Transgrid

People. Power. Possibilities.

Managing risk on Line 86 (Tamworth – Armidale)

RIT-T – Project Specification Consultation Report

Region: Northern New South Wales

Date of issue: 1 December 2021

Disclaimer

This suite of documents comprises Transgrid's application of the Regulatory Investment Test for Transmission (RIT-T) which has been prepared and made available solely for information purposes. It is made available on the understanding that Transgrid and/or its employees, agents and consultants are not engaged in rendering professional advice. Nothing in these documents is a recommendation in respect of any possible investment.

The information in these documents reflect the forecasts, proposals and opinions adopted by Transgrid as at November 2021 other than where otherwise specifically stated. Those forecasts, proposals and opinions may change at any time without warning. Anyone considering information provided in these documents, at any date, should independently seek the latest forecasts, proposals and opinions.

These documents include information obtained from the Australian Energy Market Operator (AEMO) and other sources. That information has been adopted in good faith without further enquiry or verification. The information in these documents should be read in the context of the Electricity Statement of Opportunities, the Integrated System Plan published by AEMO and other relevant regulatory consultation documents. It does not purport to contain all of the information that AEMO, a prospective investor, Registered Participant or potential participant in the National Electricity Market (NEM), or any other person may require for making decisions. In preparing these documents it is not possible, nor is it intended, for Transgrid to have regard to the investment objectives, financial situation and particular needs of each person or organisation which reads or uses this document. In all cases, anyone proposing to rely on or use the information in this document should:

1. Independently verify and check the currency, accuracy, completeness, reliability and suitability of those information
2. Independently verify and check the currency, accuracy, completeness, reliability and suitability of reports relied on by Transgrid in preparing these documents
3. Obtain independent and specific advice from appropriate experts or other sources.

Accordingly, Transgrid makes no representations or warranty as to the currency, accuracy, reliability, completeness or suitability for particular purposes of the information in this suite of documents.

Persons reading or utilising this suite of RIT-T-related documents acknowledge and accept that Transgrid and/or its employees, agents and consultants have no liability for any direct, indirect, special, incidental or consequential damage (including liability to any person by reason of negligence or negligent misstatement) for any damage resulting from, arising out of or in connection with, reliance upon statements, opinions, information or matter (expressed or implied) arising out of, contained in or derived from, or for any omissions from the information in this document, except insofar as liability under any New South Wales and Commonwealth statute cannot be excluded.

Privacy notice

Transgrid is bound by the *Privacy Act 1988 (Cth)*. In making submissions in response to this consultation process, Transgrid will collect and hold your personal information such as your name, email address, employer and phone number for the purpose of receiving and following up on your submissions.

Under the National Electricity Law, there are circumstances where Transgrid may be compelled to provide information to the Australian Energy Regulator (AER). Transgrid will advise you should this occur.

Transgrid's Privacy Policy sets out the approach to managing your personal information. In particular, it explains how you may seek to access or correct the personal information held about you, how to make a complaint about a breach of our obligations under the Privacy Act, and how Transgrid will deal with complaints. You can access the Privacy Policy here (https://www.Transgrid.com.au/Pages/Privacy.aspx).

Executive summary

We are applying the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating the risks we, and ultimately our downstream consumers, face as a consequence of the condition of the transmission poles that form part of one of the two key 330 kV lines running between Tamworth and Armidale (Line 86). Specifically, many of the poles on Line 86 have wood rot that, if unaddressed, means they are more susceptible to failure (e.g., during high wind events), which creates significant risks in our network (primarily bushfire risk).

While all of the credible options considered in this assessment mitigate these risks, they also have the potential to provide varying levels of additional wider wholesale market benefits through increasing the network transfer capacity between Tamworth and Armidale, relative to if no action is taken. These expected wider wholesale market benefits are due to the interaction with the nearby Queensland to New South Wales Interconnector (QNI), which is currently being upgraded, as well as the New England Renewable Energy Zone (REZ) around Armidale, which is being progressed under the NSW Government's Electricity Infrastructure Roadmap.

Identified need: managing risks in our network, while providing the greatest overall net benefit to the market

Given the increasing rate of defect issues on Line 86's wooden poles, we consider it is likely that all the structures on Line 86 are exhibiting various forms of decay, which is only expected to worsen over time. In addressing the condition issues on Line 86, an opportunity exists to provide extra capacity in this region of our network and, in doing so, address potential future constraints in the network and facilitate conditions that enable market benefits to be derived, associated with new generation and storage within the NEM.

We have therefore commenced this RIT-T to assess options to address the asset condition issues identified on Line 86, while also providing the greatest overall net benefit to the market over the long-term through increasing the transfer capacity between Armidale and Tamworth, relative to if no action is taken.

We consider this a 'market benefits' driven RIT-T, as opposed to a 'reliability corrective action', and expect the ultimately preferred option to have significantly positive expected net market benefits.

We propose to assess three credible network options

We have identified three network options that we consider meet the identified need for this RIT-T, as summarised in Table E-1 below.

Table E-1 – Summary of the credible options

Option	Description	Estimated capex ($2020/21)	Expected build time	Expected transfer improvement (relative to the base case)
1	Replace Line 86 like for like in-situ utilising concrete or steel poles, keeping the existing twin lime conductor and single circuit configuration, while maintaining the overall design temperature at 100°C.	95.7	3 – 4 years	280 MW
2	Rebuild Line 86 as double circuit, strung on one side initially with twin olive conductors and a 120°C design temperature along a new easement parallel to the original Line 86 (which is then removed). The other side to be strung at a later date as needed.	267.4 for the initial build. 60.2 for stringing the second side, when needed.	3 – 4 years for the initial build. 1 year for stringing the second side.	280 MW for the initial build. An additional 350 MW once the second side is strung
3	Rebuild Line 86 as a double circuit with twin olive conductors and a 120°C design temperature along a new easement parallel to the original Line 86 (which is then removed).	315.4	3 – 4 years	630 MW

Non-network options may be able to be paired with network options to help address the identified need

We consider that non-network options may be able to assist with meeting the identified need in combination with Option 1 or Option 2 (ahead of the second circuit being strung). Specifically, we consider that non-network technologies may be able to be coupled with single-circuit network options to provide an increase in transfer capacity and avoid (or defer) the need to build a second circuit.

