for all non-network solutions to adjust for the potential of double counting of capacity.[42] One submission queried the basis for this adjustment, noting that it may be unsuitable and preliminary given when it comes time to procure the services, the risk of double counting will not be possible.

Due to the large volume of non-network support required for the deferral of the network investment, it is expected that contracts with multiple non-network providers will be required. As many submissions are based substantially upon projections of customer take-up, the total capacity offered has been adjusted to account for the potential double-counting.

TransGrid and Ausgrid note that is highly probable that submitters will have carried in their estimates the same customer capability either in diesel generators, demand response or willingness to invest in solar power. In fact, in discussing with proponents of non-network solutions, it became clear that multiple proponents were discussing with the same large end-user customer in at least one instance.

For this reason, an estimate of 20 per cent double counting was carried as part of the assessment of non-network options. Tenders for non-network solutions will explore higher volumes to determine whether firm quotes indicate that a greater volume of demand management to manage load at risk or defer network investment is warranted. TransGrid and Ausgrid note that no counter assumptions regarding the extent of 'double counting' were provided by submitters.

TransGrid is currently in the process of preparing a formal two-stage RFT for non-network proponents to respond to provide non-network solutions. The two-stage process allows TransGrid to flexibly procure more demand management should demand forecasts or cable conditions change, and to procure more efficient lower cost solutions should the demand management market further develop with more non-network providers. In addition, the second stage will allow non-network proponents to learn from the first stage, and to refine their solutions to assist with deferral. These RFT processes will seek to remove any 'overlap' in non-network solutions.

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42 As outlined in section 5.5 of the PADR.

4.13 Inclusion of grid-scale energy storage

As part of the PADR assessment, a large-scale grid-scale battery at Beaconsfield using internally-sourced costs estimates was considered as one element of the demand management solution. This approach was taken as TransGrid consider that, while such a battery would be very effective in providing network support, having seen responses to the EOI from non-network proponents, such a service could be provided in a more cost-effective manner than that proposed in those responses.

One submission to the PADR requested further information on how grid-connected storage compares to customer owned storage, where they will be able to leverage the different value streams.

The feasibility of a battery up to 40 MWh for demand response for summer 2021/22 was included as part of the network support package for deferring the preferred network option by one year, if it proves to be technically and economically viable. TransGrid considers that a large-scale energy storage device is likely to also readily support multiple value streams, including fast frequency response.

The benefits of a large-scale energy storage device include the ability to better understand the performance of a battery for providing system security services and validate its technical configuration in network planning models.

TransGrid notes that this battery could be provided by either a third party, or as a network asset with additional value streams ring-fenced where appropriate. These two procurement options are treated equally in the analysis. Where a battery can recoup revenue from providing services outside of providing traditional network support, we would expect that traditional network support might be able to be provided at lower cost than a battery that cannot leverage this alternate value stream (all else being equal between the two batteries).

As outlined in section 3.2 above, TransGrid is looking to procure non-network solutions through a formal RFT process. The outcome of this may be that a battery is part of the mix of non-network support procured, if it is found to be cost effective relative to other bids received.

5. Net present value results

This section summarises the results of the NPV analysis, including the sensitivity analysis undertaken. The figures presented, and underlying assessment, have been updated since the PADR on account of revising the VCR estimates applied to Sydney CBD load, as outlined in section 4 above.

Appendix H to the PADR sets out the NPV results for each of the credible options, under each of the three scenarios. The NPV analysis shows separately the costs for each option, and the classes of material market benefit.

5.1 Different scenarios investigated

The RIT-T analysis is required to incorporate a number of different reasonable scenarios, which are used to estimate market benefits.

TransGrid and Ausgrid have adopted the following three scenarios for the PACR assessment.

Table 5-1 Reasonable scenarios assumed

Key variable/parameter	Scenario 1 – Low	Scenario 2 – Central	Scenario 3 – High
VCR	AEMO VCR Value	The VCR used by IPART in its recent review of the NSW transmission reliability standards ($90/kWh)	$170/kWh for the Sydney CBD and $90/kWh for Inner Sydney (ie, the 'central' assumptions in the PADR)
Demand	Low	Medium	High
Discount rate	8.78%	6.13%	3.48%

These three scenarios capture differences in key drivers of these benefits – namely the VCR, future demand and the underlying discount rate.

These scenarios are the same as those used in the PADR assessment, with the exception of the VCR. TransGrid and Ausgrid have updated all the economic assessment in this PACR so that it assumes the $90/kWh figure for all affected customers under the 'central' set of assumptions, ie, both Inner Suburbs and CBD customers. The original assumption of $170/kWh VCR value for the CBD has been included only in the 'high VCR' scenario.

5.2 Gross benefits

The table below summarises the gross benefit, in NPV terms, for each of the ten credible options, relative to the base case. The gross market benefit is the sum of:

- the estimated 'market benefit' associated with changes in involuntary load shedding through reduced unserved energy;
- the 'market benefit' associated with changes in network losses;
- the estimated benefit from avoided cable operating and maintenance costs; and
- the benefit from the avoided cost of complying with environmental obligations.

The gross benefit of each option has been calculated for each of the three reasonable scenarios. Table 5.1 shows significant gross benefits across all options. Even under the low scenario, because of the increased unavailability of the aged cables, benefit still can be realised through the network investment.

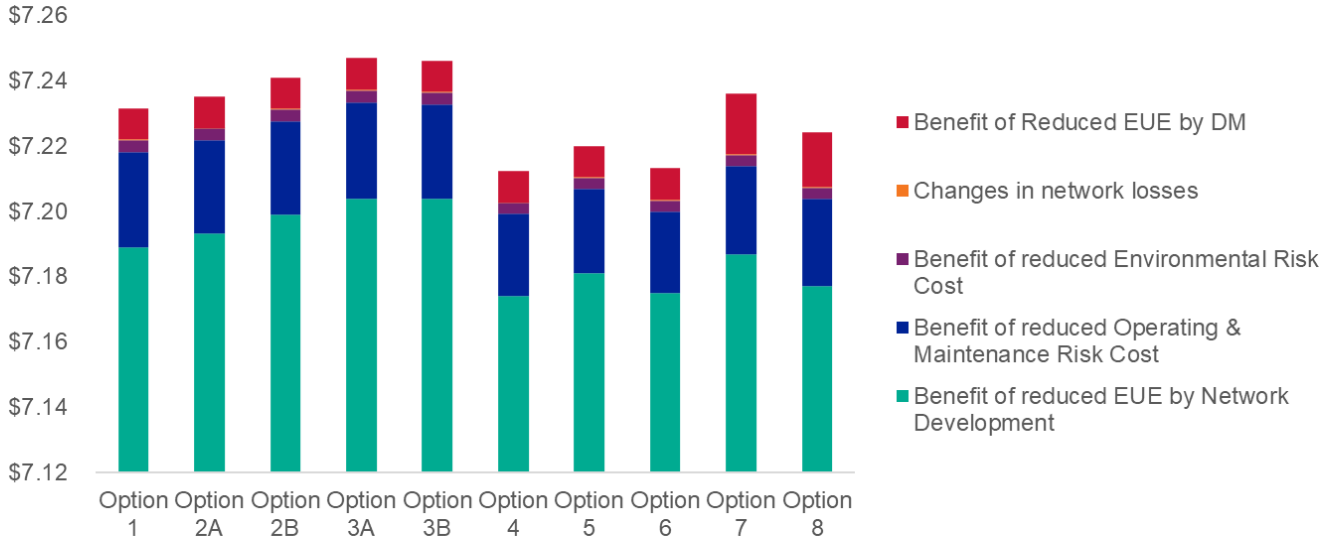
Table 5-2 Gross benefit for each credible option (NPV $m, $2017/18)

Option	Description	Scenario 1 – Low	Scenario 2 – Central	Scenario 3 – High	Weighted benefit
1	Install two 330 kV cables in stages, retire Cable 41 and decommission Ausgrid cables in two stages	$138	$7,232	$75,205	$27,525
2A	Operate Cable 41 at 132 kV, install two 330 kV cables in stages and decommission Ausgrid cables in two stages	$139	$7,235	$75,203	$27,526
2B	Operate Cable 41 at 330 kV with rating of 426MVA, install two 330 kV cables in stages and decommission Ausgrid cables in one stage	$144	$7,241	$75,209	$27,531
3A	Install two 330 kV cables at once, retire Cable 41 and decommission Ausgrid cables in one stage	$152	$7,247	$75,208	$27,536
3B	Install two 330 kV cables at once, operate Cable 41 at 330 kV with rating of 426 MVA and decommission Ausgrid cables in one stage	$152	$7,246	$75,209	$27,536
4	Remediate Cable 41, install two 330 kV cables in stages and decommission Ausgrid cables in one stage	$119	$7,212	$75,200	$27,511
5	Remediate Cable 41, install two 330 kV cables at once (initially operating at 132 kV) and decommission Ausgrid cables in two stages	$124	$7,220	$75,200	$27,515
6	Remediate Cable 41, install two 330 kV cables at once and decommission Ausgrid cables in one stage	$121	$7,213	$75,202	$27,512
7	Non-network support initially and then a deferred installation of two 330 kV cables at once and operating Cable 41 at 330kV	$150	$7,236	$75,170	$27,519
8	Non-network support initially and then a deferred installation of two 330 kV cables in stages, decommissioning of Ausgrid cables in two stages and operating Cable 41 at 132 kV	$137	$7,224	$75,166	$27,509

Figure 5.1 illustrates the four benefits estimated for each option. The major contribution to the gross benefit is the benefit of reduced expected unserved energy following a network development.[43] Outside of avoided unserved energy, all categories of market benefit estimated are similar across the options, except for ‘expected unserved energy’ due to DM for Option 7 and Option 8 since they assume additional non-network technologies.

[43] The y-axis of this figure has been amended to start from $7,120 million in order to illustrate the relativities between all market benefits estimated.

Figure 5-1 Breakdown of benefits estimated by option – Central Scenario (NPV $m, $2017/18)



5.3 Direct option costs

Table 5.2 summarises the direct cost of each option, in NPV terms, for each of the ten credible options, relative to the 'do nothing' base case. The direct costs of each option are comprised of the network capital investment costs, non-network costs and cable decommissioning costs.

The cost figures below are the present value of the various option components outlined in Appendix B.

Table 5-3 Direct cost of each credible option (NPV $m, $2017/18)

Option	Description	Scenario 1 – Low[44]	Scenario 2 – Central	Scenario 3 – High
1	Install two 330 kV cables in stages, retire Cable 41 and decommission Ausgrid cables in two stages	$189	$224	$225
2A	Operate Cable 41 at 132 kV, install two 330 kV cables in stages and decommission Ausgrid cables in two stages	$192	$221	$223
2B	Operate Cable 41 at 330 kV with rating of 426MVA, install two 330 kV cables in stages and decommission Ausgrid cables in one stage	$235	$250	$233
3A	Install two 330 kV cables at once, retire Cable 41 and decommission Ausgrid cables in one stage	$256	$246	$221
3B	Install two 330 kV cables at once, operate Cable 41 at 330 kV with rating of 426 MVA and decommission Ausgrid cables in one stage	$257	$247	$220
4	Remediate Cable 41, install two 330 kV cables in stages and decommission Ausgrid cables in one stage	$170	$263	$323
5	Remediate Cable 41, install two 330 kV cables at once (initially operating at 132 kV) and decommission Ausgrid cables in two stages	$175	$273	$323
6	Remediate Cable 41, install two 330 kV cables at once and decommission Ausgrid cables in one stage	$167	$257	$318
7	Non-network support initially and then a deferred installation of two 330 kV cables at once and operating Cable 41 at 330kV	$238	$234	$213
8	Non-network support initially and then a deferred installation of two 330 kV cables in stages, decommissioning of Ausgrid cables in two stages and operating Cable 41 at 132 kV	$179	$212	$218

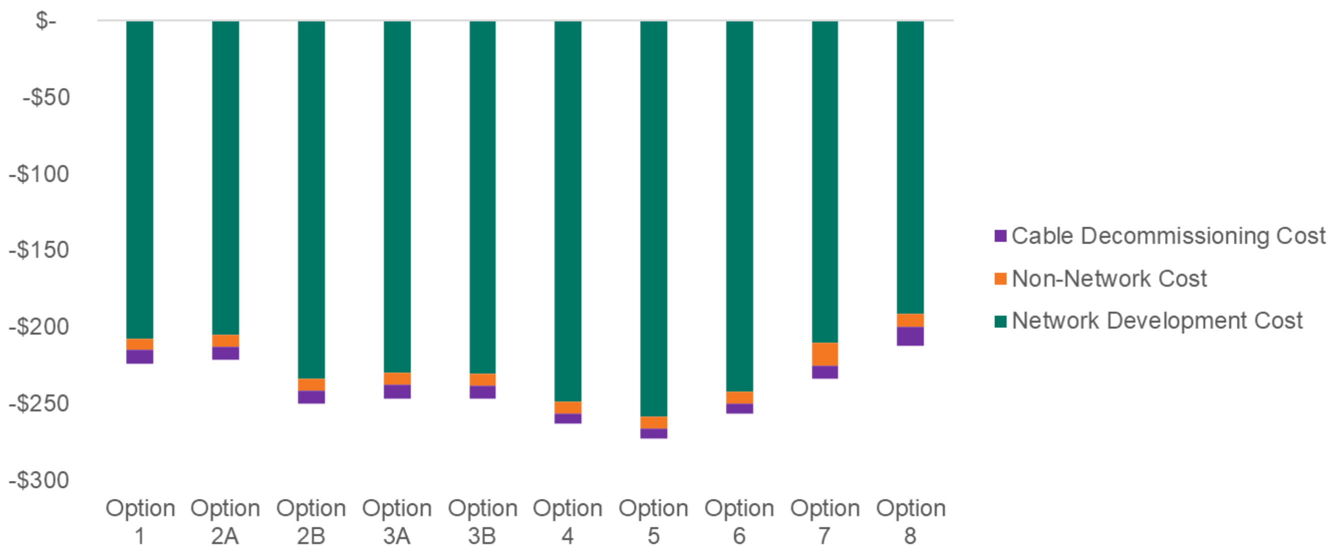
Options 4, 5 and 6 have higher direct costs (in NPV terms) than other options under the central and high scenarios because of the capital costs for cable 41 remediation works.

