Transgrid

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Managing safety and environmental risks on Line 24 (Vales Point – Eraring)

RIT-T Project Assessment Conclusions Report

Region: Newcastle and Central Coast

Date of issue: 2 June 2022

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Executive summary

Transgrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating safety and environmental risks caused by the deteriorating condition of Line 24. Publication of this Project Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

Spanning a route of 30km, Line 24 is a 330 kV transmission line that runs between Vales Point and Eraring substations. It was originally commissioned in 1969 as part of the line which ran from Vales Point substation to Newcastle substation. The section of Line 24 being addressed by this RIT-T is the single circuit section between the Eraring cut-in and Vales Point substation, a length of approximately 28km. This section is comprised of 79 steel towers.

Line 24 is a key link between two generators on the NSW Central Coast. It will continue to play a central role in supporting the flow of energy to take advantage of naturally-diverse weather patterns, and in the safe and reliable operation of the power system throughout and after the transition to a low-carbon electricity future.

The transmission line mainly traverses through semi-urban and forested areas. Two generators at Eraring and Vales Point, which are connected to Transgrid's Eraring and Vales Point substations, respectively, together contribute more than 4GW[1] to the National Electricity Market. Line 24 connects the two substations which are key nodes on the transmission network. Additionally, Vales Point substation is a customer connection point supplying Ausgrid's 132 kV network in the Western Lake Macquarie area.

Condition issues that will impact the safe and reliable operation of the network have been found on the line. These raise a number of risks associated with asset failure, including safety and environmental (bushfire) risks.

Table E-1 Condition issues along Line 24 and their consequences

Issue	Consequences if not remediated
Corrosion of tower steel members, including buried legs and ground line steel corrosion	Steel corrosion, particularly of critical members, can lead to structural failure of tower
Tower asbestos paint	Potential asbestos related safety risks
Corroded fasteners	Structural failure
Deteriorated grillage foundation	Structural failure
Corroded insulators and conductor attachment fittings	Conductor drop
Corrosion of earthwire attachment fittings	Conductor drop
Deteriorated tower earthing	Public safety risk increase in case of fault
Deteriorated anti-climber and structure signage	Public safety risk

As the asset condition deteriorates over time, the likelihood of failure and subsequent risks will increase should these issues not be addressed.

[1] Summation of approximate generation totals from Vales Point Power Station and Eraring Power Station.

Identified need: managing safety and environmental risks from corrosion on Line 24

The proposed investment will enable Transgrid to manage safety and environmental risks on Line 24. Options considered under this RIT-T have been assessed relative to a base case. Under the base case, no proactive capital investment is made and the condition of Line 24 will continue to deteriorate.

Further deterioration of the condition of the affected assets due to corrosion would mean an increase in bushfire and safety risks along Line 24 as the likelihood of failure increases. If left untreated, corrosion of some of the vital components of the steel towers could result in incidents such as conductor drop and tower collapse. Such incidents could have serious safety consequences for nearby residents and members of the public, as well as Transgrid field crew members who may be working on or near the assets.

Transgrid manages and mitigates bushfire and safety risk to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with Transgrid's obligations under the New South Wales Electricity Supply (Safety and Network Management) Regulation 2014 and Transgrid's Electricity Network Safety Management System (ENSMS).[2]

The proposed investment will enable Transgrid to continue to manage and operate this part of the network to a safety and risk mitigation level of ALARP. Consequently, it is considered a reliability corrective action under the RIT-T. A reliability corrective action differs from a 'market benefits'-driven RIT-T in that the preferred option is permitted to have negative net economic benefits on account of it being required to meet an externally imposed obligation on the network business.

No submissions received in response to Project Specification Consultation Report

Transgrid published a Project Specification Consultation Report (PSCR) on 10 December 2021 and invited written submissions on the material presented within the document. No submissions were received in response to the PSCR.

No material developments since publication of the PSCR

No additional credible options were identified during the consultation period following publication of the PSCR.

No material changes have occurred since the PSCR which have made an impact on the preferred option.

Option 1 remains the preferred option at this stage of the RIT-T process.

Transgrid considers refurbishing Line 24 is the only credible option

Transgrid put forward for consideration one technically and commercially feasible option[3]: refurbishing the existing line by remediating or replacing the identified components. This option (Option 1) involves the refurbishment of Line 24 including replacement of asset components, earthwire, remediation of steelwork and foundations.

[2] Transgrid's ENSMS follows the International Organization for Standardization's ISO31000 risk management framework which requires following hierarchy of hazard mitigation approach

[3] As per clause 5.15.2(a) of the NER.

The primary driver for the identified need is to mitigate bushfire and safety risks associated with condition issues on Line 24 caused by corrosion. Two other options to address the need were considered but were not progressed further as they were determined technically or commercially non-feasible when assessed against the preferred option. These are summarised in the following table.

Transgrid expects coronavirus (COVID-19) to continue to impact its suppliers and disrupt their supply chains, although at this time the extent of the current or future impact is unknown. Consequently, some of the costs and timing associated with the works outlined in this document may be affected.

All costs presented in this PACR are in 2021/22 dollars.

Table E-2 Options considered

Option	Description	Capital costs ($M 2021/22)	Operating costs ($ per year)	Remarks
Option 1	Line refurbishment	8.9 (+/- 25%)	10,000	Most economical and preferred option
Option 2	Line dismantling	~ 8.1	0	Line dismantling is not technically feasible. Dismantling Line 24 will reduce the supply capability from Northern NSW network to the Greater Sydney region, which may lead to reliability of supply issues.
Option 3	New transmission line from Vales Point substation to Eraring substation	~ 52.7	Not considered	Due to significant costs of this option, a new 330 kV transmission line from Vales Point substation to Eraring substation is not commercially feasible.

Non-network options are not able to assist in this RIT-T

Transgrid does not consider non-network options to be commercially and technically feasible to assist with meeting the identified need for this RIT-T, as non-network options will not mitigate the safety and environment risk posed as a result of corrosion-related asset deterioration.

Conclusion: refurbishment of Line 24 is optimal

The optimal commercially and technically feasible option presented in this PACR – Option 1 (line refurbishment) – is the preferred option to meet the identified need.

Moving forward with this option is the most prudent and economically efficient solution to manage and mitigate safety and environmental risk to ALARP. Consequently, it will ensure Transgrid's obligations under the New South Wales Electricity Supply (Safety and Network Management) Regulation 2014 and Transgrid's Electricity Network Safety Management System (ENSMS) are met.