However, we note that the cost of the network options effectively bounds the scope for any non-network options to be considered commercially feasible under the RIT-T. Specifically, the cost difference between Option 1 (maintaining a single-circuit 330 kV line) and Option 3 (a new double-circuit 330 kV line) of approximately $220 million serves as an indicative cost threshold for the provision of 350 MW of additional transfer capacity (i.e., the additional transfer capacity Option 3 provides over Option 1). While we consider this an ambitious cost for the provision of approximately 350 MW of additional transfer capacity from non-network solutions (e.g., through the use of a Virtual Transmission Line (VTL)), we are interested in hearing from proponents on their individual solutions and costs (including for smaller sized options).

We do not consider that non-network solutions can address the identified need as standalone options, since a key focus of the identified need is to address the asset condition issues on Line 86 and the risk they pose (most relevantly bushfire risk). Moreover, standalone non-network options that result in the existing line being decommissioned, and no replacement line being built, would not meet the required 'N-1' level of reliability in this area of the network[1] and so are not considered technically feasible.

[1] IPART, *Electricity transmission reliability standards*, Final Report, August 2016, pp. 72-73.

Wholesale market modelling will be adopted for the PADR analysis

The options considered are expected to affect outcomes in the wholesale market, relative to the base case, particularly for those options that increase the operating capacity of the current Line 86. This additional capacity is expected to provide for more efficient outcomes in the wholesale market through increasing the output available from the nearby QNI and New England REZ.

We expect the following seven categories of market benefit to be estimated using wholesale market modelling as part of the PADR:

- changes in fuel consumption arising through different patterns of generation dispatch;
- changes in price-responsive voluntary load curtailment;
- changes in involuntary load shedding;
- avoided/deferred capital and operating expenditure associated with new generation/storage in the NEM;[2]
- differences in the timing of unrelated transmission expenditure (eg, intra-regional transmission investment associated with the development of REZs); and
- changes in network losses.

In addition, we may investigate 'competition benefits' under the RIT-T further as part of the PADR assessment and, specifically, if the expected impact on QNI/New England REZ capacity may affect the level of competition between generating centres in the NEM.

We note the importance of ensuring that the outcome of this RIT-T assessment is robust to different assumptions about how the energy sector may develop in the future. We are intending to model the market benefits of the credible options across different scenarios as part of the PADR. These scenarios will be based on those consulted on and summarized in the 2021 Inputs, Assumptions and Scenarios report (IASR) released by AEMO in July 2021, which are also to be used in the forthcoming 2022 Integrated System Plan (ISP). These scenarios reflect a broad range of potential outcomes across the key uncertainties that are expected to affect the future market benefits of the investment options being considered. We are also expecting to use the optimal development path identified by AEMO in the forthcoming draft 2022 ISP (expected to be released on 10 December 2022) as part of the PADR modelling.

Submissions and next steps

We welcome written submissions on materials contained in this PSCR. Submissions are particularly sought on the credible options presented and from potential proponents of non-network options that could meet the technical requirements set out in this PSCR. Submissions are due on 1 March 2022.

Submissions should be emailed to Transgrid's Regulation team via regulatory.consultation@transgrid.com.au.[3] In the subject field, please reference 'Line 86 PSCR.'

[2] Referred to as 'changes in costs for parties, other than for Transgrid, due to differences in the timing of new plant, capital costs and operating and maintenance costs' under the RIT-T.

[3] Transgrid is bound by the Privacy Act 1988 (Cth). In making submissions in response to this consultation process, Transgrid will collect and hold your personal information such as your name, email address, employer and phone number for the purpose of receiving and following up on your submissions. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement. See Privacy Notice within the Disclaimer for more details.

At the conclusion of the consultation process, all submissions received will be published on Transgrid's website. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement.

Subject to any additional credible options being identified, we anticipate publication of a PADR in early 2022.

Contents

List of Tables

List of Figures

1. Introduction

This Project Specification Consultation Report (PSCR) represents the first step in the application of the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating the risks we, and ultimately our downstream consumers, face as a consequence of the condition of the transmission poles that form part of one of the two key 330 kV transmission lines running between Tamworth and Armidale (Line 86). The condition of these wood poles primarily gives rise to bushfire risks.

While all of the credible options mitigate these risks, they also have the potential to provide varying levels of additional wider wholesale market benefits, through increasing the network transfer capacity between Tamworth and Armidale. These expected wider wholesale market benefits are due to the interaction with the nearby Queensland to New South Wales Interconnector (QNI), which is currently being upgraded, as well as the New England Renewable Energy Zone (REZ) around Armidale, which is being progressed under the NSW Government's Electricity Infrastructure Roadmap.

Line 86 is 111 km in length and was constructed in 1982 using mostly composite wood pole structures.[4] Wood rot beneath the metal sleeve cylinder that holds the two wooden pole sections together (referred to as a pole 'joint sleeve') is prevalent across the line and we have replaced 26 structures with concrete poles since 2011 due to condition related issues, which represents 6 per cent of the overall number of wood poles on Line 86. In addition, we have identified a further ten wood poles over the course of 2021 that require future replacement due to condition issues within the next year.

There was one structure failure in April 2020 due to wood rot deteriorating pole strength to below that required to withstand a strong wind event. While there were no customer interruptions due to the time of year the failure occurred (i.e., being outside of the peak summer period), it did limit the transfer capability across the QNI interconnector due to Line 86 being out of service while the pole was remediated. Specifically, Line 86 was out of service for a total of five days and the average import limit on QNI was reduced by approximately 822 MW, while the average export limit was reduced by approximately 264 MW.

Line 86 is the only 330 kV line in our network not constructed using steel towers or steel/concrete poles. Due to its composite wood pole construction, Line 86 was designed and constructed to a lower set of wind design criteria more comparable to other lower capacity Transgrid wood pole lines, rather than the criteria applied to 330 kV steel towers. Its construction utilises shorter span lengths and a smaller lighter weight twin 'lime'[5] aluminium conductor, steel reinforced (ACSR) conductor (compared to typical conductors used on other Transgrid 330 kV lines), which in turn reduces the rating of the line.

We have undertaken preliminary planning studies that show there are expected to be net market benefits from replacing the ageing line with a more modern line, constructed to higher design criteria, consistent with the rest of our 330 kV network. Moreover, we consider that there may be an opportunity to augment the capacity of this region of our network and potentially add to the expected net benefits, in light of the expected future upgrades to the QNI as well as the nearby New England REZ.