Options with the ability to phase stages (eg, options 1, 2A, 2B, 4, 5, 6 and 8)[45] have lower direct costs under the low scenario due to the ability to defer the timing of later stages of the investment, and the consequently higher terminal value.

[44] In the low scenario, cable 41 remediation is not required. Options 4 and 6 are equivalent to options 2B and 3B respectively.

[45] While Options 5 and 6 do not involve installing new 330 kV cables in stage, they do remediate Cable 41, which enables flexibility in terms of when the 330 kV cables are installed under the low scenario.

Figure 5-2 Breakdown of costs estimated by option - Central Scenario



5.4 Net market benefits

Table 5.3 summarises the net market benefit in NPV terms for each credible option under each scenario. The net market benefit is the gross market benefit (as set out in Table 5.1) minus the costs of each option (as outlined in 5.2), all in present value terms.

The table also shows the corresponding ranking of each option (in brackets), for each scenario, with the options ranked in order of descending net market benefit.

Net benefits are greatest in the central and high scenarios, where options are estimated to deliver between $7 billion and $75 billion of net benefits, in PV terms, respectively. Overall, expected net benefits (ie, on a weighted-basis across all three scenario) are estimated to be positive and in the order of $27 billion for all options.

A key difference between the PACR and the PACR is that, under the low scenario, net benefits for all options are found to be marginally negative. This has come about on account of TransGrid further refining the 'optionality/flexibility' of options with stages in response to submissions and the AER's Draft Decision (ie, how the options with stages can be phased in a low demand world), as well as the lower assumed VCR value for Sydney CBD between the PADR and PACR. In addition, for clarity, the 'low scenario' has been constructed from a particularly adverse set of assumptions, which have all been selected to lower estimated market benefits, including low demand forecasts, the AEMO VCR value and a high discount rate.[46]

While comparison against a 'do-nothing' base case is currently a requirement of the RIT-T, it is unrealistic to assume escalating unserved energy of the magnitudes estimate going forward. To therefore compare the options more clearly, all options are also compared with the preferred *network* option (ie, Option 2A). This allows for a clearer comparison of the market benefits *between* options.

We have also presented the percentage difference between each option's estimated net market benefits and those estimated for the preferred *network* option in the final column of the table below. While the net benefits differ across options, we note that this difference is immaterial (eg, at most 0.20 per cent of the estimated net benefits for Option 2A) and consider that all options are effectively ranked equally.

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[46] As outlined throughout this report, TransGrid and Ausgrid consider that the low demand forecast is unrealistically low and that applying an AEMO VCR is inappropriate for the types of wide-spread and prolonged outages being considered for the PSF project (AEMO shares this view) and is inconsistent with the basis on which IPART has recently determined the transmission reliability standard for the Inner Sydney area. Further, as outlined in Appendix D, TransGrid and Ausgrid engaged independent cost of capital experts to estimate a contemporary 'commercial' discount rate, consistent with the RIT-T framework, which resulted in an estimate of 6.13 per cent (real, pre-tax) that is significantly below the high sensitivity assumed in the 'low scenario'.

Table 5-4 Net market benefit for each credible option (NPV $m, $2017/18)

Option		Scenario 1 – Low		Scenario 2 – Central		Scenario 3 – High		Weighted Average		
		Net Benefit	Ranking	Net Benefit	Ranking	Net Benefit	Ranking	Net Benefit	Ranking	Deviation from Option 2A
1	Install two 330 kV cables in stages, retire Cable 41 and decommission Ausgrid cables in two stages	-$51	=1	$7,008	=1	$74,980	=1	$27,312	=1	-$1 (0.00%)
2A	Operate Cable 41 at 132 kV, install two 330 kV cables in stages and decommission Ausgrid cables in two stages	-$54	=1	$7,014	=1	$74,980	=1	$27,313	=1	$0 (0.00%)
2B	Operate Cable 41 at 330 kV with rating of 426MVA, install two 330 kV cables in stages and decommission Ausgrid cables in one stage	-$90	=7	$6,991	=1	$74,976	=1	$27,292	=1	-$21 (0.08%)
3A	Install two 330 kV cables at once, retire Cable 41 and decommission Ausgrid cables in one stage	-$104	=7	$7,000	=1	$74,988	=1	$27,295	=1	-$19 (0.07%)
3B	Install two 330 kV cables at once, operate Cable 41 at 330 kV with rating of 426 MVA and decommission Ausgrid cables in one stage	-$105	=7	$6,999	=1	$74,988	=1	$27,294	=1	-$19 (0.07%)
4	Remediate Cable 41, install two 330 kV cables in stages and decommission Ausgrid cables in one stage	-$50	=1	$6,949	=1	$74,877	=1	$27,259	=1	-$55 (0.20%)
5	Remediate Cable 41, install two 330 kV cables at once (initially operating at 132 kV) and decommission Ausgrid cables in two stages	-$51	=1	$6,947	=1	$74,877	=1	$27,258	=1	-$56 (0.20%)
6	Remediate Cable 41, install two 330 kV cables at once and decommission Ausgrid cables in one stage	-$46	=1	$6,957	=1	$74,884	=1	$27,265	=1	-$48 (0.18%)
7	Non-network support initially and then a deferred installation of two 330 kV cables at once and operating Cable 41 at 330kV	-$88	=7	$7,003	=1	$74,957	=1	$27,290	=1	-$23 (0.08%)
8	Non-network support initially and then a deferred installation of two 330 kV cables in stages, decommissioning of Ausgrid cables in two stages and operating Cable 41 at 132 kV	-$42	=1	$7,012	=1	$74,948	=1	$27,306	=1	-$7 (0.03%)

5.5 Sensitivity analysis

TransGrid and Ausgrid have undertaken a significant sensitivity testing exercise to understand the robustness of the RIT-T assessment to assumptions about key variables.

In particular, we have undertaken two tranches of the sensitivity testing – namely:

- Stage 1 – testing the sensitivity of the optimal timing of the project ('trigger year') to different assumptions in relation to key variables; and
- Stage 2 – once a trigger year has been determined, testing the sensitivity of the total NPV benefit associated with the investment proceeding in that year, in the event that actual circumstances turn out to be different.

That is, TransGrid and Ausgrid have undertaken sensitivity analysis to first determine the optimal timing of the project, to conclude that a particular year represents the 'most likely' date at which the project will be needed.

Having assumed to have committed to the first stage of the project by this date, TransGrid and Ausgrid have also looked at the consequences of 'getting it wrong' under Stage 2 of the sensitivity testing. That is, if demand turns out to be lower than expected, for example, what would be the impact on the net market benefit associated with the first stage of the project continuing to go ahead on that date. For options which have two stages, this includes a deferral of the second stage of the project. This recognises the limited time available to commit to the first stage of the PSF project based on TransGrid's view of the most likely trigger year, given the lead times involved for both the non-network and network elements.

We outline how each of these two stages have been applied to test the sensitivity of the key findings to alternate assumptions.

5.5.1 Stage 1 – Sensitivity testing of the assumed optimal timing for each option

TransGrid and Ausgrid have estimated the optimal timing for each option based on the year in which the annualised cost of the project falls below the assumed benefit (calculated on the basis of the expected USE in that year multiplied by the assumed VCR).

This process was undertaken for both the central set of assumptions but also a range of alternate assumptions for key variables.

We note that, as part of the separate regulatory review process, the AER, in its Draft Decision for TransGrid also raised these sensitivities. In particular, the AER did not consider that the scope and optimal timing of the project had been sufficiently established. The AER stated concern that the optimal timing of the project may differ from that estimated by TransGrid and Ausgrid, due to differences in the underlying assumptions.

This section outlines the sensitivity on the identification of the trigger year to changes in the underlying assumptions. It has been prepared in response to a request from one submitter to the PADR who wished to understand further how the project trigger timing is influenced under each of the sensitivity studies.

In particular, the timing of the options is found to be largely invariant to assumptions of:[47]

- 25 per cent higher or lower capital costs for network investment;
- an assumed 20 year life for Cable 41 (as opposed to 10 years);[48]
- adopting a higher VCR value of $170/kWh for customers in the Sydney CBD (consistent with the HoustonKemp report);
- a higher assumed discount rate (8.78 per cent); and

[47] Trigger years under different variable assumptions broadly hold for all options. Some sensitivity exists for some options for high capital costs, high discount rate, low VCR and low demand. However, trigger years for all sensitivities, except for low demand, falls in the next regulatory control period, as shown in **Error! Reference source not found.** below.

[48] A major assumption in this PACR is that Cable 41 has a remaining service life of 10 years. However, TransGrid notes that there is a possibility that the service life of Cable 41 may extend to beyond 10 years provided that additional periodic maintenance works are carried out and the temperature of the hottest spots along the cable route are carefully monitored to avoid any over-temperature events. We have therefore also undertaken sensitivity analysis based on a service life of 20 years for Cable 41.

- shifting 60 per cent of the assumed corrective failure maintenance to shoulder periods.[49,50]

The optimal timing of the project is brought forward under the assumption of a lower discount rate (3.48 per cent) and high load growth.

The figure on the next page outlines the impact on the optimal trigger year for each option, under a range of alternate assumptions. It shows that for the vast majority of sensitivities, the optimal timing of each option is in, or before, 2021/22.

Although the evaluation shows some stages are needed as early as 2018/19, due to the complexity and scope of the project, the earliest practical completion year is 2021/22.[51] It is therefore expected that non-network options will be used to manage the risk of unserved energy, where it is economic to do so, until a network option can be commissioned. All economic cost-benefit analysis presented in this report is based on the practical Stage 1 completion year of 2021/22 at the earliest (with the exception of Option 7 and Option 8, which assume a one year deferral of the costs of Option 3B and Option 2A, respectively, and apply a commissioning year of 2022/23).[52]

The optimal timing of the options is found to be most strongly deferred under the following assumptions in conjunction:[53]

- low load growth; and
- a low VCR (ie, adopting AEMO's VCR values).

As outlined in section 4.2 above, TransGrid and Ausgrid consider that the central Ausgrid demand forecasts are appropriate and reflect renewed economic activity in Inner Sydney, including of a number of significant infrastructure and redevelopment projects that are already effectively committed.[54] In addition, TransGrid and Ausgrid notes that assuming the standard AEMO VCR for the types of wide-spread and prolonged outages being considered for the PSF project is widely seen as inappropriate (including by AEMO), as discussed in section D.1 below and the PADR.[55] A low VCR is also inconsistent with the basis on which IPART has recently determined the transmission reliability standard for the Inner Sydney area.

On balance, TransGrid and Ausgrid consider that the identification of the central trigger years for all options has been robustly determined and tested.

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49 As outlined in section 4.3, TransGrid and Ausgrid have investigated a lower assumed corrective failure rate in response to a query by the AER in its Draft Decision for TransGrid. The results of this investigation show that a shift of 60 per cent of corrective failures from summer to shoulder periods (shoulder period failure rate increase by 25 per cent) does not change 2021/22 as the practical need year for Options 1 to 6 and 2022/23 for Option 7 and Option 8. Corrective failure rate sensitivity has been included in **Error! Reference source not found.**.

50 Sensitivity analysis has also been undertaken to test the robustness of shifting more (or less) of corrective failure maintenance from summer to shoulder periods. The sensitivities undertaken were moving 70 per cent of corrective failure maintenance to shoulder periods and moving 50 per cent. Both sensitivities found minimal effect on the optimum investment timing, with no change for most options and only up to one year's difference for options 2B, 3A and 3B.