The estimated capital expenditure associated with this option is $8.9 million +/- 25 per cent. Routine operating and maintenance costs relating to planned checks by Transgrid field crew are approximately $10,000 per year – similar to the cost under the base case. Transgrid calculates that the avoided risk cost by undertaking Option 1 is approximately $8.8 million per year.

This preferred option, Option 1, is found to have positive net benefits under all scenarios investigated and on a weighted basis will deliver $102.4 million in net economic benefits. Transgrid also conducted sensitivity analysis on the net economic benefit to investigate the robustness of the conclusion to key assumptions. Transgrid's analysis concluded that the costs are less than the weighted benefits from mitigating bushfire and safety risks under all scenarios.

The works will be undertaken between 2021/22 and 2022/23. Planning and procurement will conclude in 2021/22, while project delivery and construction will occur in 2022/23.

All works will be completed in accordance with the relevant standards by 2022/23 with minimal modification to the wider transmission assets. Necessary outages of affected line(s) in service will be planned appropriately in order to complete the works with minimal impact on the network.

The analysis undertaken and the identification of Option 1 as the preferred option satisfies the RIT-T. Option 1 is the preferred option in accordance with NER clause 5.16.1(b) because it is the credible option that maximises the net present value of the net economic benefit to all those who produce, consume and transport electricity in the market. This preferred option, Option 1, was found to have the highest net economic benefit or least lifecycle cost while also maintaining compliance with regulatory and safety obligations. Transgrid also conducted sensitivity analysis on the net economic benefit to investigate the robustness of the conclusion to key assumptions. Transgrid finds that under all sensitivities, Option 1 delivers the most net benefit.

Next steps

This PACR represents the final step of the consultation process in relation to the application of the Regulatory Investment Test for Transmission (RIT-T) process undertaken by Transgrid. It follows a Project Specification Consultation Report (PSCR) released in December 2021. No submissions were received in response to the PSCR.

The second step, production of a Project Assessment Draft Report (PADR), was not required as Transgrid considers its investment in relation to the preferred option to be exempt from that part of the RIT-T process under NER clause 5.16.4(z1). Production of a PADR is not required[4] due to:

- the estimated capital cost of the proposed preferred option being less than $46 million;
- the PSCR stating:
  - the proposed preferred option (including reasons for the proposed preferred option)
  - the RIT-T is exempt from producing a PADR
  - the proposed preferred option and any other credible option will not have material market benefits[5] except for voluntary load curtailment and involuntary load shedding

[4] In accordance with NER clause 5.16.4(z1)(4), the exemption from producing a PADR will no longer apply if Transgrid considers that an additional credible option that could deliver a material market benefit is identified during the consultation period. No additional credible options were identified.

[5] As per clause 5.16.1(c)(6)

- the RIT-T proponent considers that there were no PSCR submissions identifying additional credible options that could deliver a material market benefit; and
- the PACR addressing any issues raised in relation to the proposed preferred option during the PSCR consultation.

Parties wishing to raise a dispute notice with the AER may do so prior to 4 July 2022 (30 days after publication of this PACR[6]). Any dispute notices raised during this period will be addressed by the AER within 40 to 120 days, after which the formal RIT-T process will conclude.

Further details on the RIT-T can be obtained from Transgrid's Regulation team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Line 24 PACR'.

[6] Additional days have been added to cover public holidays

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1. Introduction

Transgrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating safety and environmental risks caused by the deteriorating condition of Line 24, a single circuit 330 kV transmission line between Vales Point substation and Eraring substation.

Transgrid manages and mitigates bushfire and safety risk to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with Transgrid's obligations under the New South Wales Electricity Supply (Safety and Network Management) Regulation 2014 and Transgrid's Electricity Network Safety Management System (ENSMS).[7]

The proposed investment will enable Transgrid to continue to manage and operate this part of the network to a safety and risk mitigation level of ALARP. Consequently, it is considered a reliability corrective action under the RIT-T.

1.1. Purpose of this report

The purpose of this PACR[8] is to:

- describe the identified need
- describe and assess credible options to meet the identified need
- describe the assessment approach used
- provide details of the proposed preferred option to meet the identified need

1.2. Exemption from preparing a Project Assessment Draft Report (PADR)

Subject to additional credible options being identified during the consultation period, publication of a Project Assessment Draft Report (PADR) is not required for this RIT-T as Transgrid considers its investment in relation to the preferred option to be exempt from that part of the process under NER clause 5.16.4(z1). Production of a PADR is not required due to:

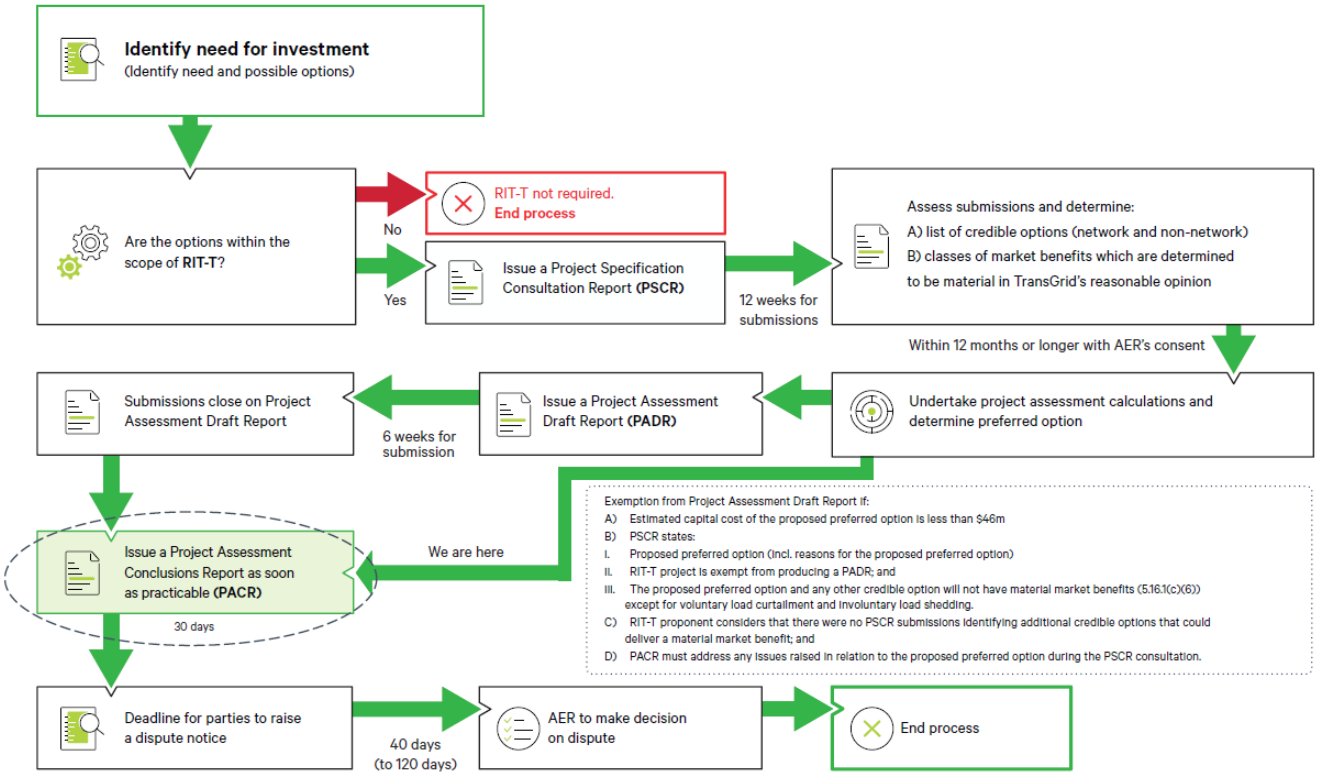
- the estimated capital cost of the proposed preferred option being less than $46 million[9];
- the PSCR states:
  - the proposed preferred option (including reasons for the proposed preferred option)
  - the RIT-T is exempt from producing a PADR
  - the proposed preferred option and any other credible option will not have material market benefits[10] except for voluntary load curtailment and involuntary load shedding
- the RIT-T proponent considers that there were no PSCR submissions identifying additional credible options that could deliver a material market benefit; and
- the PACR must address any issues raised in relation to the proposed preferred option during the PSCR consultation.