4 A short section (3.72km) of the line outside Tamworth is constructed on steel towers.

5 A 'lime' conductor has strand sized at 30 / 7/ 3.5mm. This compares to 'mango' conductors that have strand sized at 54 /7/3.00mm and 'olive' conductors that have strand sized at 54 /7/3.50mm. The stranding gives the number and diameter of aluminium and steel strands, e.g. lime 30 / 7/ 3.5mm means 30 strands of aluminium and 7 strands of steel, all 3.5mm in diameter.

This RIT-T therefore examines various network and non-network options for addressing the asset condition issues identified on Line 86, while providing the greatest net benefit to the market over the long-term.

1.1. Purpose

The purpose of this PSCR is to:

- set out the reasons why we propose that action be undertaken (that is, the 'identified need');
- present the options that we currently consider would address the identified need;
- outline the technical characteristics that non-network options would need to provide;
- summarise how we intend to assess options for addressing the identified need in the Project Assessment Draft Report (PADR); and
- allow interested parties to make submissions and provide input to the RIT-T assessment.

1.2. Submissions and next steps

We welcome written submissions on materials contained in this PSCR. Submissions are particularly sought on the credible options presented and from potential proponents of non-network options that could meet the technical requirements set out in this PSCR. Submissions are due on 1 March 2022.

Submissions should be emailed to Transgrid's Regulation team via regulatory.consultation@transgrid.com.au.[6] In the subject field, please reference 'Line 86 PSCR.'

At the conclusion of the consultation process, all submissions received will be published on Transgrid's website. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement.

Subject to any additional credible options being identified, we anticipate publication of a PADR in early 2022.

[6] Transgrid is bound by the Privacy Act 1988 (Cth). In making submissions in response to this consultation process, Transgrid will collect and hold your personal information such as your name, email address, employer and phone number for the purpose of receiving and following up on your submissions. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement. See Privacy Notice within the Disclaimer for more details.

2. The identified need

2.1. Background

This section outlines two key sets of information as important background to the identified need for this RIT-T. It first outlines the condition issues with poles on Line 86 that are expected to expose Transgrid and its customers to unacceptable levels of risk going forward if unaddressed. It then outlines the key position of Line 86 in our network and how upgrading the capacity of the line is expected to also provide wider wholesale market benefits (i.e., in addition to the avoided risk).

2.1.1. Pole condition issues resulting in an unacceptable level of risk

Line 86 is a 330 kV single-circuit line, running between Tamworth and Armidale (111 km), and was constructed in 1982 using mostly composite wood pole[7] structures.[8]

Line 86 is the only 330 kV line in our network that was not constructed using steel towers. Due to its composite wood pole construction, Line 86 was designed and constructed to a lower set of wind design criteria more comparable to other lower capacity Transgrid 132kV wood pole lines than the criteria applied to 330 kV steel towers. Its construction utilises shorter span lengths and a smaller lighter weight twin 'lime' ACSR conductor (compared to typical 'mango'/'olive' conductors used on other Transgrid 330 kV lines), which reduces the rating of the line.

Wood rot beneath the composite pole joint sleeve is prevalent throughout the composite wooden poles that are utilised along the line. We have replaced 26 structures with concrete poles since 2011 due to condition related issues, which represents 6 per cent of the overall number of wood poles on Line 86.

Figure 2-1 shows an example of wood rot on one of the poles that required replacing.

Figure 2-1: Example of wood rot on Line 86

[7] A composite wood pole consists of a two-piece pole arrangement that is held together by a metal cylinder/sleeve.
[8] A short section (3.72km) of the line outside Tamworth is constructed on steel towers.

We undertake frequent monitoring and condition reporting on Line 86, which has consistently identified issues with wood decay beneath the composite pole joint sleeves. For example, in 2011, twenty two structures were identified to be defective and required replacement due to condition related issues. Further, in the past two years, an additional four defective poles have had to be replaced and, over the course of 2021, we have identified a further ten wood pole structures that require replacement over the next year due to the condition issues.

Defective wood poles are ideally identified and replaced before they fail structurally. However, sometimes poles fail before defects are able to be identified and/or the poles replaced. For example, in April 2020, we had a pole structurally fail due to wood rot deteriorating pole strength to below that required to withstand a strong wind event. While there were no customer interruptions due to the time of year the failure occurred (i.e., being outside of the peak summer period), it did limit the transfer capability across the QNI interconnector due to Line 86 being out of service while the pole was remediated. Line 86 was out of service for a total of five days and the average import limit on QNI tightened by approximately 822 MW, while the average export limit tightened by approximately 264 MW.

The condition of the wood poles on Line 86 featured in the NSW Government's 2020 Bushfire Inquiry. Specifically, the Inquiry heard that the capacity of the QNI interconnector relies in part on wood power poles and stated that "the QNI is a vital asset and should be made more resilient through the replacement of the timber poles with suitable alternatives that are more fire resistant." This statement reinforces the identified need for this RIT-T.[9]

The location of Line 86 means that investment can also provide wider wholesale market benefits.

Figure 2-2 illustrates the location of Line 86 in our Northern NSW transmission network, i.e., running between Armidale and Tamworth.

9 Final Report of the NSW Bushfire Inquiry, 31 July 2020, p. 327 – available at: https://www.dpc.nsw.gov.au/assets/dpc-nsw-gov-au/publications/NSW-Bushfire-Inquiry-1630/Final-Report-of-the-NSW-Bushfire-Inquiry.pdf.

Figure 2-2: Northern NSW transmission network

Line 86 is a critical transmission line in the evolving National Electricity Market (NEM) and there are expected to be material wholesale market benefits from expanding its transfer capacity in light of future wholesale market developments. Specifically:

- with Liddell Power Station, shown at the bottom of Figure 2-2, retiring in April 2023, Line 86 will transfer more power from Queensland and Northern NSW to supply major load centres in NSW (and elsewhere in the NEM);
- the New England REZ, shown in light blue in Figure 2-2, is to be developed in the area surrounding Armidale as part of the NSW Government's Electricity Strategy and Electricity Infrastructure Roadmap and is planned to support the development of up to 8,000 MW of renewable generation capacity,[10] which will rely in part on Line 86 to transmit this electricity to the wider NEM; and
- following the completion of the QNI minor upgrade (a now committed transmission project), in July 2022,[11] the lines between Tamworth and Armidale will be the main constraint in the sharing of capacity between NSW and Queensland. In the event of a failure of Line 86, significant operating constraints will need to be applied on QNI to manage the next credible contingency (the trip of the remaining Armidale-Tamworth line) that would result in separation of Queensland and northern NSW from mainland NEM.