51 As outlined in section 3.3 of the PADR.

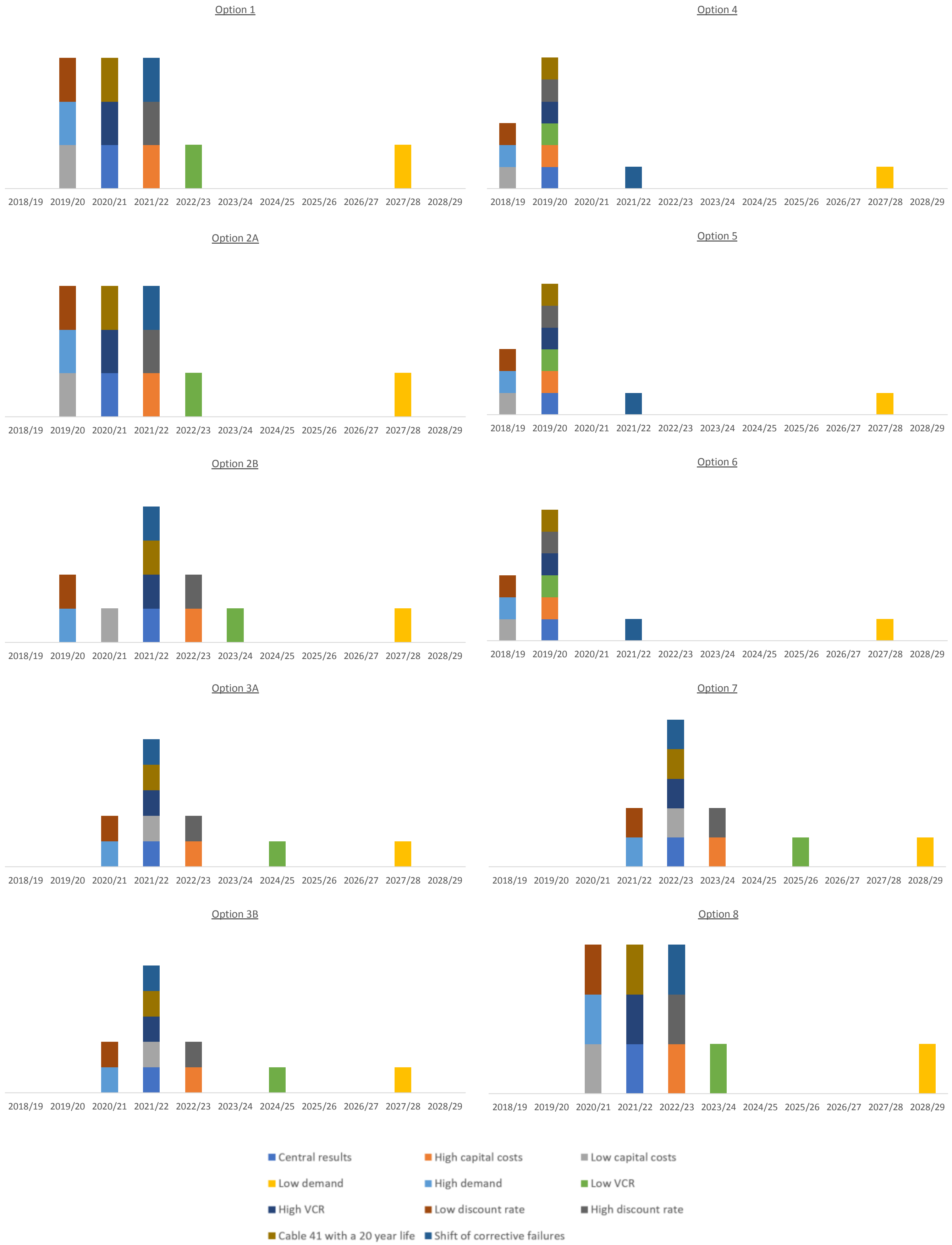
52 TransGrid and Ausgrid have run a range of studies (as detailed in section 5 and Appendix I of the PADR) and do not consider that non-network solutions can be drawn upon to defer the network option more than one year

53 We note that for Options 3A, 3B and 7, the optimal timing is also found to be deferred by one year under the assumption of high capital costs and a high discount rate.

54 All of these New South Wales government initiatives have now 'broken ground' and are now well underway.

55 As outlined in D.1, TransGrid and Ausgrid have now applied one VCR estimate to all assumed load (as opposed to two as used in the PADR), to align with the approach adopted by IPART in recently reviewing the transmission reliability standards. The timing of the project is robust to adopting a $90/kWh VCR value.

Figure 5-3 Distribution of project need years under each sensitivity investigated



5.5.2 Stage 2 – Sensitivity testing of the overall net market benefit

TransGrid and Ausgrid have also conducted sensitivity analysis on the overall NPV of the net market benefit, based on the assumed option timing.

Specifically, TransGrid and Ausgrid have investigated the following sensitivities on key assumptions:

- a 25 per cent increase/decrease in the assumed network costs;
- alternate forecasts of maximum demand growth, based on POE10 (high) and POE90 (Low);
- a lower VCR and higher VCR value;
- a lower discount rate of 3.48% as well as a higher rate of 8.78%; and
- a longer service life for Cable 41.

All these sensitivities investigate the consequences of 'getting it wrong' having committed to a certain investment decision, which is consistent with how the RIT-T is designed to operate.

The table on the next page presents the results of these sensitivity tests. The analysis reaffirms the finding that all options are expected to have extremely high gross benefits, due to the significant unserved energy reduction when compared to the do-nothing option for the next twenty years, and that they are all effectively ranked equal first under the RIT-T. For example, even assuming low load growth going forward, which effectively assumes that major NSW government infrastructure developments in Sydney that have already commenced are abandoned, it is expected that all options will generate approximately $200-250 million in net market benefits.[56]

[56] Please note that these estimates relate to the low demand sensitivity (shown in Table 5-4 below) and not the 'low scenario' – for clarity, the 'low scenario' has been constructed from a particularly adverse set of assumptions, which have all been selected to lower estimated market benefits, such as the low demand forecasts but also using the AEMO VCR value and a high discount rate.

Table 5-5 Net market benefits (with rankings shown in brackets) under various sensitivity test (NPV $m, 2017/18)

Option	Central set of results	25 % higher capital costs	25 % Lower capital costs	Low demand (POE90L)	High demand (POE10H)	Low VCR (AEMO VCR)	High VCR (+20%)	Low discount rate (3.48%)	High discount rate of (8.78%)	Cable 41 with a 20 year life
1	$7,008 [=1]	$6,956 [=1]	$7,060 [=1]	$241 [=1]	$43,018 [=1]	$3,064 [=1]	$7,938 [=1]	$10,596 [=1]	$4,690 [=1]	$7,008 [=1]
2A	$7,014 [=1]	$6,962 [=1]	$7,065 [=1]	$241 [=1]	$43,020 [=1]	$3,065 [=1]	$7,945 [=1]	$10,601 [=1]	$4,695 [=1]	$7,014 [=1]
2B	$6,991 [=1]	$6,934 [=1]	$7,049 [=1]	$215 [=1]	$43,012 [=1]	$3,041 [=1]	$7,924 [=1]	$10,587 [=1]	$4,667 [=1]	$6,991 [=1]
3A	$7,000 [=1]	$6,943 [=1]	$7,058 [=1]	$211 [=1]	$43,025 [=1]	$3,044 [=1]	$7,934 [=1]	$10,597 [=1]	$4,675 [=1]	$7,000 [=1]
3B	$6,999 [=1]	$6,942 [=1]	$7,057 [=1]	$210 [=1]	$43,025 [=1]	$3,043 [=1]	$7,933 [=1]	$10,596 [=1]	$4,673 [=1]	$6,999 [=1]
4	$6,949 [=1]	$6,887 [=1]	$7,011 [=1]	$200 [=1]	$42,930 [=1]	$3,024 [=1]	$7,876 [=1]	$10,508 [=1]	$4,657 [=1]	$6,949 [=1]
5	$6,947 [=1]	$6,890 [=1]	$7,008 [=1]	$204 [=1]	$42,930 [=1]	$3,019 [=1]	$7,879 [=1]	$10,504 [=1]	$4,655 [=1]	$6,947 [=1]
6	$6,957 [=1]	$6,902 [=1]	$7,015 [=1]	$208 [=1]	$42,943 [=1]	$3,032 [=1]	$7,887 [=1]	$10,512 [=1]	$4,666 [=1]	$6,957 [=1]
7	$7,003 [=1]	$6,950 [=1]	$7,055 [=1]	$221 [=1]	$43,005 [=1]	$3,051 [=1]	$7,936 [=1]	$10,592 [=1]	$4,683 [=1]	$7,003 [=1]
8	$7,012 [=1]	$6,964 [=1]	$7,060 [=1]	$248 [=1]	$42,997 [=1]	$3,068 [=1]	$7,944 [=1]	$10,594 [1]	$4,698 [1]	$7,012 [=1]

6. Preferred option and next steps

The RIT-T assessment shows that all credible options can be expected to deliver significant net market benefits, when compared to the do nothing base case option. This is due primarily to the fact that all credible options have been designed to manage the risk of substantial unserved energy to the inner part of Australia's largest city.

Net benefits are greatest in the central and high scenarios, where options are estimated to deliver between $7 billion and $75 billion of net benefits, in PV terms, respectively. Under the low scenario, net benefits for all options are found to be marginally negative.[57] Overall, expected net benefits (ie, on a weighted-basis across all three scenarios) are estimated to be in the order of $27 billion for all options.

TransGrid and Ausgrid consider Option 8 is the preferred option, which involves:

- the use of non-network solutions before network commissioning;
- use of non-network solutions to defer network build by one year from when it would need to be commissioned without this support (ie, from 2021/22);
- installing two 330 kV cables in two stages, with commissioning of the first cable in time for the 2022/23 summer;
- operating Cable 41 at 132 kV; and
- decommissioning Ausgrid's cables in two stages.

TransGrid and Ausgrid note that this conclusion is broadly consistent with that presented in the PADR (ie, in terms of being able to use non-network solutions to defer network expenditure by a year) but differs in terms of the preferred ultimate network component. In particular, the PADR recommended installing the two new 330 kV cables *in one stage* on account of minimising the inconvenience and disruption on the community and environment,[58] while this PACR recommends these cables are installed in two stages.

TransGrid and Ausgrid note that there is a balance between minimising wider community disruption[59] and having a lower initial capital cost as well as the 'optionality'/flexibility that comes with installing the two cables in two stages.

In addition, subsequent to the issue of the PADR, the AER and the CCP expressed concern, through the separate regulatory review process relating to TransGrid, relating to a lack of flexibility with the preferred option at that stage. We therefore reviewed the options to consider the appropriate balance between retaining optionality, decreasing the initial capital cost and minimising community disruption and, consequently,

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57 For clarity, the 'low scenario' has been constructed from a particularly adverse set of assumptions, which have all been selected to lower estimated market benefits, such as using the AEMO VCR value, low demand forecasts and a high discount rate.

58 In particular, the proposed cable route for all network options will pass through the highly developed Inner Sydney area and it is expected that the project construction works will have a significant impact to the community and environment, including the inconvenience caused by traffic disruption, increased noise due to excavation works, etc. Installing the two 330 kV cables in one go minimises these impacts, compared to other network options that construct these two cables in two stages.

59 While TransGrid and Ausgrid note that the benefit to the wider community from avoiding this disruption and cost cannot be included in the RIT-T economic assessment, an indication of the number of parties that are likely to be affected by digging up the proposed cable route helps to illustrate the inconvenience and wider community costs from installing the two 330 kV cables in two stages (eg, under Option 2A). A current New South Wales government traffic counter that corresponds to one section of the proposed cable route records that approximately 27,000 vehicles of which 1,600 relate to 'heavy vehicles' (ie, trucks), pass that section on average each day – this implies that approximately 820,000 vehicles will be affected through traffic disruption and congestion for every month that particular section of road is under construction (sourced from the New South Wales government Roads and Maritime Services Georges River Road traffic station, which corresponds to one section of the proposed route –see Station ID 7275 at http://www.rms.nsw.gov.au/about/corporate-publications/statistics/traffic-volumes/aadt-map/index.html#/?z=13&lat=-33.90921191659774&lon=151.0794010162358&id=7275&tb=1&hv=1). We note that this is a very narrow estimate of the wider effects. eg, it only focuses on one particular section of the proposed route (ie, where there is a NSW government traffic counter currently located) and excludes additional inconvenience caused through noise due to excavation works and pollution. It has been included to help demonstrate the magnitude of this wider disruption on the community from installing the cables in two stages.

developed Option 8. We also sought the views of customers and stakeholders in our TransGrid Advisory Council, who also expressed support for a two-stage option.

Under Option 8, the installation of the second 330 kV cable could be delayed if demand growth is slower than forecast and/or a higher quantity of lower cost non-network options emerges as part of the formal RFT process TransGrid will shortly commence (outlined below). The opposite could also occur and this option would allow TransGrid to respond with a second cable earlier than planned should that become necessary.

Overall, the strength and quality of submissions and interest from non-network proponents to this RIT-T has driven this exciting result. There has been a very strong response from non-network proponents in response to the PSCR and PADR and TransGrid and Ausgrid have assessed proposals from these parties in detail and consider that there is scope for deferring the commissioning of network through the use of non-network solutions. As far as TransGrid and Ausgrid are aware, this is one of the largest capital expenditure deferrals by non-network solutions in Australia to-date.

TransGrid is currently in the process of preparing a formal two-stage RFT for non-network proponents to respond to for non-network solutions. The two-stage process allows TransGrid to flexibly procure more demand management should demand forecasts or cable conditions change, and to procure more efficient lower cost solutions should the demand management market further improve with more non-network providers. In addition, the second stage would allow non-network proponents to learn from the first stage, and to refine their solutions to assist with deferral.

The first stage will seek approximately 40-60 MW of non-network capacity over a four-year program (based on the preferred Option 8) from 2018/19 summer to 2021/22 summer, and include binding contracts for the provision of non-network solutions that will be entered into. This RFT will be released after the AER provides certainty that funding is available to TransGrid to pursue non-network solutions, which is expected to align with the timing of its final determination on the revenue proposal in April 2018.

The second stage is a ‘top-up’ round (ie, in addition to the first stage) that will seek approximately 20-40 MW from 2020/21 summer to 2021/22 summer (a two-year program). A necessary precondition for any network deferral to occur is the procurement of appropriate non-network support from the market by TransGrid, sufficiently before the date at which the network component would otherwise need to be committed. TransGrid anticipate that the second RFT will be released around September 2018.