[7] Transgrid's ENSMS follows the International Organization for Standardization's ISO31000 risk management framework which requires following hierarchy of hazard mitigation approach.
[8] See Appendix A for the National Electricity Rules requirements.
[9] Varied to $46m based on the AER Final Determination: 2021 RIT and APR cost threshold review, November 2021.
[10] As per clause 5.16.1(c)(6)

1.3. Next steps

This PACR represents the third and final step of the consultation process in relation to the application of the Regulatory Investment Test for Transmission (RIT-T) process undertaken by Transgrid. It follows a Project Specification Consultation Report (PSCR) released in December 2021. No submissions were received in response to the PSCR.

Figure 1-1 This PACR is the final stage of the RIT-T process[11]



Parties wishing to raise a dispute notice with the AER may do so prior to 4 July 2022 (30 days after publication of this PACR[12]). Any dispute notices raised during this period will be addressed by the AER within 40 to 120 days, after which the formal RIT-T process will conclude.

Further details on the RIT-T can be obtained from Transgrid's Regulation team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Line 24 PACR'.

[11] Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.65. Accessed 14 May 2020. https://www.aemc.gov.au/sites/default/files/content/89fbf559-2275-4672-b6ef-c2574eb7ce05/Final-rule-determination.pdf

[12] Additional days have been added to cover public holidays

2. The identified need

This section outlines the identified need for this RIT-T, as well as the assumptions and data underpinning it. It first sets out background information related to the Newcastle and Central Coast transmission network and existing electricity supply arrangements.

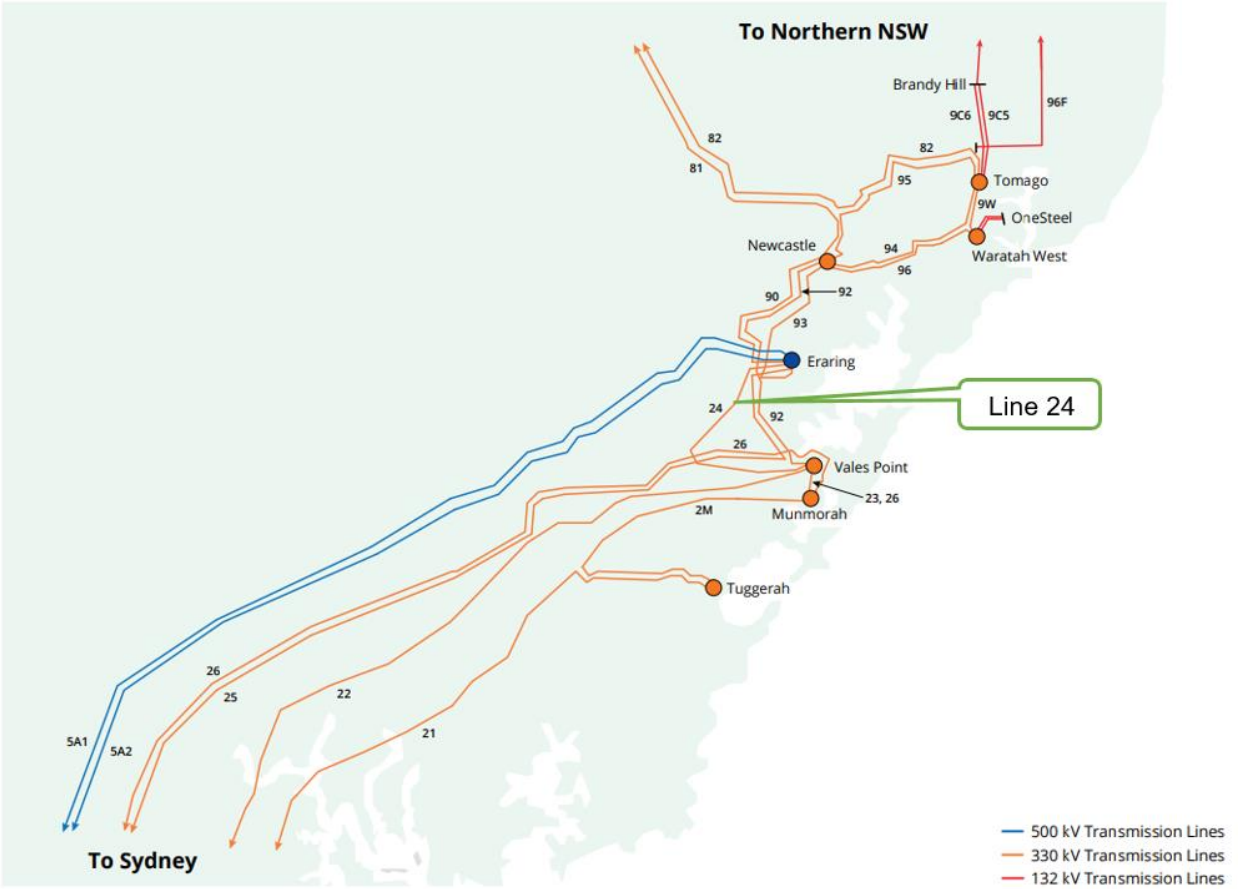
2.1. Background to the identified need

Spanning a route of 30km, Line 24 is a 330 kV transmission line that runs between Vales Point and Eraring substations. It was originally commissioned in 1969 as part of the line which ran from Vales Point substation to Newcastle substation. The section of Line 24 being addressed by this RIT-T is the single circuit section between the Eraring cut-in and Vales Point substation, a length of approximately 28km. This section is comprised of 79 steel towers.