We have undertaken preliminary modelling that shows there is an opportunity to address both the existing asset condition issues on Line 86 and to augment the transfer capacity of this region of our network to provide wider wholesale market benefits to the NEM as it evolves. The notional transfer capacity increases

[10] https://www.energy.nsw.gov.au/renewables/renewable-energy-zones

[11] AEMO, *2021 Inputs, Assumptions and Scenarios Report*, July 2021, p. 126.

for each of the options in this report are a result of our modelling of the thermal limitations under each option, as well as the base case.

2.2. Description of the 'identified need'

Given the increasing rate of defect issues, including required pole replacements, and past experience with composite wood pole structures, we consider it is likely that all the structures on Line 86 are exhibiting various forms of decay, which is only expected to worsen over time. The benefit expected from addressing these issues proactively (i.e., ahead of when they fail) is expected to far exceed the replacement costs.

In addressing the condition issues on Line 86, an opportunity exists to provide extra capacity in this region of our network, and in doing so address the potential for future constraints in the network and facilitate conditions that enable greater access to market benefits associated with new generation and storage within the NEM.

We have therefore commenced this RIT-T to assess options to address the asset condition issues identified on Line 86, while also providing the greatest overall net benefit to the market over the long-term through potentially increasing the transfer capacity between Armidale and Tamworth.

We consider this a 'market benefits' driven RIT-T, as opposed to a 'reliability corrective action', and expect the ultimately preferred option to have positive expected net market benefits.

2.3. Assumptions underpinning the identified need

Key assumptions underpinning the identified need relate to the estimated risk cost associated with the deterioration in the condition of the composite wood poles utilised for Line 86 and the assumed impact of an increase in the capacity of the line, or of a non-network option, on the wider NEM, through its impact on improving transfer capacity between Armidale and Tamworth.

This section describes the assumptions underpinning our assessment of the base case risk costs, i.e., the value of the risk avoided by undertaking the credible options below. While the aggregate risk cost is currently estimated at around $0.6 million/year, it is expected to increase rapidly going forward if action is not taken and the poles are left to deteriorate further (reaching approximately $13.5 million/year by 2044/45).

The wider wholesale market benefits from augmenting the capacity of the line will be assessed through wholesale market modelling in the PADR, which will draw on the latest AEMO Inputs, Assumptions and Scenarios report (IASR) released in July 2021. Our proposed approach to undertaking this component of the RIT-T assessment is outlined in section 6.3.

2.3.1. Bushfire risk

This risk refers to the consequence to the community of an asset failure that results in a bushfire starting. We have recently undertaken assessment with the University of Melbourne to improve our quantification of bushfire risks across our network, including the moderation of risk costs.

Our new model uses an electricity industry-developed approach to increase consistency with other networks. The model:

- models the potential spread from a fire started at each asset in the network using recognised fire modelling software;
- calculates the consequence based on the number of houses, agricultural and forestry land use (and other infrastructure in the predicted burn area); and
- moderates the consequence using a statistical distribution of fire conditions across the year to come up with a most likely consequence to be used in the investment decision.

Bushfire risk is the largest of all risks quantified under the base case for this RIT-T, making up approximately 56 per cent of the total estimated risk cost.

2.3.2. Financial risk

This risk refers to the direct financial consequence arising from the failure of an asset including the cost of replacement or repair of the asset which may need to be under emergency conditions. For the purposes of the PSCR (and for initially assessing the identified need pre-RIT-T), this risk also includes a market impact component that proxies the increased aggregate generator fuel costs arising from network constraints that are required during the outage caused by the asset failure. The market impact component will not be included in the PADR modelling and, will instead be replaced with wholesale market modelling.

Financial risk is the second largest of all risks quantified under the base case for this RIT-T, making up 42 per cent of the total estimated risk cost.

2.3.3. Reputational risk

This risk refers to the direct financial consequence associated with the cost of liaison and engagement with media, the community and other stakeholders arising from the failure of an asset.

Reputational risk has been quantified at a much lower order of magnitude under the base case for this RIT-T, making up only 2 per cent of the total estimated risk cost.

2.3.4. Reliability risk

This risk refers to the system reliability and security consequence of an asset failure. The estimated value takes into account the expected load-at-risk and duration of loss-of-supply (MWh of lost load) due to the failure and any subsequent actions, and a customer value of reliability (VCR) for the customer type impacted.

We have recently updated our reliability risk model to consider the quantity of load that can be restored through the distribution system following an asset failure. The consequence modelling has also been updated to a weighted-scenario basis using low and high load scenarios to reflect variations in load throughout the day and the year. The unavailability and return-to-service time assumptions have also been reviewed to ensure unusual historic outage events (where there was no urgent need for restoration) are not factored into the typical outage durations assumed.

Reliability risk makes up 0.2 per cent of the total estimated risk cost.

2.3.5. Safety risk

This risk refers to the safety consequence to our workforce, contractors and/or members of the public of an asset failure whose failure modes can create harm. The estimated value takes into account the cost associated with a fatality or injury including compensation, loss of productivity, litigation fees, fines and any other related costs.

Our safety model has recently been updated and developed in conjunction with asset management specialist consultancy AMCL. The main changes to the model relate to consequence and likelihood quantifications with our safety risk now considering a range of consequences, from minor injury to fatality, and the likelihood of each based on historical events, human movement data and land use.

Safety risk is the smallest of all risks quantified under the base case for this RIT-T, making up 0.02 per cent of the total estimated risk cost.

2.3.6. Asset health and the probability of failure

Our asset health modelling aligns with Chapter 5.2 of the AER's Asset Replacement Planning guideline.[12] Condition information for each asset is assessed to generate an Asset Health Index and assets in relatively poor condition, as identified through the Asset Health Index, are candidates for a replacement or refurbishment intervention.

Asset Health is used to estimate the remaining life of an asset and forecast the associated probability of failure (PoF) of the asset now and into the future. The future health of an asset (health forecasting) is a function of its current health and any factors causing accelerated (or decelerated) degradation or 'age shifting' of one or more of its components. Such moderating factors can represent the cumulative effects arising from continual or discrete exposure to unusual internal, external stresses, overloads and faults.

Asset condition information is the primary source of information on the current health of the transmission line and its components. Condition information obtained through routine inspections of transmission lines, such as condition rating of each component, and asset information, such as natural age, location and ideal life expectancy, form the basis for deriving current health.