TransGrid considers that the date of 31 January 2019 reflects the date at which TransGrid would need to enter into a contract for the cabling required *should Option 2A not be deferred by one year using non-network solutions*. This effectively reflects the latest date that TransGrid can decide whether to commit to Option 2A, for commissioning during 2021/22, or to commit to deferring Option 2A by a year using non-network solutions. Should sufficient non-network contracts *not be entered into* by this date, TransGrid will proceed with procuring the necessary cabling contracts and other arrangements in order to commission Option 2A before the summer of 2021/22.

Appendix A – Checklist of compliance clauses

This section sets out a compliance checklist which demonstrates the compliance of this PACR with the requirements of clause 5.16.4(v) of the National Electricity Rules version 102.

Table A-1 Compliance checklist

Rules clause	Summary of requirements	Relevant section(s) in the PACR
5.16.4(v)	The project assessment conclusions report must set out:	-
	(1) the matters detailed in the project assessment draft report as required under paragraph (k); and	See below.
	(2) a summary of, and the RIT-T proponent's response to, submissions received, if any, from interested parties sought under paragraph (q).	Section 4
5.16.4(k)	The project assessment draft report must include:	-
	(1) a description of each credible option assessed;	Section 3 & Appendix B
	(2) a summary of, and commentary on, the submissions to the project specification consultation report;	Appendix E
	(3) a quantification of the costs, including a breakdown of operating and capital expenditure, and classes of material market benefit for each credible option;	Section 5 and Appendix B
	(4) a detailed description of the methodologies used in quantifying each class of material market benefit and cost;	Appendices C & D
	(5) reasons why the RIT-T proponent has determined that a class or classes of market benefit are not material;	Appendix D
	(6) the identification of any class of market benefit estimated to arise outside the *region* of the *Transmission Network Service Provider* affected by the RIT-T project, and quantification of the value of such market benefits (in aggregate across all regions);	Appendices B & C
	(7) the results of a net present value analysis of each credible option and accompanying explanatory statements regarding the results;	Section 5
	(8) the identification of the proposed preferred option;	Section 6
	(9) for the proposed preferred option identified under subparagraph (8), the RIT-T proponent must provide: (i) details of the technical characteristics; (ii) the estimated construction timetable and commissioning date; (iii) if the proposed preferred option is likely to have a *material inter-network impact* and if the *Transmission Network Service Provider* affected by the RIT-T project has received an *augmentation technical report*, that report; and (iv) a statement and the accompanying detailed analysis that the preferred option satisfies the *regulatory investment test for transmission*.	Section 6 & Appendix B

Appendix B – Further detail on the credible options assessed in this RIT-T

The RIT-T defines a 'credible option' as an option that addresses the identified need, is (or are) commercially and technically feasible and can be implemented in sufficient time to meet the identified need.

TransGrid and Ausgrid have considered a range of options and their ability to address the future risk to consumers from ageing electricity infrastructure. Both network and non-network solutions have been considered as potential credible options for this RIT-T analysis – in particular:

- the **network options** included vary primarily in terms of whether or not a new 330kV cable is installed in stages, or at once, and whether the existing Cable 41 is retired, remediated or operated at 132 kV or 330 kV; and
- **non-network options** have been incorporated into the assessment of all network options in order to manage the risk of unserved energy prior to commissioning of the network option, and to assess whether the network option can efficiently be deferred.

This appendix provides a summary of the network and non-network options assessed as part of this RIT-T – much of which is also provided in the earlier PADR. It repeats the material contained in section 3 of the PADR and has been included in-part to satisfy NER clause 5.16.4(v)(1).

B1 Network options – summary

The following **network options** have been included in the RIT-T assessment:

- **Option 1:** install two 330 kV cables in stages, retire Cable 41 and decommission Ausgrid cables in two stages;
- **Option 2A:** operate Cable 41 at 132 kV, install two 330 kV cables in stages and decommission Ausgrid cables in two stages;
- **Option 2B:** operate Cable 41 at 330 kV, install two 330 kV cables in stages and decommission Ausgrid cables in one stage;
- **Option 3A:** install two 330 kV cables at once, retire Cable 41 and decommission Ausgrid cables in one stage;
- **Option 3B:** install two 330 kV cables at once, operate Cable 41 at 330 kV and decommission Ausgrid cables in one stage;
- **Option 4**: remediate Cable 41, install two 330 kV cables in stages and decommission Ausgrid cables in one stage;
- **Option 5**: remediate Cable 41, install two 330 kV cables at once (initially operating at 132 kV) and decommission Ausgrid cables in two stages; and
- **Option 6:** remediate Cable 41, install two 330 kV cables at once and decommission Ausgrid cables in one stage.

The majority of these network options are the same as those presented in the PSCR[60], with the following details refined: (1) capital and operating costs, which have been estimated to a greater degree of detail; and (2) the timing of when individual option components are able to be commissioned.

Two new options (Option 2B and 3B) were introduced at the PADR stage and assessed. Both of these options involve continuing to operate Cable 41 at 330 kV. This follows the Cable 41 condition and remaining life assessment report that has confirmed the capability of Cable 41 to operate at 330 kV with a rating of 426MVA.

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60 Options 2 and 3 in the PSCR have been renamed Options 2A and 3A in this PACR as well as the PADR.

B2 Non-network options – summary

As part of the PSCR, TransGrid and Ausgrid invited public submissions on potential credible non-network options that could meet the required technical characteristics. In response to this, TransGrid and Ausgrid received eleven submissions from non-network proponents, offering a range of different technologies.

The non-network proposals were assessed to determine whether they can economically assist in managing the risk of unserved energy prior to the commissioning of the preferred network option. Specifically, a non-network option of approximately $7-10 million (in aggregate) has been calculated and included as part of the assessment of each of the network options.[61] Submissions to the PADR requested more detail on how this figure has been estimated, which is provided in section 4.7 below.

In addition, the non-network options have been assessed by TransGrid and Ausgrid to see whether they have the potential to defer the network investment, either permanently or temporarily. This has involved testing whether the costs of adding an additional non-network component are outweighed by the deferral benefits it is expected to deliver.

In assessing the ability of non-network options to defer or avoid the network investment, TransGrid and Ausgrid investigated two options that couple a network option with a range of non-network options to defer the network investment – namely:

- **Option 7:** where Option 3B[62] is coupled with a range of non-network options to defer the network investment; and
- **Option 8:** where Option 2A[63] is coupled with a range of non-network options to defer the network investment.

The assessment of these options has shown that it is possible to defer the network investment by one year from 2021/22 (the need year) to 2022/23.

Due to the magnitude of the non-network requirement, in terms of both capacity and duration, the non-network options are assumed to be comprised of a combination of non-network solutions from a range of providers encompassing a range of technologies.

The box at the end of section 3 outlines important information for non-network proponents regarding the process going forward for engaging and negotiating with proponents going forward.

B3 Identification of the time at which each option is required

The benefits associated with each option are evaluated over a 20-year period. The following benefits can be realised through network and non-network options: reduced expected unserved energy, reduced likelihood of costly repairs, reduced environment risk and reduced losses.

For each option and stage[64], under each scenario[65], TransGrid and Ausgrid have identified the first year in which the total benefit from these sources exceeds the benefit from deferring capital expenditure (project trigger year). This year then forms the basis for the optimal timing of each stage of each option.

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[61] TransGrid and Ausgrid note that the $7-10 million cost range has been derived using a probability based assessment of expected dispatch. Should an actual cable failure occur of the magnitudes being considered these costs would be far greater due to the actual cost of dispatching these solutions.

[62] Option 3B was the preferred network option by TransGrid and Ausgrid at the PADR stage based on both quantitative NPV modelling as well as qualitative considerations centred on minimising disruptions to the community.

[63] Option 2A is the preferred network option by TransGrid and Ausgrid at this final PACR stage – for the reasons set out in section 6 above.

[64] Each of the 'Stages' are independent sequential phases of works.

[65] Refer Section 6.4.

Table B-1 Project trigger year of each stage for all options for all scenarios

Option	Low Scenario		Central Scenario			High Scenario		
Stages	Stage 1	Stage 2	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
1	2027/28	2030/31	2021/22	2026/27	-	2021/22	2022/23	-
2A	2027/28	2030/31	2021/22	2027/28	-	2021/22	2023/24	-
2B	2027/28	2028/29	2021/22	2024/25	-	2021/22	2022/23	-
3A	2027/28	-	2021/22	-	-	2021/22	-	-
3B	2027/28	-	2021/22	-	-	2021/22	-	-
4	2027/28	2028/29	2021/22	2026/27	2027/28	2021/22	2022/23	2025/26
5	2027/28	2029/30	2021/22	2025/26	2027/28	2021/22	2022/23	2024/25
6	2027/28	-	2021/22	2026/27	-	2021/22	2023/24	-
7	2028/29	–	2022/23	-	-	2022/23	–	–
8	2022/23	2034/35	2022/23	2027/28	-	2022/23	2023/24	-

Although the evaluation shows some stages are needed as early as 2019/20 in the central scenario, due to the complexity and scope of the project, the earliest practical completion year is 2021/22. As stated above, it is expected that non-network options will be used to manage the risk of unserved energy, where it is economic to do so, until a network option can be commissioned. The cost-benefit analysis presented in this report is based on the practical Stage 1 completion year of 2021/22 at the earliest. Option 7 and Option 8 assume a one year deferral of the costs of Option 3B and 2A, respectively, and apply a commissioning year of 2022/23.

For commissioning years noted in this report, TransGrid and Ausgrid have assumed that the network option will be commissioned at the start of the financial year, that is, in time for summer of that financial year.

B4 Option 1: install two 330 kV cables in stages and retire Cable 41

Option 1 involves ultimately installing two 330 kV 750 MVA cable circuits between Rookwood Road and Beaconsfield substations, retiring Cable 41 and retiring the eight Ausgrid oil-filled cables in two stages.

The two cables would be installed and commissioned in two stages – namely:

- Stage 1: build one 330 kV 750 MVA cable between Rookwood Road and Beaconsfield substations, terminate the new cable onto existing transformers at Beaconsfield, extend the 330 kV GIS at Rookwood Road, and then retire Cable 41 along with six Ausgrid oil-filled cables (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2); and
- Stage 2: install a second 330 kV750 MVA cable from Rookwood Road to Beaconsfield, extend the 330 kV GIS at Beaconsfield and connect the two 330 kV cables from Rockwood Road. Stage 2 also involves extending the 330 kV GIS at Haymarket and converting cable 9S4 from Beaconsfield to Haymarket to 330 kV750 MVA operation. This allows two additional Ausgrid oil-filled cables to be retired (cables 9S2, 90T/1).

Capital costs for this option are estimated to be approximately $369 million with major cost components shown in the table below. Operating costs include non-network costs to manage the risk of unserved energy before the network option can be commissioned as well as the annual operating costs associated with the new capital costs, which are estimated to be about two per cent of the capital cost.

It is estimated that the environmental approval and construction timeline for Stage 1 of Option 1 is five years, with commissioning possible during 2021/22. It is further estimated that the construction timeline for Stage 2 of Option 1 is three years, with commissioning proposed during 2025/26. The complete construction timeline is shown in the table below.

Table B-2 Option 1 - install two 330kV cables in stages and retire Cable 41

Project description	Cost ($2016/17real)	Construction timetable; commissioning date
Stage 1		
Install one 330 kV cable circuit from Rookwood Road to Beaconsfield and provision for a second 330 kV circuit that is to be installed at a later date	$235 million (CAPEX)	5 years, with commissioning possible during 2021/22
Ausgrid decommissioning costs (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2)	$11 million (Ausgrid Cost)	Proposed during 2022/23
TransGrid decommissioning costs (cable 41)	$3 million (OPEX)	Proposed during 2022/23
Non-network costs to reduce the unserved energy	$7-10 million (OPEX)	2018/19-2020/21
Stage 2		
Install second 330 kV cable circuit from Rookwood Road to Beaconsfield	$117 million (CAPEX)	3 years, with commissioning proposed during 2025/26
Convert cable 9S4 to 330 kV	$17 million (CAPEX)	
Ausgrid decommissioning costs (cables 9S2, 90T/1)	$1 million (Ausgrid Cost)	

B5 Option 2A: operate Cable 41 at 132 kV and install two 330 kV cables in stages

Option 2A involves ultimately installing two 330 kV 750 MVA cable circuits between Rookwood Road and Beaconsfield substations, reconfiguring Cable 41 to operate at 132 kV with rating of 170 MVA and retiring the eight Ausgrid oil-filled cables in two stages.

The two cables would be installed and commissioned at in two stages – namely:

- Stage 1: build one 330 kV cable between Rookwood Road and Beaconsfield, terminate the new cable onto existing transformers at Beaconsfield, extend the 330 kV GIS at Rookwood Road, reconfigure Cable

41 to operate at 132 kV with a rating of 170 MVA and retire six Ausgrid oil-filled cables (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2); and

- Stage 2: install a second 330 kV 750 MVA cable from Rookwood Road to Beaconsfield, extend the 330 kV GIS at Beaconsfield and connect the two 330 kV cables from Rockwood Road. Stage 2 also involves retiring Cable 41, extending the 330 kV GIS at Haymarket, converting cable 9S4 from Beaconsfield to Haymarket to 330 kV 750 MVA operation and connection to the 330 kV GIS at Beaconsfield and Haymarket. This allows two additional Ausgrid oil-filled cables to be retired (cables 9S2, 90T/1).

Capital costs for this option are estimated to be approximately $377 million, with major cost components shown in the table below. Operating costs include non-network costs to manage the risk of unserved energy before the network option can be commissioned, ongoing OPEX associated with the continued operation of Cable 41 as well as annual operating costs associated with new capital costs, which are estimated to be about two per cent of the capital cost.