Line 24 is a key link between two generators on the NSW Central Coast.

The current arrangement of the circuits between Vales Point and Eraring is shown in Figure 2-1 below.

Figure 2-1 Location of Line 24 on Transgrid's network



Line 24 will continue to play a central role in supporting the flow of energy to take advantage of naturally-diverse weather patterns, and in the safe and reliable operation of the power system throughout and after the transition to a low-carbon electricity future.

The transmission line mainly traverses through semi-urban and forested areas.

Two generators at Eraring and Vales Point, which are connected to Transgrid's Eraring and Vales Point substations, respectively, together contribute more than 4GW[13] to the National Electricity Market. Line 24 connects the two substations which are key nodes on the transmission network. Additionally, Vales Point substation is a customer connection point supplying the Ausgrid 132 kV network in the Western Lake Macquarie area. Located approximately 130km north of Sydney, the Lake Macquarie Local Government Area is home to a population of more than 207,000 which is forecast to grow by an additional 28,000 by 2036.[14]

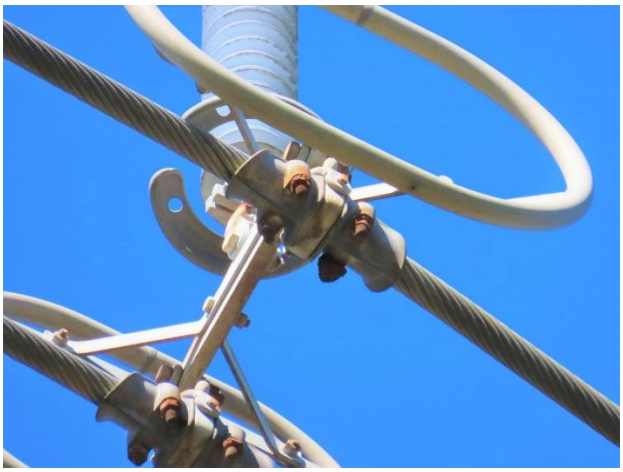
Condition issues that will impact the safe and reliable operation of the network have been found on the line. These raise a number of risks associated with asset failure, including safety and environmental (bushfire) risks.

Transgrid has commenced this RIT-T to examine and consult on options that will enable the identified need to be met by 2022/23. The proposed investment will enable Transgrid to continue to appropriately manage and operate this part of the network to a safety and risk mitigation level of ALARP. Consequently, it is considered a reliability corrective action under the RIT-T.

A condition assessment performed by Transgrid in FY2017 identified a number of issues with Line 24. Further condition inspections were performed in FY2020 identified advance condition deterioration of some line components compared to the FY2017 inspection data indicated.

A significant proportion of the steel transmission structures of Line 24 are impacted by various levels of deterioration and corrosion. The affected components include tower steelwork, tower grillage foundation, insulators, conductor and earthwire fittings, deteriorated tower earthing and tower asbestos paint. This greatly increases the likelihood of transmission structure failures, conductor drop, and subsequent bushfire and safety risks.

Figure 2-2 Corroded conductor fittings



[13] Summation of approximate generation totals from Vales Point Power Station and Eraring Power Station.
[14] Lake Macquarie City Council. *"City by numbers"*, accessed 15 October 2021. https://www.lakemac.com.au/Our-Council/About-us/City-by-numbers

Figure 2-3 Corroded tower members

2.2. Description of identified need

The proposed investment will enable Transgrid to manage safety and environmental risks on Line 24. Options considered under this RIT-T have been assessed relative to a base case. Under the base case, no proactive capital investment is made and the condition of Line 24 will continue to deteriorate.

Further deterioration of the condition of the affected assets due to corrosion would mean an increase in bushfire and safety risks along Line 24 as the likelihood of failure increases. If left untreated, corrosion of some of the vital components of the steel towers could result in incidents such as conductor drop and tower collapse. As the line traverses forested areas, the risk of bushfire from conductor drop or structure failure is increased. Further, the condition of the asbestos paint which is present on some of the tower legs may further deteriorate, leading it to de-bond from the steel and flake. Such incidents could have serious safety consequences for nearby residents and members of the public, as well as field crew members who may be working on or near the assets.

Transgrid manages and mitigates bushfire and safety risk to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with Transgrid's obligations under the New South Wales Electricity Supply (Safety and Network Management) Regulation 2014 and TransGrid's Electricity Network Safety Management System (ENSMS).[15]

The proposed investment will enable Transgrid to continue to manage and operate this part of the network to a safety and risk mitigation level of ALARP. Consequently, it is considered a reliability corrective action under the RIT-T. A reliability corrective action differs from a 'market benefits'-driven RIT-T in that the preferred option is permitted to have negative net economic benefits on account of it being required to meet an externally imposed obligation on the network business.

2.3. Assumptions underpinning the identified need

Transgrid adopts a risk cost framework to quantify and valuate the risks and consequences of increased

[15] Transgrid's ENSMS follows the International Organization for Standardization's ISO31000 risk management framework which requires following hierarchy of hazard mitigation approach.

failure rates. Appendix B provides an overview of the Risk Assessment Methodology adopted by Transgrid.

2.3.1. **Deteriorating asset condition**

Assessing the condition of the line using Transgrid's Risk Cost Framework revealed that the key asset condition issues, summarised in Table 2-1, suggest accelerated deterioration of the affected assets which will result in increase in line failure rates.