The PoF is the likelihood that an asset will fail during a given period resulting in a particular adverse event, e.g., pole failure on Line 86 as occurred in April 2020. The probability of each failure mode is calculated using reliability engineering techniques that take into account conditional age (chronological age moderated by asset health), failure and defect history, and industry benchmarking studies. We screen out failures that are not related to end-of-life when quantifying risk for replacement projects because such risks are not addressed by these works.

Defect and condition information for each type of pole taken from pole inspections for Line 86 were analysed to assess the level of degradation expected by effective service life. Two parameter Weibull curves were then constructed to predict the level of functional failures of these pole types.

These functional failure statistics were then used by a subject matter expert to estimate the rate of decay, in accordance with the relevant decay models from AS 1720 for the pole type with service life. Catastrophic PoF curves were then constructed for each pole type by calculating the probability of the applied wind pressure exceeding the residual strength at discrete points in time, as per the design basis of the structures. The resulting overlap of the applied stress and residual strength curves give the probability density of a catastrophic failure occurring, represented as a two parameter Weibull equation.

The outputs of the PoF calculation are a PoF time series that provides a mapping between the effective age, discussed above, and the yearly PoF value. This analysis is performed by generating statistical failure

---

12 AER, *Industry practice application note – Asset replacement planning*, January 2019 – available at https://www.aer.gov.au/system/files/D19-2978%20-%20AER%20-Industry%20practice%20application%20note%20Asset%20replacement%20planning%20-%2025%20January%202019.pdf

curves, normally using Weibull analysis, to determine a PoF time series set for each asset that gives a PoF for each further year of asset life.

3. Options that meet the identified need

We consider credible options in this RIT-T assessment as those that would meet the identified need from a technical, commercial, and project delivery perspective.[13] This will include any credible options that are put forward by proponents in response to this PSCR.

We have identified three network options that we consider meet the identified need for this RIT-T, as summarised in Table 3-1 below.

Table 3-1: Summary of the credible options

Option	Description	Estimated capex ($2020/21)	Expected build time	Expected transfer improvement (relative to the base case)
1	Replace Line 86 like for like in-situ utilising concrete or steel poles, keeping the existing twin lime conductor and single circuit configuration, while maintaining the overall design temperature at 100°C.	95.7	3 – 4 years	280 MW
2	Rebuild Line 86 as double circuit, strung on one side initially with twin olive conductors and a 120°C design temperature along a new easement parallel to the original Line 86 (which is then removed). The other side to be strung at a later date as needed.	267.4 for the initial build. 60.2 for stringing the second side, when needed.	3 – 4 years for the initial build. 1 year for stringing the second side.	280 MW for the initial build. An additional 350 MW once the second side is strung
3	Rebuild Line 86 as a double circuit with twin olive conductors and a 120°C design temperature along a new easement parallel to the original Line 86 (which is then removed).	315.4	3 – 4 years	630 MW

In addition, we consider that non-network solutions may be able to form credible options for this RIT-T, in combination with network options. Section 4 provides details on the technical information that proponents of non-network options need to provide in order to enable their option to be considered in this RIT-T.

While we have provided indicative cost estimates for the credible options, more accurate figures may be used for the cost-benefit analysis in the PADR.

3.1. Base case

Consistent with the RIT-T requirements, the assessment undertaken in the PADR will compare the costs and benefits of each option to a base case 'do nothing' option. The base case is the (hypothetical) projected case if no action is taken, i.e.:[14]

> *"The base case is where the RIT-T proponent does not implement a credible option to meet the identified need, but rather continues its 'BAU activities'. 'BAU activities' are ongoing, economically prudent activities that occur in absence of a credible option being implemented"*

13 As per clause 5.15.2(a) of the NER.

14 AER, *Regulatory Investment Test for Transmission Application Guidelines*, August 2020, p. 21.

Under the base case, where affected poles are not replaced, there is expected to be significant risk to our network and customers as outlined in section 2.3 above. In particular, we consider the base case to involve material risk costs and, in particular, bushfire, reliability, safety and financial risks.

In addition, the base case will also result in a reduction in the transfer limit between Armidale and Tamworth, and hence the QNI interconnector, during periods of outage on Line 86. This includes outages required to perform planned maintenance activities, which will routinely be required on at least 60 per cent of the structures.

While the base case is not a situation we plan to encounter, and this RIT-T has been initiated specifically to avoid it, the assessment is required under the RIT-T to use this base case as a common point of reference when estimating the net benefits of each credible option.

The base case for the PADR assessment will include the cost of replacing the wood pole structures identified over the course of inspections in 2021 that require replacement due to the condition issues (since these assets have failed our inspection/serviceability tests and require reactive replacement).

3.2. Option 1 – Replace Line 86 like for like in-situ with concrete or steel poles

Option 1 involves replacing Line 86 like for like in-situ with concrete or steel poles, keeping the existing twin lime conductor and single circuit configuration. The scope of this option does not involve replacing the existing concrete poles and maintains the overall design temperature at 100°C.

It is expected that the works will be undertaken in various stages between 2021/22 and 2025/26. While physical delivery and replacement of the identified assets is planned to occur over this period, it will be delivered in a staged fashion with replacement targeted based on asset condition. All work is expected to be completed by 2026/27.

Option 1 provides an increase in transfer capacity between Armidale and Tamworth of approximately 280 MW, relative to the base case, by avoiding the expected periods of line outage when the existing wood poles fail. However, it does not result in any increase in actual line capacity, compared to when the existing line is in-service under the base case, i.e., it maintains the same operating capacity as the current line.

Given the existing line is already in service, outages will be planned as necessary in order to complete the works. The impact of these planned outages on the wholesale market are intended to be captured for Option 1 in the PADR market modelling but are not expected to be material.

The estimated capital cost of this option is approximately $95.7 million. Routine operating and maintenance costs are expected to be approximately $80,000/annum (around 0.08 per cent of the capital expenditure), which compares to $290,000/annum under the base case (where more frequent inspections are required).

We note that Option 1 only replaces the poles on Line 86 and does not replace the actual line (‘conductor’). Our current view is that the existing conductor will need to be replaced under Option 1 in 30-40 years’ time and so is not proposed to be included in the NPV assessment.[15]

[15] Specifically, we are not proposing to include the replacement of the existing conductor under Option 1 in the analysis on account of how far into the future it is expected to be required, as well as its relatively low expected cost (currently estimated at $27 million).

3.3. Option 2 – Rebuild Line 86 as a double circuit line (initially strung on one side only)

Option 2 involves rebuilding Line 86 as a new double circuit line with twin olive conductors and a 120°C design temperature along a new easement parallel to Line 86.