It is estimated that the environmental approval and construction timeline for Stage 1 of Option 2 is five years, with commissioning possible during 2021/22. It is further estimated that the construction timeline for Stage 2 of Option 2 is three years, with commissioning proposed during 2027/28. The complete construction timeline is shown in the table below.

Table B-3 Option 2A - operate Cable 41 at 132 kV and install two 330 kV cables in stages

Project description	Cost ($2016/17 real)	Construction timetable; commissioning date
Stage 1		
Install one 330 kV cable circuit from Rookwood Road to Beaconsfield and provision for a second 330 kV circuit that is to be installed at a later date.	$235 million (CAPEX)	5 years, with commissioning possible during 2021/22
Operate Cable 41 at 132 kV	$8 million (CAPEX)	
Ausgrid decommissioning costs (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2)	$11 million (Ausgrid Cost)	Proposed during 2022/23
Non-network costs to reduce the unserved energy	$7-10 million (OPEX)	2018/19-2020/21
Stage 2		
Install second 330 kV cable circuit from Rookwood Road to Beaconsfield	$117 million (CAPEX)	3 years, with commissioning proposed during 2027/28
Convert cable 9S4 to 330 kV	$17 million (CAPEX)	
Ausgrid decommissioning costs (cables 9S2, 90T/1)	$1 million (Ausgrid Cost)	

B6 Option 2B: operate Cable 41 at 330 kV and install two 330 kV cables in stages

Option 2B involves ultimately installing two 330 kV 750 MVA cable circuits between Rookwood Road and Beaconsfield substations, operating Cable 41 at 330 kV with rating of 426 MVA and retiring the eight Ausgrid oil-filled cables in one stage.

The two cables would be installed and commissioned at in two stages – namely:

- Stage 1: build one 330 kV 750 MVA cable between Rookwood Road and Beaconsfield and extend the 330 kV GIS at Rookwood Road and Beaconsfield. Stage 1 would also involve extending the 330 kV GIS at Haymarket and converting cable 9S4 from Beaconsfield to Haymarket to operate at 330 kV with a 750 MVA rating. This allows eight Ausgrid oil-filled cables to be retired at once; and
- Stage 2: install a second 330 kV 750 MVA cable from Rookwood Road to Beaconsfield.

Capital costs for this option are estimated to be approximately $370 million, with major cost components shown in the table below. Operating costs include non-network costs to manage the risk of unserved energy before the network option can be commissioned, ongoing OPEX associated with the continued operation of

Cable 41 as well as annual operating costs associated with new capital costs, which are estimated to be about two per cent of the capital cost.

It is estimated that the environmental approval and construction timeline for Stage 1 of Option 2 is five years, with commissioning possible during 2021/22. TransGrid and Ausgrid further estimate that the construction timeline for Stage 2 of Option 2 is three years, with commissioning proposed during 2024/25. The complete construction timeline is shown in the below.

Table B-4 Option 2B – operate Cable 41 at 330kV and install 2 330 kV cables in stages

Project description	Cost ($2016/17 real)	Construction timetable; commissioning date
Stage 1		
Install one 330 kV cable circuit from Rookwood Road to Beaconsfield and provision for a second 330 kV circuit that is to be installed at a later date	$281 million (CAPEX)	5 years, with commissioning possible during 2021/22
Convert cable 9S4 to 330 kV	$17 million (CAPEX)	
Ausgrid decommissioning costs (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2, 9S2, and 90T/1)	$12 million (Ausgrid Cost)	Proposed during 2022/23
Non-network costs to reduce the unserved energy	$7-10 million (OPEX)	2018/19-2020/21
Stage 2		
Install second 330 kV cable circuit from Rookwood Road to Beaconsfield	$72 million (CAPEX)	3 years, with commissioning proposed during 2024/25

B7 Option 3A: install two 330 kV cables at once and retire Cable 41

Option 3A involves installing two 330 kV 750 MVA cable circuits between Rookwood Road and Beaconsfield substations at once, retiring Cable 41 and retiring the eight Ausgrid oil-filled cables at once.

Two 330 kV 750 MVA cables would be built between Rookwood Road and Beaconsfield substations and connected to the extended 330 kV GIS at Rookwood Road and Beaconsfield substations. Then Cable 41 would be retired. Option 3 also involves extending the 330 kV GIS at Haymarket substation and converting cable 9S4 from Beaconsfield to Haymarket substations to 330 kV 750 MVA operation. This allows eight Ausgrid oil-filled cables to be retired at the same time.

Capital costs for this option are estimated to be approximately $352 million, with major cost components shown in the table below. Operating costs include non-network costs to manage the risk of unserved energy before the network option can be commissioned, as well as annual operating costs associated with the new capital costs, which are estimated to be about two per cent of the capital cost.

It is estimated that the construction timeline for Option 3 is five years, with commissioning proposed during 2021/22.

Table B-5 Option 3A – install two 330kV cables at once and retire Cable 41

Project description	Cost ($2016/17 real)	Construction timetable; commissioning date
Install two 330 kV cable circuits from Rookwood Road to Beaconsfield	$335 million (CAPEX)	5 years, with commissioning proposed during 2021/22
Convert cable 9S4 to 330 kV	$17 million (CAPEX)	
TransGrid decommissioning costs (cable 41)	$3 million (OPEX)	Proposed during 2022/23
Ausgrid decommissioning costs (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2, 9S2, 90T/1)	$12 million (Ausgrid Cost)	Proposed during 2022/23
Non-network costs to reduce the unserved energy	$7-10 million (OPEX)	2018/19-2020/21

B8 Option 3B: install two 330 kV cables at once and operating Cable 41 at 330kV

Option 3B involves installing two 330 kV 750 MVA cable circuits between Rookwood Road and Beaconsfield substations at once, operating Cable 41 at 330 kV with rating of 426 MVA and retiring the eight Ausgrid oil-filled cables at once.

Two 330 kV 750 MVA cables would be built between Rookwood Road and Beaconsfield substations and connected to the extended 330 kV GIS at Rookwood Road and Beaconsfield substations. Option 3B also involves extending the 330 kV GIS at Haymarket substation and converting Cable 9S4 from Beaconsfield to Haymarket substations to 330 kV 750 MVA operation. This allows eight Ausgrid oil-filled cables to be retired at the same time.

Capital costs for this option are estimated to be approximately $352 million, with major cost components shown in the table below. Operating costs include non-network costs to manage the risk of unserved energy before the network option can be commissioned, ongoing OPEX associated with the continued operation of Cable 41 as well as annual operating costs associated with the new capital costs, which are estimated to be about two per cent of the capital cost.

It is estimated that the construction timeline for Option 3B is five years, with commissioning proposed during 2021/22.

Table B-6 Option 3B – install two 330kV cables at once and operate Cable 41 at 330 kV with a rating or 426MVA

Project description	Cost ($2016/17 real)	Construction timetable; commissioning date
Install two 330 kV cable circuits from Rookwood Road to Beaconsfield	$335 million (CAPEX)	5 years, with commissioning proposed during 2021/22
Convert cable 9S4 to 330 kV	$17 million (CAPEX)	
Ausgrid decommissioning costs (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2, 9S2, 90T/1)	$12 million (Ausgrid Cost)	Proposed during 2022/23
Non-network costs to reduce the unserved energy	$7-10 million (OPEX)	2018/19-2020/21

B9 Option 4: remediate Cable 41 and install two 330 kV cables in stages

Option 4 is to remediate Cable 41 thermal backfill to increase the cyclic rating to approximately 575 MVA as detailed in the Cable 41 Investigation Summary Report provided in Appendix B, ultimately install two 330 kV 750 MVA cables between Rookwood Road to Beaconsfield and retire eight Ausgrid oil-filled cables in one stage.

The option would be conducted in three stages – namely:

- Stage 1: remediate Cable 41 and continue to operate at 330 kV with a rating of 575 MVA;
- Stage 2: build one 330 kV 750 MVA cable between Rookwood Road and Beaconsfield and extend the 330 kV GIS at Rookwood Road and Beaconsfield. Stage 2 also involves extending the 330 kV GIS at Haymarket and converting Cable 9S4 from Beaconsfield to Haymarket to operate at 330 kV with 750 MVA rating. This allows eight Ausgrid oil-filled cables to be retired at once; and
- Stage 3: install a second 330 kV 750 MVA cable from Rookwood Road to Beaconsfield.

Capital costs for this option are estimated to be approximately $495 million, with major cost components shown in the table below. Operating costs include non-network costs to manage the risk of unserved energy before the network option can be commissioned, ongoing OPEX associated with the continued operation of Cable 41 as well as annual operating costs associated with the new capital costs, which are estimated to be about two per cent of the capital cost.

It is estimated that the construction timeline for Stage 1 is five years, with commissioning possible during 2021/22. The estimated construction timeline for Stage 2 is five years, with commissioning proposed during

2025/26. It is further estimated the construction timeline for Stage 3 is three years, with commissioning proposed during 2027/28.

Table B-7 Option 4 – remediate Cable 41 and install two 330 kV cables in stages

Project description	Cost ($2016/17 real)	Construction timetable; commissioning date
Stage 1		
Remediate backfill and reinstate the Cable 41 rating to 575 MVA	$125 million (CAPEX)	5 years, with commissioning possible during 2021/22
Non-network costs to reduce the unserved energy	$7-10 million (OPEX)	2018/19-2020/21
Stage 2		
Install one 330 kV cable circuit from Rookwood Road to Beaconsfield and provision for a second 330 kV circuit that is to be installed at a later date	$281 million (CAPEX)	5 years, with commissioning proposed during 2025/26
Convert cable 9S4 to 330 kV	$17 million (CAPEX)	
Ausgrid decommissioning costs (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2, 9S2, and 90T/1)	$12 million (Ausgrid Cost)	
Stage 3		
Install second 330 kV cable circuit from Rookwood Road to Beaconsfield	$72 million (CAPEX)	3 years, with commissioning proposed during 2027/28

B10 Option 5: remediate Cable 41 and install two 330 kV cables at once, initially operating at 132 kV

Option 5 is to remediate Cable 41 thermal backfill to increase the cyclic rating to approximately 575 MVA as detailed in the Cable 41 Investigation Summary Report provided in Appendix B, and install two new 330 kV cables between Rookwood Road and Beaconsfield that would initially operate at 132 kV.

The option would be conducted in three stages – namely:

- Stage 1: remediate Cable 41 and continue to operate at 330 kV with a rating of 575 MVA;
- Stage 2: build two 330 kV cables between Rookwood Road and Beaconsfield and operate at 132 kV with 290 MVA ratings[66], as well as retiring six Ausgrid oil-filled cables (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2); and
- Stage 3: extend the 330 kV GIS at Rookwood Road and Beaconsfield and convert the cables from Rookwood Road to Beaconsfield to 330 kV 750 MVA operation. Stage 3 also involves extending the 330 kV GIS at Haymarket and converting Cable 9S4 from Beaconsfield to Haymarket to 330 kV 750 MVA operation. This allows two additional Ausgrid oil-filled cables to be retired (cables 9S2, 90T/1).

Capital costs for this option are estimated to be approximately $491 million, with major cost components shown in the table below. Operating costs include non-network costs to manage the risk of unserved energy before the network option can be commissioned, ongoing OPEX associated with the continued operation of Cable 41 as well as the annual operating costs associated with new capital costs, which are estimated to be about two per cent of the capital cost.

It is estimated that the construction timeline for Stage 1 is five years, with commissioning possible during 2021/22. The estimated construction timeline for Stage 2 is five years, with commissioning proposed during

66 Taking into account the dielectric losses, the normal cyclic rating for a single circuit in service the rating may be 330 MVA.

2025/26. It is further estimated the construction timeline for Stage 3 is three years, with commissioning proposed during 2027/28.

Table B-8 Option 5 – remediate Cable 41 and install two 330 kV cables at once, initially operating at 132 kV

Project description	Cost ($2016/17 real)	Construction timetable; commissioning date
Stage 1		
Remediate backfill and reinstate the Cable 41 rating to 575 MVA	$125 million (CAPEX)	5 years, with commissioning possible during 2021/22
Non-network costs to reduce the unserved energy	$7-10 million (OPEX)	2018/19-2020/21
Stage 2		
Install two 330 kV cable circuits from Rookwood Road to Beaconsfield operating at 132 kV initially	$270 million (CAPEX)	5 years, with commissioning proposed during 2025/26
Ausgrid decommissioning costs (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2)	$11 million (Ausgrid Cost)	
Stage 3		
Convert the Rookwood Road to Beaconsfield cables from 132 kV to 330 kV	$79 million (CAPEX)	3 years, with commissioning proposed during 2027/28
Convert cable 9S4 to 330 kV	$17 million (CAPEX)	
Ausgrid decommissioning costs (cables 9S2 and 90T/1)	$1 million (Ausgrid Cost)	

B11 Option 6: remediate Cable 41 and install two 330 kV cables at once

Option 6 is to remediate Cable 41 thermal backfill to increase the cyclic rating to approximately 575 MVA as detailed in the Cable 41 Investigation Summary Report provided in Appendix B, and install two new 330 kV cables between Rookwood Road and Beaconsfield.