Table 2-1 Condition issues along Line 24 and their consequences

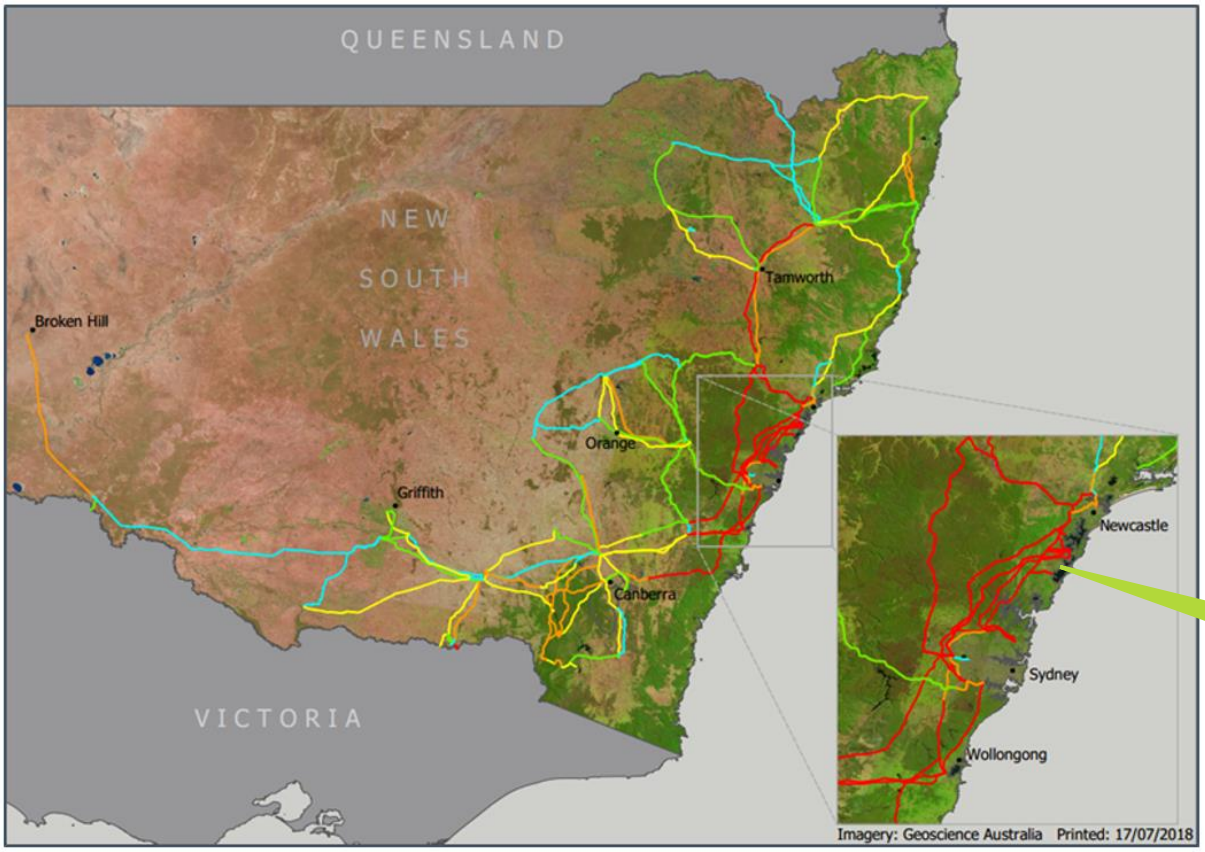
Issue	Consequences if not remediated
Corrosion of tower steel members, including buried legs and ground line steel corrosion	Steel corrosion, particularly of critical members, can lead to structural failure of tower
Tower asbestos paint	Potential asbestos related safety risks
Corroded fasteners	Structural failure
Deteriorated grillage foundation	Structural failure
Corroded insulators and conductor attachment fittings	Conductor drop
Corrosion of earthwire attachment fittings	Conductor drop
Deteriorated tower earthing	Public safety risk increase in case of fault
Deteriorated anti-climber and structure signage	Public safety risk

2.3.2. **Safety and environmental risk costs**

Figure 2-7 below shows a heat map of transmission line risks. Transmission lines in red have the highest safety and environment risks. This has been developed based on an assessment of risk factors of specific locations.

The figure shows that Line 24 is a high risk line. The transmission line mainly traverses semi-urban and forested areas. The environmental and safety risks associated with this line are considered to be amongst the highest in Transgrid's network.

Figure 2-4 Transgrid's line risks heat map



*Line colours on Figure 2-7 represent the level of risk from highest risk to lowest risk respectively: red, orange, yellow, green, and blue.

The safety and environment risk costs from the condition issues identified in Table 2-1 are approximately $8.8 million per year. This figure will increase over time as the assets continue to deteriorate.

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3. Potential credible options

This section describes the options explored by Transgrid to address the need, including the scope of each option and the associated costs. Refer to section 6.1 for benefits of each option.

Transgrid considers that there is one feasible option from a technical, commercial, and project delivery perspective which can be implemented in sufficient time to meet the identified need. Two other options were considered but not progressed for reasons for various reasons which are outlined in Table 3 5.

Transgrid expects coronavirus (COVID-19) to continue to impact its suppliers and disrupt their supply chains, although at this time the extent of the current or future impact is unknown. Consequently, some of the costs associated with the works outlined in this document may be affected.

All costs presented in this PACR are in 2021/22 dollars.

3.1. Base case

The costs and benefits of each option in this PACR are compared against those of a base case.[16] Under this base case, no proactive capital investment is made to remediate the deterioration of Line 24, the line will continue to operate and be maintained under the current regime.

The regular maintenance regime will not be able to mitigate the risk of asset failure which will expose Transgrid and end-customers to approximately $8.8 million per year in safety and environmental risk costs. The main contributor to the safety and environmental risk costs[17] are primarily due to the consequences of a bushfire event resulting from a conductor drop or structure failure. Under the base case, all of these risks will continue to increase as the line continues to deteriorate, and increased reactive corrective maintenance will be required to address defects and/or asset failures in order to keep the line operating at the required standard. This has not been included in the NPV analysis.

The table below provides a breakdown of the operating expenditure under the base case.

Table 3-1 Operating expenditure breakdown under the base case ($ 2021/22)

Item	Operating expenditure ($)
Annualised routine maintenance activities	10,000
Total operating cost	**10,000 (+/-25%)**

[16] Transgrid notes that the December 2018 AER RIT-T Guidelines state that 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'. The AER define 'BAU activities' as ongoing, economically prudent activities that occur in the absence of a credible option being implemented.

[17] This determination of yearly risk costs is based on Transgrid's Network Asset Risk Assessment Methodology and incorporates variables such as likelihood of failure/exposure, various types of consequence costs and corresponding likelihood of occurrence.