Under Option 2, the new line would be strung on one side only initially with the other side strung at a later date, as required to meet future load or where that would provide further net market benefits. While we are planning to further investigate an appropriate trigger for stringing the second side as part of the PADR market modelling exercise, at this stage we consider it could be around 500 MW of new renewable generation connecting in northern NSW.

The first stage of Option 2 is expected to provide an increase in transfer capacity between Armidale and Tamworth of approximately 280 MW, relative to the base case, by avoiding the expected periods of line outage when the existing wood poles fail. Stringing the second side is expected to result in a further increase in transfer capacity of approximately 350 MW relative to the base case.

It is expected that the initial works will be undertaken between 2021/22 and 2026/27, with ultimate commissioning of the new line in 2027/28. Once the new line is commissioned the existing line will be removed and the cost of this has been included in the cost for Option 2. The estimated timing for stringing the second side of the line will be determined in the PADR using the market modelling results.

The estimated initial capital cost of this option is approximately $267.4 million, including the additional easement cost. The estimated later upgrade capital cost is approximately $60.2 million.

Routine operating and maintenance cost are expected to be approximately $92,000/annum (around 0.03 per cent of the initial capital expenditure), which compares to $290,000/annum under the base case (where more frequent inspections are required).

3.4. Option 3 – Rebuild Line 86 as a double circuit line (strung on both sides)

Option 3 is essentially the same option as Option 2 (i.e., rebuilding Line 86 as a double circuit line with twin olive conductors and a 120°C design temperature). The key difference from Option 2 is that Option 3 involves stringing the line on both sides initially.

Option 3 is expected to provide an increase in transfer capacity between Armidale and Tamworth of approximately 630 MW, relative to the base case, through both avoiding the expected periods of line outage when the existing wood poles fail (i.e., consistent with Option 1 and the first stage of Option 2) and providing an additional circuit in this part of the network (i.e., consistent with the second stage of Option 2).

It is expected that the works will be undertaken between 2021/22 and 2026/27, with ultimate commissioning of the new line in 2027/28. Once the new line is commissioned the existing line will be removed and the cost of this has been included in the cost for Option 3.

The estimated capital cost of this option is approximately $315.4 million, including the additional easement cost. Routine operating and maintenance cost are expected to be approximately $92,000/annum (around 0.03 per cent of the capital expenditure), which compares to $290,000/annum under the base case (where more frequent inspections are required).

3.5. Non-network options

We consider that non-network solutions may be able to form credible options for this RIT-T, in combination with network options. These technologies are not considered able to meet the identified need as standalone options, as outlined in section 4 below.

We consider that a non-network option needs to target both northerly and southerly thermal limits with two equally sized components, controlled by a System Integrity Protection Scheme (SIPS). The operation of the non-network option would therefore provide a 'virtual transmission line' (VTL) following a critical transmission line contingency.

While the ultimate assessment of non-network options will depend on responses received to this PSCR, at this stage, we consider these technologies may include, but are not limited to, the following:

- generation (both embedded and grid-connected); and
- energy storage (bulk systems), including:
  - sealed batteries;
  - flow batteries;
  - concentrated solar thermal with storage;
  - compressed air storage; and
  - pumped hydro.
- voluntary curtailment of customer load.

Section 4 provides details on the technical information that proponents of non-network options need to provide in order to enable their option to be considered in this RIT-T.

3.6. Options considered but not progressed

We have also considered whether other options could meet the identified need. Reasons these options were not progressed are summarised in Table 3-2.

Table 3-2: Options considered but not progressed

Option	Reason(s) for not progressing
Further uprating the existing line (e.g., by installing taller poles)	Not economically or technically feasible. Line 86 is constructed with a twin lime ACSR conductor with an original design temperature of 85°C. It has since been upgraded to a design temperature of 100°C. While the option to uprate the line to a design temperature of 120°C has been considered, it results in only a negligible contingency rating increase.

Staging the replacement works under Option 1.	Not technically feasible. Replacing Line 86 in stages would not avoid the line being unavailable for periods when unreplaced defective poles fail (and so would not address the risk or wider market impact components of the identified need).
Rebuild Line 86 as single circuit with twin mango conductors and a 120°C design temperature parallel to the original Line 86 (which is then removed) on a new easement.	Not commercially feasible. This option has been considered but not progressed since it costs significantly more than Option 1 ($192.7 million, compared to $95.7 million) and is expected to provide the same increase in transfer capacity (i.e., 280 MW increase compared to the base case). While this option would avoid an extended period of outage during construction, relative to Option 1, since the new line is built on a separate easement, this is not expected to be material to the assessment as all outages would be planned to have minimal impact on the market.

3.7. Material inter-market network impact is expected

We have considered whether the credible options listed above are expected to have a material inter-regional impact.[16] A 'material inter-network impact' is defined in the NER as:

> *"A material impact on another Transmission Network Service Provider's network, which may include (without limitation): (a) the imposition of power transfer constraints within another Transmission Network Service Provider's network; or (b) an adverse impact on the quality of supply in another Transmission Network Service Provider's network."*

AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following:[17]

- a decrease in power transfer capability between transmission networks or in another Transmission Network Service Provider's (TNSP's) network of no more than the minimum of 3 per cent of the maximum transfer capability and 50 MW
- an increase in power transfer capability between transmission networks or in another TNSP's network of no more than the minimum of 3 per cent of the maximum transfer capability and 50 MW
- an increase in fault level by less than 10 MVA at any substation in another TNSP's network
- the investment does not involve either a series capacitor or modification in the vicinity of an existing series capacitor.

We consider that Option 3 (and Option 2 once the second side is strung) will potentially increase the fault level at Bulli Creek (in Queensland) by more than 10 MVA (around 57MVA).

We intend to request an augmentation technical report from AEMO in relation to the options being considered in this RIT-T.[18]

16 As per clause 5.16.4(b)(6)(ii) of the NER.

17 Inter-Regional Planning Committee. "*Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations.*" Melbourne: Australian Energy Market Operator, 2004. Appendix 2 and 3, available at: https://aemo.com.au/-/media/files/electricity/nem/network_connections/transmission-and-distribution/170-0035-pdf.pdf

18 NER clause 5.21(d)(1)-(3).

4. Technical characteristics for non-network options

We consider that non-network options may be able to assist with meeting the identified need in combination with Option 1 or Option 2 (ahead of the second side being strung). Specifically, we consider that non-network technologies may be able to be coupled with single-circuit options to provide an increase in transfer capacity and avoid (or defer) the need to build a second circuit.