The option would be conducted in two stages – namely:

- Stage 1: remediate Cable 41 and continue to operate at 330 kV with a rating of 575 MVA;
- Stage 2: extend the 330 kV GIS at Rockwood Road and Beaconsfield and build two 330 kV cables between Rookwood Road and Beaconsfield. Stage 2 also involves extending the 330 kV GIS at Haymarket and the conversion of Cable 9S4 from Beaconsfield to Haymarket to 330 kV 750 MVA operation. This allows eight Ausgrid oil-filled cables to be retired at once.

Capital costs for this option are estimated to be approximately $477 million, with major cost components shown in the table below. Operating costs include non-network costs to manage the risk of unserved energy before the network option can be commissioned, ongoing opex associated with the continued operation of Cable 41 as well as the annual operating costs associated with new capital costs, which are estimated to be about two per cent of the capital cost.

It is estimated that the construction timeline for Stage 1 is five years, with commissioning possible during 2021/22. It is further estimated that the construction timeline for Stage 2 is five years, with commissioning proposed during 2026/27.

Table B-9 Option 6 – remediate Cable 41 and install two 330 kV cables at once

Project description	Cost ($2016/17 real)	Construction timetable; commissioning date
Stage 1		
Remediate backfill and reinstate the Cable 41 rating to 575 MVA	$125 million (CAPEX)	5 years, with commissioning possible during 2021/22
Non-network costs to reduce the unserved energy	$7-10 million(OPEX)	2018/19-2020/21
Stage 2		
Install two 330 kV cable circuits from Rookwood Road to Beaconsfield	$335 million (CAPEX)	5 years, with commissioning proposed during 2026/27
Convert cable 9S4 to 330 kV	$17 million (CAPEX)	
Ausgrid decommissioning costs (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2, 9S2, 90T/1)	$12 million (Ausgrid Cost)	

B12 Option 7: non-network support initially and then a deferred installation of two 330 kV cables at once and operating Cable 41 at 330kV

Option 7 has been included following the response to the PSCR by non-network proponents. In particular, it has been included to investigate whether non-network solutions can efficiently defer the timing of Option 3B (since it was identified as the referred option at the PADR stage), taking into consideration quantitative NPV modelling and qualitative considerations of minimising disruptions to the community and environment.

Capital costs of the network component of this option are estimated to be approximately $352 million, with major cost components shown in the table below. Operating costs include:

- Sufficient non-network solutions to defer the network investment by a year;[67]
- non-network costs to manage the risk of unserved energy before the network option could be commissioned at the earliest;
- ongoing opex associated with the continued operation of Cable 41; and
- annual operating costs associated with new capital costs, which are estimated to be about two per cent of the capital cost.

It is estimated that the construction timeline for Option 7 is five years, with commissioning proposed during 2022/23.

Table B-10 Option 7 – non-network support initially and then a deferred installation of two 330 kV cables at once and operating Cable 41 at 330 kV

Project description	Cost ($2016/17 real)	Construction timetable; commissioning date
Non-network support to defer the network component by a year	$9.5 million (OPEX)	2021/22
Install two 330 kV cable circuits from Rookwood Road to Beaconsfield	$335 million (CAPEX)	5 years, with commissioning proposed during 2022/23
Convert cable 9S4 to 330 kV	$17 million (CAPEX)	
Ausgrid decommissioning costs (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2, 9S2, 90T/1)	$12 million (Ausgrid Cost)	Proposed during 2023/24
Non-network costs to reduce the unserved energy	$7-10 million(OPEX)	2018/19-2020/21

[67] The cumulative cost of non-network solutions required to defer the network component by more than a year, and be compliant with the revised reliability standards, are deemed to be not economically feasible by TransGrid and Ausgrid.

B13 Option 8: non-network support initially and then a deferred installation of two 330 kV cables in stages, decommissioning of Ausgrid cables in two stages and operating Cable 41 at 132 kV

Option 8 has been included subsequent to the PADR in response to feedback from AER and the CCP supporting two-stage option for the lower initial capital cost and 'optionality' it affords. In particular, it has been included to investigate whether non-network solutions can efficiently defer the timing of Option 2A, which is the preferred network options for the reasons outlined in Section 6.

Capital costs of the network component of this option are estimated to be approximately $377 million, with major cost components shown in the table below. Operating costs include:

- Sufficient non-network solutions to defer the network investment by a year;[68]
- non-network costs to manage the risk of unserved energy before the network option could be commissioned at the earliest;
- ongoing opex associated with the continued operation of Cable 41; and
- annual operating costs associated with new capital costs, which are estimated to be about two per cent of the capital cost.

It is estimated that the environmental approval and construction timeline for Stage 1 of Option 2 is five years, with commissioning possible during 2022/23. It is further estimated that the construction timeline for Stage 2 of Option 2 is three years, with commissioning proposed during 2027/28.

Table B-10 Option 8 – non-network support initially then operate Cable 41 at 132 kV and install two 330 kV cables in stages

Project description	Cost ($2016/17 real)	Construction timetable; commissioning date
Stage 1		
Non-network support to defer the network component by a year	$9.5 million (OPEX)	2021/22
Install one 330 kV cable circuit from Rookwood Road to Beaconsfield and provision for a second 330 kV circuit that is to be installed at a later date.	$235 million (CAPEX)	5 years, with commissioning possible during 2022/23
Operate Cable 41 at 132 kV	$8 million (CAPEX)	
Ausgrid decommissioning costs (cables 928/3, 929/1, 92C, 92X, 91X/2, 91Y/2)	$11 million (Ausgrid Cost)	Proposed during 2022/23
Non-network costs to reduce the unserved energy	$7-10 million (OPEX)	2018/19-2020/21
Stage 2		
Install second 330 kV cable circuit from Rookwood Road to Beaconsfield	$117 million (CAPEX)	3 years, with commissioning proposed during 2027/28
Convert cable 9S4 to 330 kV	$17 million (CAPEX)	
Ausgrid decommissioning costs (cables 9S2, 90T/1)	$1 million (Ausgrid Cost)	

68 The cumulative cost of non-network solutions required to defer the network component by more than a year, and be compliant with the revised reliability standards, are deemed to be not economically feasible by TransGrid and Ausgrid.

Appendix C – General modelling approaches adopted to assessing net market benefits

This appendix provides a summary of the general modelling approaches adopted to quantify market benefits and costs in the assessment presented in this PACR (as well as the PADR), including a description of the reasonable scenarios considered.[69] It largely repeats the material contained in section 6 of the PADR.

C1 Analysis period

The RIT-T analysis has been undertaken over a 20-year period, from 2017 to 2036.

TransGrid and Ausgrid consider that a 20-year period takes into account the size, complexity and expected life of the relevant credible options to provide a reasonable indication of the market benefits and costs of the options. Specifically, consistent with the AER RIT-T Application Guidelines, we consider that by the end of the modelling period, the network will be in a 'similar state' in relation to needing to meet a similar identified need to where it is at the time of this investment.[70]

While the capital components of the credible options have asset lives greater than 20 years, TransGrid and Ausgrid have taken a terminal value approach to incorporating capital costs in the assessment. This ensures that the capital cost of long-lived options is appropriately captured in the 20-year assessment period.

C2 Discount rate

The commercial discount rate is applied to calculate the NPV of costs and benefits of credible options.[71]

The RIT-T requires that:[72]

> *The present value calculations must use a commercial discount rate appropriate for the analysis of a private enterprise investment in the electricity sector. The discount rate used must be consistent with the cash flows being discounted*

TransGrid and Ausgrid have adopted a real, pre-tax discount rate of 6.13 per cent as the central assumption for the NPV analysis presented in this report.

TransGrid engaged HoustonKemp to estimate an appropriate commercial discount rate for application in this RIT-T. HoustonKemp estimated an indicative commercial discount rate of 6.13 per cent (real, pre-tax) on the basis of:

- adopting the return on equity of an average firm on the Australian stock exchange - by adopting an equity beta of 1.0 within the AER's capital asset pricing model (CAPM);
- assuming that this firm would hold an investment grade credit rate (i.e., BBB) and raise 10-year Australian corporate debt;
- adopting a debt gearing ratio of an average business listed on the Australian stock exchange (estimated using Bloomberg data for the 2014-15 financial year); and
- adopting the current non-concessional corporate income tax rate, the AER's approach to forecasting inflation and a gamma value of 0.4.

HoustonKemp's report was attached as Appendix C to the PADR.

The RIT-T requires that sensitivity testing be conducted on the discount rate and that the regulated weighted average cost of capital (WACC) be used as the lower bound discount rate in the sensitivity testing. TransGrid

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69 In accordance with NER clause 5.16.4(k)(4).

70 AER, *Final Regulatory Investment Test for Transmission* Application Guidelines, June 2010, version 1, p 41.

71 AER, *Final | Regulatory investment test for transmission*, 29 June 2010, paragraph 2.

72 AER, *Final | Regulatory investment test for transmission*, 29 June 2010, paragraph 14.

and Ausgrid have therefore tested the sensitivity of the results to changes in this discount rate assumption, and specifically to the adoption of a lower bound discount rate of 3.48% (based on the HoustonKemp estimate of the regulatory WACC over the same period as the indicative commercial discount rate), and an upper bound discount rate of 8.78% (i.e., a symmetrical upwards adjustment).

C3 Market dispatch modelling has not been applied

The RIT-T requires that in estimating the magnitude of market benefits, a market dispatch modelling methodology must be used, unless the Transmission Network Service Provider (TNSP) can provide reasons why this methodology is not relevant.[73]

TransGrid and Ausgrid have not adopted a market dispatch modelling approach to estimating the market benefits for this RIT-T, as it would involve a disproportionate level of resources, given the credible options are not expected to affect wholesale market outcomes.

In addition, those categories of market benefit that arise due to effects of an option on outcomes in the wholesale market are not considered relevant for this RIT-T and hence do not need to be estimated. These categories of market benefit are those that typically require market dispatch modelling.

C4 Description of reasonable scenarios

The RIT-T analysis is required to incorporate a number of different reasonable scenarios, which are used to estimate market benefits. The RIT-T states that the number and choice of reasonable scenarios must be appropriate to the credible options under consideration.

The choice of reasonable scenarios must reflect any variables or parameters that:[74]

- are likely to affect the ranking of the credible options, where the identified need is reliability corrective action; and
- are likely to affect the ranking of the credible options, or the sign of the net economic benefits of any of the credible options, for all other identified needs.

TransGrid and Ausgrid have adopted the following three scenarios, shown in the table below, in undertaking the RIT-T analysis presented in this PACR. These three scenarios capture differences in key drivers of these benefits – namely the VCR, future demand and the underlying discount rate. These scenarios are the same as those used in the PADR assessment, with the exception of the VCR. TransGrid and Ausgrid have updated all the economic assessment in this PACR so that it assumes the $90/kWh figure for all affected customers under the ‘central’ set of assumptions, ie, both Inner Suburbs and CBD customers. The original assumption of $170/kWh VCR value for the CBD has been included only in the ‘high VCR’ scenario.

Table C-1 Reasonable scenarios assumed

Key variable/parameter	Scenario 1 – Low	Scenario 2 – Central	Scenario 3 – High
VCR estimates	AEMO VCR Value[75]	The VCR used by IPART in its recent review of the NSW transmission reliability standards ($90/kWh)	$170/kWh for the Sydney CBD and $90/kWh for Inner Sydney (ie, the ‘central’ assumptions in the PADR)
Demand	Low	Medium	High
Discount rate	8.78%	6.13%	3.48%

73 AER, *Final Regulatory Investment Test for Transmission*, June 2010, version 1, paragraph 11.

74 AER, *Final Regulatory Investment Test for Transmission*, June 2010, version 1, paragraph 16, p. 7

75 VCR value is a weighted value calculated based on AEMO methodology using different NSW customer segment VCR values as in AEMO report – *Value of Customer Reliability – Application Guide, December 2014.*

C4.1 Weighting of reasonable scenarios

The RIT-T requires that the market benefits of credible options for each scenario (relative to the base case) are weighted by the probability of each relevant reasonable scenario occurring. The AER states in its RIT-T guideline that, where a TNSP has no material evidence for assigning a higher probability for one reasonable scenario over another, a TNSP may weight all reasonable scenarios equally.[76]

TransGrid and Ausgrid do not consider there is material evidence for assigning a higher probability for one reasonable scenario over another. Each of the three scenarios outlined above have therefore been assigned equal weights. One submission to the PADR queried the use, and implications, of equal weighting – TransGrid and Ausgrid have responded to this query in section 4.9.