3.2. Option 1 – Line refurbishment

Option 1 involves the refurbishment of Line 24 to prevent further deterioration and corrosion to tower steelwork. Details of the scope of works under Option 1 are summarised in Table 3-2.

Table 3-2 Option 1 scope of works

Issue	Remediation
Corrosion of tower steel members	Replacement of tower members and/or blasting and painting of steelwork, nuts & bolts and structure ladders
Tower asbestos paint	Removal of paint via solvents
Deteriorated grillage foundation	Structural bracing and cathodic protection systems
Corrosion of insulators	Replacement of complete insulator arrangement
Corrosion of conductor attachment fittings	
Corrosion of earthwire attachment fittings	Replacement of earthwire including fittings
Deteriorated tower earthing	Replacement of tower earths
Deteriorated anti-climber and structure signage	Public safety risk
Site works	Site establishment and access

The works will be undertaken between 2020/21 and 2022/23. Planning and procurement (including completion of the RIT-T) commenced in 2020/21 and is due to conclude in 2021/22, while project delivery and construction will occur in 2022/23.

All works will be completed in accordance with the relevant standards by 2022/23 with minimal modification to the wider transmission assets. Necessary outages of affected line(s) in service will be planned appropriately in order to complete the works with minimal impact on the network.

The estimated capital expenditure associated with this option is $8.9 million +/-25%.

Table 3-3 Capital expenditure breakdown under Option 1 ($M 2021/22)

Item	Capital expenditure ($M)
Site Establishment	2.2
Access Work	0.2
Transmission tower steelwork remediation	4.6
Asbestos works	0.1
Grillage foundation remediation	0.1
Insulator and fitting replacement works	1.5
Earthwire and fitting replacement works	0.2
Total capital cost	**8.9 (+/- 25%)**

Routine operating and maintenance costs will remain unchanged at approximately $10,000 per year. The table below provides a breakdown. Following the remediation of condition issues, it is expected that the level of reactive corrective maintenance needed to keep the line operating at the required standard will remain in line with average historical levels. This has not been included in the NPV analysis.

Table 3-4 Operating expenditure breakdown under Option 1 ($ 2021/22)

Item	Operating expenditure ($)
Annualised routine maintenance activities	10,000
Total operating cost	**10,000 (+/- 25%)**

Following the refurbishment under this option, the risk reduction from remediating this line comes from environment and safety categories due to reduction in the likelihood of conductor drop. Transgrid calculates the annual safety, environmental and operational risk costs associated with Line 24 under Option 1 to be approximately $10,000.[18]

3.3. Options considered but not progressed

Table 3-5 summarises the reasons the following credible options were not progressed further.

Table 3-5 Options considered but not progressed

Option	Description	Reason(s) for not progressing
Option 2	Line dismantling	Dismantling Line 24 will reduce the supply capability from Northern NSW network to the Greater Sydney region, which may lead to reliability of supply issues.
Option 3	New transmission line from Vales Point to Eraring substation	Due to significant costs of this option (> $50 million), a new 330 kV transmission line from Eraring substation to Vales Point substation is not commercially feasible.

3.4. No material inter-network impact is expected

Transgrid has considered whether the credible option listed above is expected to have material inter-regional impact[19]. A 'material inter-network impact' is defined in the NER as:

"A material impact on another Transmission Network Service Provider's network, which impact 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."

[18] This determination of yearly risk costs is based on Transgrid's Network Asset Risk Assessment Methodology and incorporates variables such as likelihood of failure/exposure, various types of consequence costs and corresponding likelihood of occurrence.

[19] As per clause 5.16.4(b)(6)(ii) of the NER.

AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following[20]:

- a decrease in power transfer capability between transmission networks or in another TNSP's network of no more than the minimum of 3% 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% 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.

Transgrid notes that each credible option satisfies these conditions as it does not modify any aspect of electrical or transmission assets. By reference to AEMO's screening criteria, there is no material inter-network impacts associated with any of the credible options considered.

3.5. Non-network options

Transgrid does not consider non-network options to be commercially and technically feasible to assist with meeting the identified need for this RIT-T, as non-network options will not mitigate the safety and environment risk posed as a result of corrosion-related asset deterioration. Notwithstanding, as part of this consultation process, interested parties were able to make submissions regarding non-network options that satisfy, or contribute to satisfying, the identified need.

Transgrid did not receive any responses from proponents of non-network options to the PSCR.

[20] 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. Accessed 23 June 2021. https://aemo.com.au/-/media/files/electricity/nem/network_connections/transmission-and-distribution/170-0035-pdf.pdf

4. Materiality of market benefits

This section outlines the categories of market benefits prescribed in the National Electricity Rules (NER) and whether they are considered material for this RIT-T.[21]

4.1. Wholesale electricity market benefits are not material

The AER has recognised that if the credible options considered will not have an impact on the wholesale electricity 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.[22]

Transgrid determines that the credible options considered in this RIT-T will not address network constraints between competing generating centres and are therefore not expected to result in any change in dispatch outcomes and wholesale market prices. Transgrid therefore considers that the following classes of market benefits are not material for this RIT-T assessment:

- 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 the RIT-T proponent
- changes in ancillary services costs
- changes in network losses
- competition benefits
- Renewable Energy Target (RET) penalties.

4.2. No other classes of market benefits are material

In addition to the classes of market benefits listed above, NER clause 5.16.1(c)(4) requires Transgrid to consider the following classes of market benefits, listed in Table 4-1, arising from each credible option. Transgrid considers that none of the classes of market benefits listed are material for this RIT-T assessment for the reasons in the table below.

Table 4-1 Reasons non-wholesale electricity market benefits are considered immaterial

Market benefits	Reason
Changes in involuntary load curtailment	Since Line 24 forms part of a meshed network (N-1 redundant) required to supply Greater Sydney Region, a failure due to the corroded assets results in low chance of unserved energy.
Differences in the timing of expenditure	Options considered will provide an alternative to meeting reliability requirements but are unlikely to affect decisions to undertake unrelated expenditure in the network. Consequently, material market benefits will neither be gained nor lost due to changes in the timing of expenditure from any of the options considered.

[21] The NER requires that all classes of market benefits identified in relation to the RIT-T are included in the RIT-T assessment, unless the TNSP can demonstrate that a specific class (or classes) is unlikely to be material in relation to the RIT-T assessment for a specific option – NER clause 5.16.1(c)(6). See Appendix A for requirements applicable to this document.