However, we note that the cost of the network options may act to effectively bound the cost available for any non-network options to be considered commercially feasible. Specifically, the cost difference between Option 1 (maintaining a single-circuit 330 kV line) and Option 3 (a new double-circuit 330 kV line) of approximately $220 million serves as an indicative cost threshold for the provision of 350 MW of additional transfer capacity (i.e., the additional transfer capacity Option 3 provides over Option 1). While we consider this an ambitious cost for the provision of approximately 350 MW of additional transfer capacity from non-network solutions (e.g., through the use of a Virtual Transmission Line (VTL)), we are interested in hearing from proponents on their individual solutions and costs (including for smaller sized options).

We do not consider that non-network solutions can address the identified need as standalone options since a key focus of the identified need is to address the asset condition issues on Line 86 and the risk they pose (most relevantly bushfire risk and financial risk). Moreover, standalone non-network options that result in the existing line being decommissioned (and no replacement line being built) would not meet the required 'N-1' level of reliability in this area of the network[19] and so are not considered technically feasible.

The section below sets out the technical requirements for non-network options to be considered in combination with either Option 1 or Option 2 (ahead of the second side being strung) as part of this RIT-T.

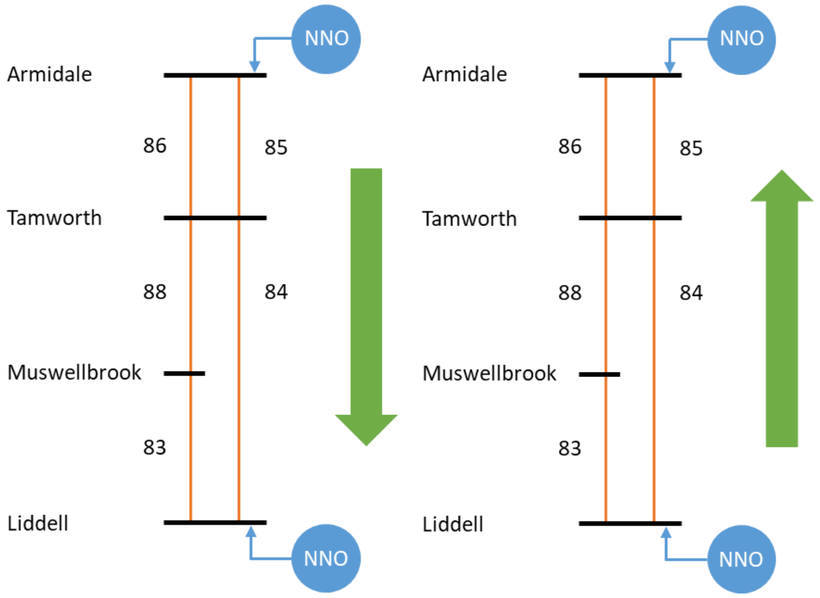
We note that the role that non-network options are expected to be able to play in this RIT-T is different to that for the QNI minor upgrade RIT-T. This is because any solutions for this RIT-T are primarily to address the thermal limitation, while the QNI minor upgrade RIT-T focussed on a transient stability requirement that required a faster response time.

4.1. Required technical characteristics of non-network options

We consider that the high-level objective of a non-network option is to further increase the northerly and southerly QNI thermal limits between Tamworth and Armidale in combination with either Option 1 or Option 2 (ahead of the second side being strung), as shown in Figure 4-1.

[19] IPART, *Electricity transmission reliability standards*, Final Report, August 2016, pp. 72-73.

Figure 4-1: Objective of non-network options



We consider that a non-network option needs to target both northerly and southerly thermal limits with two equally sized components, controlled by a SIPS, located at Armidale and as far south as Liddell.[20] The operation of the non-network option would therefore provide a VTL following a critical transmission line contingency.

Following the expected New England REZ developments, transmission flows in the corridor between Liddell and Armidale will remain limited by the thermal capacity of adjacent transmission lines (Line 83, 84, and 88), even with a rebuild of Line 86. A VTL in combination with Option 1 or 2 could be an alternative solution to Option 3 as the further transmission improvement between Armidale and Tamworth will remain limited by the thermal capacity between Liddell and Tamworth.

The VTL would unlock additional transmission capacity from the existing transmission lines under system normal conditions. During contingencies, the non-network option would need to quickly (in 5 mins or less) reduce the transmission flows on these group of transmission lines to within their continuous thermal ratings.

At this stage, we consider that technologies that may be able to assist include:

- generation (both embedded and grid-connected); and
- energy storage (bulk systems), including:
  - sealed batteries;
  - flow batteries;
  - concentrated solar thermal with storage;
  - compressed air storage; and
  - pumped hydro.
- voluntary curtailment of customer load.

[20] Liddell represents the next major constraint to the south and has been included as the southern location for a VTL since there is likely able to be spare connection space at the Liddell substation following the retirement of Liddell Power Station in 2023.

The tables below describe the indicative size, location, and expected operation of any non-network solutions in anticipation of a contingency. As a minimum, the non-network option must operate for at least half an hour to allow for generation and loads to be dispatched to meet the contingency in the network.

Table 4-1: Indicative technical characteristics for non-network solutions

Location	Voltage	Size	Nature of operation
		Southerly QNI flows	
Armidale	132 kV or 330 kV	200+ MW	• Charging Energy Storage • Turn-off local generation • Turn-on local load
Liddell	132 kV or 330 kV	200+ MW	• Discharging Energy Storage • Turn-on local generation • Turn-off local load
		Northerly QNI flows	
Armidale	132 kV or 330 kV	200+ MW	• Discharging Energy Storage • Turn-on local generation • Turn-off local load
Liddell	132 kV or 330 kV	200+ MW	• Charging Energy Storage • Turn-off local generation • Turn-on local load

5. Materiality of market benefits

The NER requires that all categories of market benefit identified in relation to the RIT-T are included in the RIT-T assessment, unless the TNSP can demonstrate that a specific category (or categories) is unlikely to be material in relation to the RIT-T assessment for a specific option.

The PSCR is required to set out the classes of market benefit that the TNSP considers are not likely to be material for a particular RIT-T assessment.

At this stage, Transgrid considers that all categories of market benefit identified in the RIT-T have the potential to be material with the exception of changes in ancillary services costs.