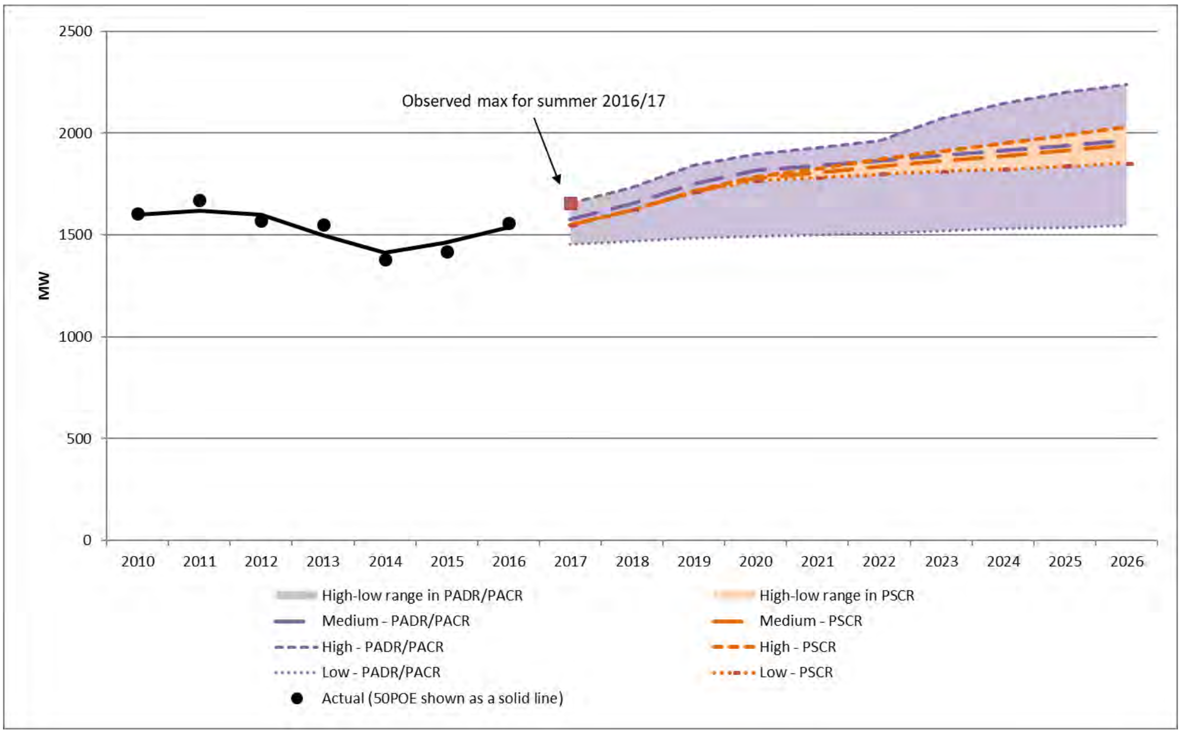
C4.2 Maximum demand forecasts

TransGrid and Ausgrid consider that the range of demand forecasts investigated in this RIT-T is sufficiently broad to capture all reasonable expectations regarding the future. Testing the credible options to these different demand forecasts ensures the robustness of the recommended preferred option. The demand forecasts used were raised in submission to the PADR and TransGrid and Ausgrid have elaborated on the range of underlying assumptions in section 4.2.

Sensitivity Analysis of Maximum Demand

The figure below shows the high and low range of the demand forecasts used for sensitivity analysis. In addition, the actual summer 2016/17 maximum demand for the Inner Sydney area of 1,654 MW is also shown, which occurred on Friday 10 February 2017. This actual maximum demand is approximately 5% higher than the Medium scenario forecast for summer 2016/17 and is in line with the High scenario forecast.

Figure C-1 Historical and forecast Inner Sydney peak demand growth



The POE50, or 50% probability of exceedance, medium demand forecast is used in the Central scenario in this RIT-T assessment. The figure below shows a breakdown of the components of the forecast to show the underlying contributions to demand. The largest contribution to demand growth is from future spot loads, mainly composed of large transport, infrastructure and residential development projects currently underway.

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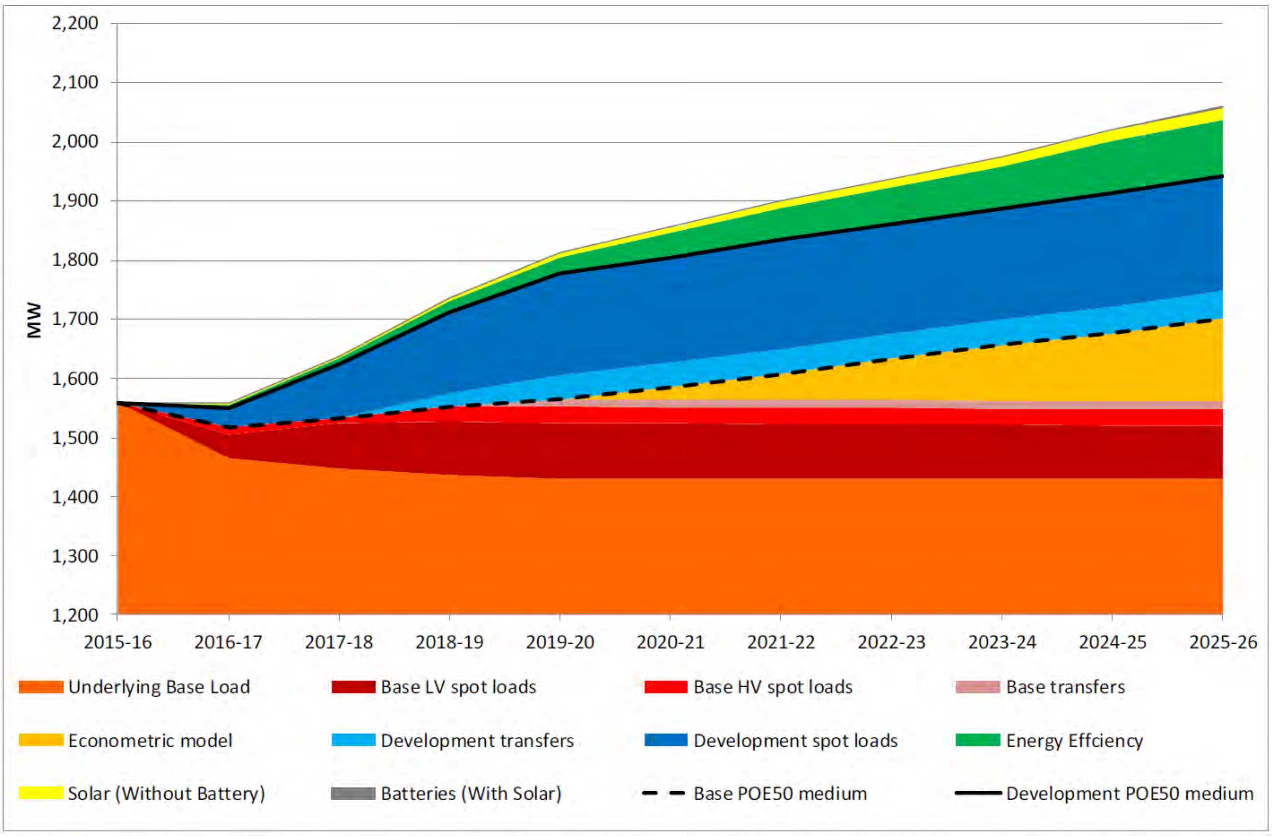
76 AER, *Final Regulatory Investment Test for Transmission* Application Guidelines, June 2010, version 1, p 33.

Figure C-2 Contributions to the POE 50 Medium Development forecast



High and low sensitivities have been applied to test the robustness of the RIT-T assessment to variations in the demand forecast. The high and low scenarios have been based on variations in the following elements of the demand forecast and are shown in the table below.

Table C-2 Scenarios assumed including breakdown elements

Element	Scenario 1 – Low	Scenario 2 – Central	Scenario 3 – High
Weather correction	POE90	POE50	POE10
Economic activity	Lower	Medium	Higher
Household income growth	Lower	Medium	Higher
Electricity prices	Higher	Medium	Lower
New solar power and battery connections	Higher	Medium	Lower
Energy efficiency	Higher	Medium	Lower
New large customer load connections	Lower	Medium	Higher

High demand forecast scenario

The high scenario is based on a POE10 demand forecast, or 10% probability of exceedance, under a higher economic growth scenario, lower uptake of small scale technologies such as customer solar power and battery systems, lower demand suppressing impacts from energy efficiency programs and inclusion of specific infrastructure and redevelopment projects that are not included in the medium demand scenario. In the PSCR it was mentioned that the medium development forecast did not include demand from a number of significant infrastructure and redevelopment projects. These have been included in the high forecast scenario and are anticipated to occur over the next 5 to 10 years (many of which have already commenced work):

- Westconnex Stage 3;

- Sydney Metro and associated station and commercial development at the proposed Barangaroo, Martin Place, Pitt St, Central and Waterloo stations;
- Central to Eveleigh redevelopment; and
- White Bay precinct redevelopment.

C4.3 Low demand forecast scenario

The low scenario is based on a POE90 demand forecast, or 90% probability of exceedance, under a lower economic growth scenario, higher uptake of small scale technologies such as customer solar power and battery systems, higher demand suppressing impacts from energy efficiency programs and exclusion of all development forecast customer spot loads. These new customer loads are anticipated, and in some cases customer investment underway, but may not materialise if significant disruption to economic activity occurs. The new customer loads excluded under the low demand forecast scenario include:

- 80 MW in new load to service major road, rail and air transport infrastructure, of which the initial stages are currently under construction;
- 80 MW in new load for major commercial redevelopment and expansion; and
- 30 MW in additional load from medium sized customer developments.

Committed spot loads are still included in the low demand forecast scenario as these represent projects that are sufficiently advanced in the connection process where there is a reasonably high level of confidence that the additional demand will go ahead.

The low forecast does assume that major NSW government infrastructure developments in Sydney that have already commenced are abandoned (eg, Westconnex and Sydney Metro), which is considered unrealistic.

Appendix D – Specific approaches to assessing net market benefits

This section largely repeats the material contained in section 7 of the PADR and has been included in-part to satisfy NER clause 5.16.4(v)(1).

TransGrid and Ausgrid consider that for this particular RIT-T, the following categories of market benefit are likely to be material:

- changes in involuntary load shedding through reduced unserved energy; and
- changes in network losses.

Categories of market benefit under the RIT-T are considered material where they are likely to affect the identification of the preferred option.

One of the benefits of addressing the identified need will be the avoided operating and maintenance costs as well as the lower cost of complying with environmental obligations associated with continued use of oil-filled cables. Reductions in these costs are not captured under the prescribed RIT-T 'market benefit' categories but, instead, are included in the RIT-T assessment as reduced costs relative to the base case. Section D3 below outlines the approach taken to estimating these reduced costs.

All other categories of market benefit under the RIT-T are unlikely to be material in relation to the RIT-T assessment for all options. This is discussed in section D5 below.

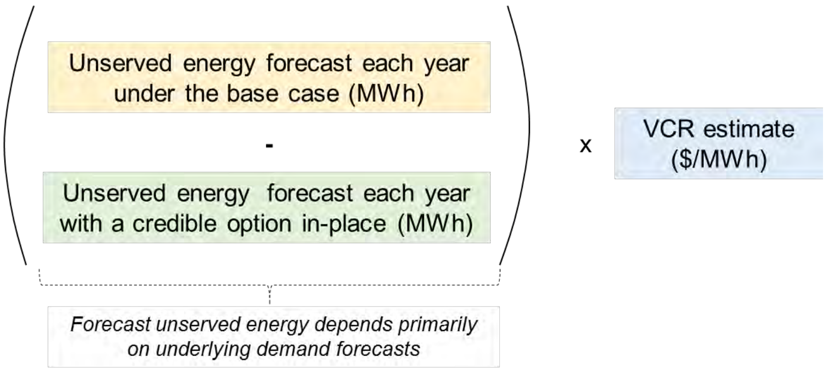
In addition, Section 5 of the PADR summarised the non-network assessment methodology that TransGrid and Ausgrid have applied in investigating non-network solutions. Responses to a variety of points raised on this approach in submissions to the PADR are summarised in section 4.

D1 Approach to estimating the market benefit from changes in involuntary load shedding through reduced unserved energy

The ageing oil-filled cables in Inner Sydney are at a stage in their technical life where they are associated with an increasing likelihood of failure. When a failure occurs the cable is required to be out of service for lengthy periods to enable repairs, generally up to 3 months but can be longer for difficult locations. This increases the chances that these network elements are out of service when failure of another network element occurs, which may result in undelivered, or 'unserved', energy. Electricity consumers in Inner Sydney are therefore becoming increasingly vulnerable in terms of the expected level of disruption to their electricity supply unless one of the credible options is put in place to protect against the chance of this unserved energy.

The figure below illustrates how the market benefit associated with changes in involuntary load shedding through reduced unserved energy is calculated under the RIT-T.

Figure D-1 Estimation of the market benefit from changes in involuntary load shedding through reduced unserved energy



This section outlines the approach TransGrid and Ausgrid have taken to valuing changes in involuntary load shedding through reduced unserved energy, both in terms of forecasting the change in unserved energy (in MWh) and how this change is valued (i.e., the VCR).

D1.1 Calculation of change in unserved energy (in MWh)

A key benefit for this RIT-T is the reduction in the amount of expected unserved energy in Inner Sydney going forward under each of the credible options.

TransGrid and Ausgrid consider that a key determinant of the reductions in unserved energy that the credible options afford is the underlying demand forecast going forward (as outlined in the figure above). In order to ensure the assessment is robust, TransGrid and Ausgrid have investigated a range of maximum demand forecasts. Specifically, maximum demand forecasts of POE10, POE50 and POE90 have been investigated as part of the scenario analysis for this RIT-T.

The forecast unserved energy used in the NPV modelling has been calculated by tallying selected critical system states that result in the inability of the network to service the required load.

This calculation has been done for half hourly load intervals during a financial year, then scaled by the maximum demand forecast to evaluate future load. For each critical system state, the unserved energy has been determined based on the network topology, equipment availability, load level and system capacity.

The expected unserved energy has been calculated using approximately 1600 contingency states, which were selected on the basis of network impact and likelihood of occurring.

TransGrid and Ausgrid have used a historical yearly load profile (2013/14) to calculate the unserved energy, which is illustrated in Section 3.4 of the PSCR (along with an Inner Sydney typical summer day of maximum demand in 2013/14 and the Inner Sydney load duration curve). in response to a submission to the PADR, we have elaborated in Section 4.2 on why this approach was taken, why its considered to be reasonable and what the implications of adopting a more recent load profile are.