[22] Australian Energy Regulator. "*Application guidelines Regulatory Investment Test for Transmission - August 2020*." Melbourne: Australian Energy Regulator. https://www.aer.gov.au/system/files/AER%20-%20Regulatory%20investment%20test%20for%20transmission%20application%20guidelines%20-%2025%20August%202020.pdf

Option value	Transgrid notes the AER's view that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available is likely to change in the future, and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[23] Transgrid also notes the AER's view 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 notes that no credible option is sufficiently flexible to respond to change or uncertainty. Additionally, a significant modelling assessment would be required to estimate the option value benefits but it would be disproportionate to potential additional benefits for this RIT-T. Therefore, Transgrid has not estimated additional option value benefit.

[23] Australian Energy Regulator. "*Application guidelines Regulatory Investment Test for Transmission - August 2020*." Melbourne: Australian Energy Regulator. https://www.aer.gov.au/system/files/AER%20-%20Regulatory%20investment%20test%20for%20transmission%20application%20guidelines%20-%2025%20August%202020.pdf

5. Overview of the assessment approach

This section outlines the approach that Transgrid has applied in assessing the net benefits associated with each of the credible options against the base case.

5.1. Description of the base case

The costs and benefits of each option in this document are compared against the base case. Under this base case, no investment is undertaken, Transgrid incurs regular and reactive maintenance costs, and the line will continue to operate with an increasing level of risk.

Transgrid notes that this course of action is not expected in practice. However, this approach has been adopted since it is consistent with AER guidance on the base case for RIT-T applications.[24]

5.2. Assessment period and discount rate

A 20 year post-commissioning assessment period from 2023/24 to 2042/43 was considered in this analysis. This period takes into account the size, complexity and expected asset life of the options.

Transgrid adopted a central real, pre-tax 'commercial' discount rate[25] of 5.50 per cent as the central assumption for the NPV analysis presented in this report. Transgrid considers that this is a reasonable contemporary approximation of a commercial discount rate and it is consistent with the central estimate discount rate adopted by AEMO in its 2021 IASR[26].

Transgrid also tested the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 2.30 per cent equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this document[27], and an upper bound discount rate of 8.70 per cent (a symmetrical adjustment upwards) were used to maintain consistency with the assessment approach used in the PSCR.

5.3. Approach to estimating option costs

Transgrid has estimated the capital costs of the options based on the scope of works necessary together with costing experience from previous projects of a similar nature. Transgrid estimates that the actual cost is within +/- 25 per cent of the central capital cost.

Routine operating and maintenance costs are based on works of similar nature.

[24] Transgrid notes that the AER RIT-T Guidelines state that 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'. The AER define 'BAU activities' as ongoing, economically prudent activities that occur in the absence of a credible option being implemented. Australian Energy Regulator. "*Application guidelines Regulatory Investment Test for Transmission - August 2020*." Melbourne: Australian Energy Regulator.

[25] 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.

[26] AEMO, 2021 Inputs, Assumptions and Scenarios Report, July 2021

[27] The lower bound discount rate is based on the WACC (pre-tax, real) in the most recent final decision for a TNSP revenue determination which was Powerlink in April 2022.

5.4. Three different scenarios have been modelled to address uncertainty

The assessment was conducted under three net economic benefits scenarios. These are plausible scenarios which reflect different assumptions about the future market development and other factors that are expected to affect the relative market benefits of the options being considered. All scenarios (low, central and high) involve a number of assumptions that result in the lower bound, the expected, and the upper bound estimates for present value of net economic benefits respectively.

A summary of the key variables in each scenario is provided in the table below.

Table 5-1 Summary of scenarios

Variable / Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Discount rate	5.50%	8.70%	2.30%
Costs			
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Operating and maintenance costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Benefits			
Reduction in safety and environmental risk costs	Base estimate	Base estimate - 25%	Base estimate + 25%

Transgrid considered that the central scenario was most likely since it was based primarily on a set of expected assumptions. Transgrid therefore assigned this scenario a weighting of 50 per cent, with the other two scenarios being weighted equally with 25 per cent each.

6. Assessment of credible options

This section outlines the assessment Transgrid has undertaken of the credible network options. The assessment compares the costs and benefits of each credible option to the base case. The benefits of each credible option are represented by reduction in costs or risks compared to the base case.

All costs presented in this PACR are in 2021/22 dollars.

6.1. Estimated gross benefits

The table below summarises the present value of the gross benefit estimates for each credible option relative to the base case under the three scenarios.

The benefits included in this assessment are:

- Reduction in safety and environmental risks.

Table 6-1 Estimated gross benefits from credible options relative to the base case, present value ($M)

Option/scenario	Central	Low benefit scenario	High benefit scenario	Weighted
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	102.4	58.2	175.5	109.6

6.2. Estimated costs

The table below summarises the capital costs of the options, relative to the base case, in present value terms. The cost of each credible option has been calculated for each of the three reasonable scenarios outlined in section 5.4.

Table 6-2 Costs of credible options relative to the base case, present value ($M)

Option/Scenario	Central	Low benefit scenario	High benefit scenario	Weighted
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	8.5	10.3	6.5	8.5

6.3. Estimated net economic benefits

These net economic benefits are the differences between the estimated gross benefits less the estimated costs. The table below summarises the present value of the net economic benefits for each credible option across the three scenarios and the weighted net economic benefits.

Option 1 is found to have positive net benefits for the central and high benefit scenarios investigated. On a weighted basis, Option 1 will deliver approximately $102.4 million in net economic benefits above the base case.

Table 6-3 Net economic benefits for Option 1 relative to the base case, present value ($M)

Option	Central	Low benefit scenario	High benefit scenario	Weighted	Ranking
Scenario weighting	*50%*	*25%*	*25%*		
Option 1	93.9	47.9	169.0	101.2	1

Figure 6-1 Net economic benefits, present value ($M)

6.4. Sensitivity testing

Transgrid undertakes sensitivity testing to understand the robustness of the RIT-T assessment to underlying assumptions about key variables. In particular, Transgrid undertakes two sets of sensitivity tests – namely:

- Step 1 – testing the sensitivity of the optimal timing of the project ('trigger year') to different assumptions in relation to key variables
- Step 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.

Having assumed to have committed to the project by this date, Transgrid has also looked at the consequences of 'getting it wrong' under step 2 of the sensitivity testing. That is, if expected safety and environmental risks are not as high as expected, for example, the impact on the net economic benefit associated with the project continuing to go ahead on that date.

The application of the two steps to test the sensitivity of the key findings is outlined below.