5.1. Wholesale market modelling will be adopted for the PADR analysis

The options considered in this PSCR are expected to affect outcomes in the wholesale market, relative to the base case, particularly for those options which increase the operating capacity of the current Line 86. This additional capacity is expected to provide for more efficient outcomes in the wholesale market through increasing the output available from the nearby QNI and New England REZ.

We expect the following seven categories of market benefit to be estimated using wholesale market modelling as part of the PADR:

- changes in fuel consumption arising through different patterns of generation dispatch;
- changes in price-responsive voluntary load curtailment;
- changes in involuntary load shedding;
- avoided/deferred capital and operating expenditure associated with new generation/storage in the NEM;[21]
- differences in the timing of unrelated transmission expenditure (eg, intra-regional transmission investment associated with the development of REZs); and
- changes in network losses.

We will take into account option value as part of the PADR for any options that exhibit the requisite flexibility for option value to exist (e.g., Option 2 where the second side of the double-circuit line can be strung at a future date).

In addition, we may investigate 'competition benefits' under the RIT-T further as part of the PADR assessment and, specifically, if the expected impact on QNI/New England REZ capacity may affect the level of competition between generating centres in the NEM (which may justify the additional complexity associated with modelling competition benefits).

A discussion of why we consider changes in ancillary service costs are not expected to be material for this RIT-T assessment is provided in the section below.

[21] Referred to as 'changes in costs for parties, other than for Transgrid, due to differences in the timing of new plant, capital costs and operating and maintenance costs' under the RIT-T.

5.2. Changes in ancillary service costs are not expected to be material

While the cost of Frequency Control Ancillary Services (FCAS) may change as a result of changed generation dispatch patterns and changed generation development following any increase to transfer capacity from the options, we consider that changes in FCAS costs are not likely to be materially different between options and are not expected to be material in the selection of the preferred option. FCAS costs are relatively small compared to total market costs.

There is no expected change to the costs of Network Control Ancillary Services (NCAS), or System Restart Ancillary Services (SRAS) as a result of the options being considered. These costs are therefore not considered material to the outcome of the RIT-T assessment.

6. Overview of the assessment approach

This section outlines the approach that we are proposing to apply in assessing the net benefits associated with each of the credible options.

6.1. Assessment period and discount rate

The RIT-T will consider a 25-year period, from 2021/22 to 2045/46. We consider that this takes into account the size, complexity and expected lives of the options and provide a reasonable indication of the costs and benefits over a long outlook period.

Where the capital components of the credible options have asset lives extending beyond the end of the assessment period, the NPV modelling will include a terminal value to capture the remaining asset life. This ensures that the capital cost of long-lived options over the assessment period is appropriately captured, and that all options have their costs and benefits assessed over a consistent period, irrespective of option type, technology or asset life. The terminal values will be calculated as the undepreciated value of capital costs at the end of the analysis period and can be interpreted as a conservative estimate for benefits (net of operating costs) arising after the analysis period.

We will adopt a central real, pre-tax 'commercial'[22] discount rate of 5.50 per cent as the central assumption for the NPV analysis presented in this report. We consider that this is a reasonable contemporary approximation of a commercial discount rate, consistent with the RIT-T and the latest AEMO IASR released in July 2021.

We will also test the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 2.23 per cent equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PSCR,[23] and an upper bound discount rate of 7.50 per cent (consistent with the upper bound in the latest IASR).

6.2. Approach to estimating project costs

The initial cost estimates presented in this PSCR have been at a high level based on experience from previous projects involving similar options or based on publicly available information.

It is intended that cost estimates will be further refined in the PADR stage and this process may be informed by responses to the PSCR. Our objective is to achieve costs that are estimated to be within +/- 25 per cent of the actual cost as part of the PADR.

6.3. The wholesale market modelling will be based on the 2021 AEMO IASR assumptions and the forthcoming draft 2022 ISP optimal development path

We note the importance of ensuring that the outcome of this RIT-T assessment is robust to different assumptions about how the energy sector may develop in the future. Transmission investments are long-

[22] The use of a 'commercial' discount rate is consistent with the RIT-T and is distinct from the regulated cost of capital (or 'WACC') that applies to network businesses like Transgrid.

[23] See Directlink's Post-tax Revenue Model (PTRM) for the 2020-25 period, available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/directlink-determination-2020-25

lived assets, and it is important that the market benefits associated with these investments do not depend on a narrow view of potential future outcomes, given that the future is inherently uncertain.

Uncertainty is captured under the RIT-T framework through the use of scenarios, which reflect different assumptions about future market development and other factors that are expected to affect the relative market benefits of the options being considered.

We are intending to model the market benefits of the credible options across different scenarios using wholesale market modelling. These scenarios will be based on those consulted on and summarized in the 2021 IASR released by AEMO in July 2021 (which are also to be used in the forthcoming 2022 ISP) and will reflect a sufficiently broad range of potential outcomes across the key uncertainties that are expected to affect the future market benefits of the investment options being considered.

We are also expecting to use the optimal development paths identified by AEMO in the forthcoming draft 2022 ISP (expected to be released on 10 December 2022) as part of the PADR modelling.

Appendix A – Compliance checklist

This appendix sets out a compliance checklist which demonstrates the compliance of this PSCR with the requirements of clause 5.16.4(b) of the Rules version 174.

Rules clause	Summary of requirements	Relevant section(s) in PSCR
5.16.4 (b)	A RIT-T proponent must prepare a report (the project specification consultation report), which must include:	–
	(1) a description of the identified need;	2
	(2) the assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, why the RIT-T proponent considers reliability corrective action is necessary);	2.3 & 6
	(3) the technical characteristics of the identified need that a non- network option would be required to deliver, such as: (i) the size of load reduction of additional supply; (ii) location; and (iii) operating profile;	4
	(4) if applicable, reference to any discussion on the description of the identified need or the credible options in respect of that identified need in the most recent Integrated System Plan;	NA
	(5) a description of all credible options of which the RIT-T proponent is aware that address the identified need, which may include, without limitation, alterative transmission options, interconnectors, generation, demand side management, market network services or other network options;	3
	(6) for each credible option identified in accordance with subparagraph (5), information about: (i) the technical characteristics of the credible option; (ii) whether the credible option is reasonably likely to have a material inter-network impact; (iii) the classes of market benefits that the RIT-T proponent considers are likely not to be material in accordance with clause 5.16.1(c)(6), together with reasons of why the RIT-T proponent considers that these classes of market benefits are not likely to be material; (iv) the estimated construction timetable and commissioning date; and (v) to the extent practicable, the total indicative capital and operating and maintenance costs.	3 & 5