D2 Approach to estimating the market benefit from changes in network losses

Whenever electricity is transported through transmission and distribution lines a portion of it is 'lost' in the process. Any credible option that changes the way in which electricity is transported through these lines consequently affects the amount of electricity that is lost and hence the amount that needs to be produced by generators in order to satisfy demand. The credible network options outlined in section 3 all result in less losses than would occur if nothing was done since they essentially involved replacing 10 old, ageing 132 kV oil-filled cables (which have higher losses) with two new 330kV XLPE cables.

The losses are calculated by the multiplication of the forecast yearly energy consumption (GWh) within Transmission corridor 1 (TC1)[77] and the loss factor. The loss factor is calculated using the equation below based on the average demand. This approximation approach is considered appropriate since the total market benefits of each option are almost exclusively driven by reductions in unserved energy (see NPV results in section 5.1) and so a more detailed approach to estimating network losses will not result in any change to the ranking of credible options and the selection of the preferred option.

$$Loss\ Factor = \frac{Total\ MW\ Supply\ to\ Cutset\ 1 - Total\ MW\ Demand\ within\ cutset\ 1}{Total\ MW\ Supply\ to\ Cutset\ 1}$$

These estimates have then been used to calculate the difference in losses (in MWh) between the base case and with each option in place.

TransGrid and Ausgrid have applied an annual value of losses ($66/MWh)reflecting the average short-run marginal cost (SRMC) of generation in New South Wales, to the annual MWh difference in losses, in order to estimate the value of the change in losses for each. This figure has been calculated by HoustonKemp and is the 2016 demand-weighted average fuel price for the NEM.

77 TC1 includes TransGrid's 330 kV cables 41 and 42, as well as a number of parallel Ausgrid 132 kV cable circuits supplying Inner Sydney area.

D3 Approach to valuing the benefit from avoided cable repairing and maintenance costs

One of the benefits of addressing the identified need is the avoided operating and maintenance costs associated with continued use of oil-filled cables. In particular, if nothing is done and the ageing cables are kept in-service, then consumers will continue to pay for the costs associated with repairing and maintaining these cables, which will escalate due to the deteriorating condition of these cables. For each credible option that retires these cables, there is therefore a benefit associated with avoiding these costs once these cables are retired.

Reductions in these costs are not captured under the prescribed RIT-T 'market benefit' categories but, instead, have been included in the RIT-T assessment as reduced costs relative to the base case. The specific approach adopted by TransGrid and Ausgrid has been to develop probability-weighted annual operating and maintenance costs based on the likelihood of repairs being required.

Appendix E to the PADR shows the results of this probabilistic assessment.

D4 Approach to valuing the benefit from the avoided cost of complying with environmental obligations

Another benefit associated with addressing the identified need is the lower financial cost of complying with environmental obligations associated with the continued use of oil-filled cables. If nothing is done and the ageing cables are kept in-service, then they can be expected to fail more frequently going forward due to their condition. When these old oil-filled cables fail it often results in oil leaks that require costs associated with remediating any affected areas (which may include waterways). For each credible option that retires these cables, there is therefore a benefit associated with avoiding these remediation costs once these cables are retired.

TransGrid and Ausgrid have included an environmental remediation cost associated with each cable failure type under the base case. These costs appear in the base case and each option up until the point that Ausgrid cables and/or Cable 41 are retired, i.e., there is assumed to be a cost savings for options relative to the base case associated with retiring these old oil-filled cables (the magnitude of this saving in NPV terms depends on when cables are retired under each option).

There are different ways of valuing environmental impacts and the RIT-T places restrictions how this is done. In particular, while leaky oil-filled cables have the potential to cause widespread damage to the environment, the cost of avoiding this can only be included in the analysis insofar as it is readily quantifiable by reference to an actual financial cost. For this RIT-T, these avoided financial costs have been included under the 'cost of complying with laws, regulations and applicable administrative requirements'.

D5 Classes of market benefits not expected to be material

TransGrid and Ausgrid consider that all categories of market benefit under the RIT-T besides 'changes in involuntary load shedding through reduced unserved energy' and 'changes in network losses' are unlikely to be material in relation to the RIT-T assessment for all options.[78]

This section re-presents the reasons from the PSCR (and PADR) as to why all other categories of market benefit are not considered material for this RIT-T. No parties commented on these reasons in submissions.

TransGrid and Ausgrid notes that the NER clearly prescribe the categories of market benefits that can be estimated in a RIT-T.[79] This section therefore limits its scope to those market benefits and does not comment on any benefits that may fall outside of this.

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[78] In accordance with NER clause 5.16.4(k)(5).

[79] NER, 5.16.1(4).

D5.1 Market benefits relating to the wholesale market

The AER has recognised that if the proposed investment will not have an impact on the wholesale market, then a number of classes of market benefits will not be material in the RIT-T assessment and so do not need to be estimated.[80]

The credible network options described in section 3 do not address network constraints between competing generating centres and are therefore not considered to result in any change in dispatch outcomes and wholesale market prices.

TransGrid and Ausgrid therefore consider that the following classes of market benefits are not material for this RIT-T assessment for any of the credible network options:

- changes in fuel consumption arising through different patterns of generation dispatch;
- changes in voluntary load curtailment (since there is no impact on pool price);
- changes in costs for parties, other than for TransGrid and Ausgrid (since there will be no deferral of generation investment);
- changes in ancillary services costs; and
- competition benefits.

D5.2 Differences in the timing of unrelated expenditure

TransGrid and Ausgrid do not consider that any of the credible options for this RIT-T will affect the timing of other transmission or distribution investments (to meet unrelated needs).

D6 Option value

The AER's is view that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available in the future is likely to change and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[81]

There is uncertainty regarding future demand in Inner Sydney since a large component of it is driven by significant new customer connections. In the future, new information may result in changes to the volume and impact of new customer connections which would lead to changes in the demand forecast. However, the primary driver of the identified need in this RIT-T is the fact that certain fluid-filled cables owned by TransGrid and Ausgrid are ageing and consequently deteriorating in condition, which is known with a high degree of certainty and is unlikely to change going forward.

The AER's view is that appropriate identification of credible options and reasonable scenarios captures any option value, thereby meeting the NER requirement to consider option value as a class of market benefit under the RIT-T. TransGrid and Ausgrid have incorporated several reasonable scenarios in conducting the RIT-T analysis, which reflect differences in the future level of expected spot load development, amongst other factors.

TransGrid and Ausgrid note that options that involve staging have been considered in this RIT-T (ie, options 1, 2A, 2B, 4 and 8 all involve staging). For these options, in scenarios in which demand turns out to be low, the assumed timing of the second stage has been deferred. Therefore these options have already captured some 'option value' of being able to delay future elements of capex, if it turns out that future demand is lower than the current central scenario.

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80 AER, Final Regulatory Investment Test for Transmission Application Guidelines, June 2010, version 1, p 15.

81 AER, Final Regulatory Investment Test for Transmission Application Guidelines, June 2010, version 1, p. 39 & 75.

Appendix E – Summary of, and commentary on, the submissions to the PSCR

The PSCR released in October 2016 called for submissions from interested parties regarding the credible options presented by TransGrid and Ausgrid, and from proponents of alternative potential credible options that met the technical characteristics. Further, in November 2016, a Powering Sydney's Future workshop was held for our stakeholders, which included a dedicated non-network options session for potential non-network service providers.

This section summarises the submissions received. It repeats the material contained in section 4 of the PADR and has been included in-part to satisfy NER clause 5.16.4(v)(1).

E1 Summary of submissions received on non-network solutions

In response to the PSCR, TransGrid and Ausgrid received enquiries from several non-network service providers and in December 2016, as requested by potential non-network service providers, extended the submission deadline to February 2016.

In total eleven submissions were received from the following service providers:

1. AGL Energy Ltd
2. Beijing Hyper Strong Technology Co Ltd
3. BuildingIQInc
4. City of Sydney Council
5. EnergyAustralia Home Services Pty Ltd
6. ERM Power Retail Pty Ltd
7. Jones Lang LaSalle IP Inc
8. Origin Energy Retail Ltd
9. Planet Ark Power, received 5 February 2016
10. Pooled Energy Pty Ltd
11. RES Australia Pty Ltd

TransGrid and Ausgrid have jointly assessed the viability of these submissions for the Inner Sydney area. We have engaged with the proponents to determine the reliability, viability, and technical feasibility of their solutions. We have also used the indicative rates – establishment, availability, and dispatch fees – provided by the proponents to determine the desktop feasibility of non-network options.

The rates provided were indicative (non-binding) and the submissions are subject to commercial confidentiality agreements for customer privacy. Due to the magnitude of the non-network requirement, it is acknowledged that some non-network capacities are largely based on customer acquisition projections rather than existing firm capability. For these reasons, details from individual submissions are not provided in the PADR.

E2 Summary of submissions received on other aspects of this RIT-T

There were no other submissions received on any other aspect of this RIT-T outlined in the PSCR; such as the credible network options proposed, the materiality of the market benefits expected, the failure rates of existing ageing cables, the approach to valuing customer reliability or the approach to proxying a commercial discount rate.

Appendix F – NPV results

Scenario breakdowns - all figures are 2017/18 $m

Central scenario

Option	Benefit of reduced EUE by Network Development	Benefit of reduced Operating & Maintenance Risk Cost	Benefit of reduced Environmental Risk Cost	Changes in network losses	Benefit of Reduced EUE by DM	Network Development Cost	Non-Network Cost	Cable Decommissioning Cost	Net benefits
Option 1	$7,189	$29	$4	$0	$10	-$208	-$7	-$9	$7,008
Option 2A	$7,193	$28	$4	$0	$10	-$205	-$7	-$9	$7,014
Option 2B	$7,199	$29	$4	$0	$10	-$234	-$7	-$9	$6,991
Option 3A	$7,204	$29	$4	$0	$10	-$230	-$7	-$9	$7,000
Option 3B	$7,204	$29	$4	$0	$10	-$231	-$7	-$9	$6,999
Option 4	$7,174	$25	$3	$0	$10	-$249	-$7	-$7	$6,949
Option 5	$7,181	$26	$3	$0	$10	-$259	-$7	-$7	$6,947
Option 6	$7,175	$25	$3	$0	$10	-$242	-$7	-$7	$6,957
Option 7	$7,187	$27	$3	$0	$19	-$210	-$15	-$8	$7,003
Option 8	$7,177	$27	$3	$0	$17	-$191	-$13	-$8	$7,012

High scenario

Option	Benefit of reduced EUE by Network Development	Benefit of reduced Operating & Maintenance Risk Cost	Benefit of reduced Environmental Risk Cost	Changes in network losses	Benefit of Reduced EUE by DM	Network Development Cost	Non-Network Cost*	Cable Decommissioning Cost	Net benefits
Option 1	$75,160	$40	$5	$0	$0	-$207	-$8	-$10	$74,980
Option 2A	$75,158	$39	$5	$0	$0	-$205	-$8	-$10	$74,980
Option 2B	$75,165	$39	$5	$0	$0	-$214	-$8	-$10	$74,976
Option 3A	$75,163	$40	$5	$0	$0	-$203	-$8	-$10	$74,988
Option 3B	$75,165	$39	$5	$0	$0	-$202	-$8	-$10	$74,988
Option 4	$75,157	$38	$5	$0	$0	-$306	-$8	-$10	$74,877
Option 5	$75,157	$38	$5	$0	$0	-$305	-$8	-$10	$74,877
Option 6	$75,159	$38	$5	$0	$0	-$300	-$8	-$10	$74,884
Option 7	$75,128	$37	$5	$0	$0	-$187	-$16	-$10	$74,957
Option 8	$75,123	$37	$5	$0	$0	-$194	-$14	-$10	$74,948

Low scenario

Option	Benefit of reduced EUE by Network Development	Benefit of reduced Operating & Maintenance Risk Cost	Benefit of reduced Environmental Risk Cost	Changes in network losses	Benefit of Reduced EUE by DM	Network Development Cost	Non-Network Cost*	Cable Decommissioning Cost	Net benefits
Option 1	$113	$22	$3	$0	$0	-$174	-$7	-$7	-$51
Option 2A	$115	$21	$3	$0	$0	-$178	-$7	-$7	-$54
Option 2B	$120	$22	$3	$0	$0	-$220	-$7	-$8	-$90
Option 3A	$127	$22	$3	$0	$0	-$241	-$7	-$8	-$104
Option 3B	$127	$22	$3	$0	$0	-$242	-$7	-$8	-$105
Option 4	$101	$16	$2	$0	$0	-$159	-$7	-$3	-$50
Option 5	$105	$16	$2	$0	$0	-$164	-$7	-$4	-$51
Option 6	$103	$16	$2	$0	$0	-$157	-$7	-$3	-$46
Option 7	$127	$20	$3	$0	$0	-$217	-$14	-$7	-$88
Option 8	$115	$20	$2	$0	$0	-$160	-$12	-$7	-$42

** Please note that the non-network costs for all options under the low and high scenarios have been assumed to equal those of the central scenario. While, under both these scenarios, the actual non-network costs will be different to the central scenario (both in the 'interim' and for 'deferral'), TransGrid and Ausgrid note that the overall costs are not expected to be materially different between options and so are not expected to affect the overall conclusions, ie, that all options are ranked equally and that Option 8 is preferred for 'optionality' reasons. TransGrid and Ausgrid note that the cost of non-network solutions will be further informed, and ultimately known with a high degree of confidence, following the formal RFT process TransGrid will shortly commence (as detailed in the PACR).*