6.4.1. **Step 1 – Sensitivity testing of the optimal timing**

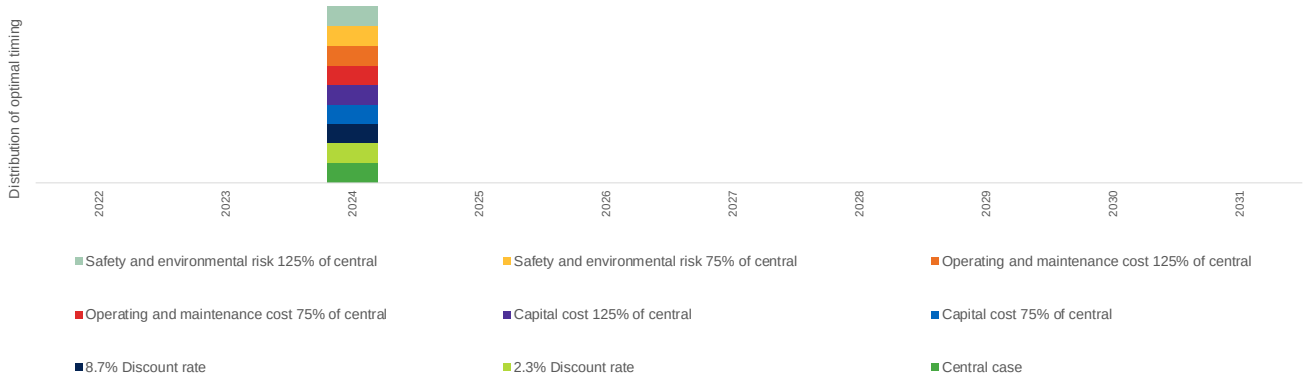
Transgrid has estimated the optimal timing for Option 1 based on the year in which the NPV is maximised. This process was undertaken for both the central set of assumptions and also a range of alternative assumptions for key variables. This section outlines the sensitivity of the identification of the commissioning

year to changes in the underlying assumptions. In particular, the optimal timing of the option is found to be invariant to the assumptions of:

- a 25 per cent increase/decrease in the assumed network capital costs
- lower discount rate of 1.96 per cent as well as a higher rate of 9.04 per cent
- lower (or higher) assumed operation and maintenance costs
- lower (or higher) assumed safety and environmental risks

The figure below outlines the impact on the optimal commissioning year, under a range of alternative assumptions. It illustrates that for Option 1, the optimal commissioning date is found to be in 2022/23, such that the benefits are realised from 2023/24, for all of the sensitivities investigated.

Figure 6-2 Optimal timing of Option 1



6.4.2. **Step 2 – Sensitivity of the overall net benefit**

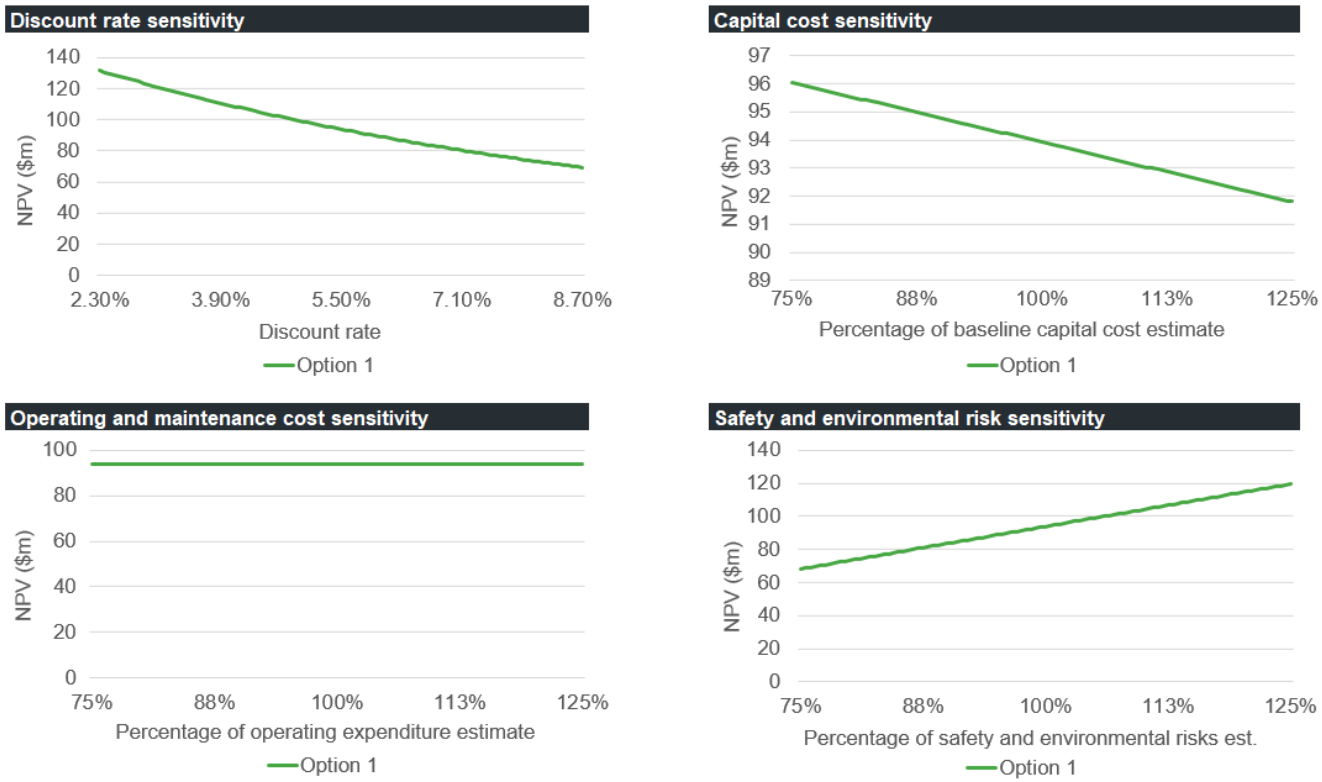
Transgrid has conducted sensitivity analysis on the present value of the net economic benefit, based on having to undertake the project by 2022/23. Specifically, Transgrid has investigated the same sensitivities under this step as in the first step:

- a 25 per cent increase/decrease in the assumed network capital costs
- lower discount rate of 2.30 per cent as well as a higher rate of 8.70 per cent
- lower (or higher) assumed operation and maintenance costs
- lower (or higher) assumed safety and environmental risks

All these sensitivities investigate the consequences of 'getting it wrong' having committed to a certain investment decision.

The figures below illustrate the estimated net economic benefits for each option if separate key assumptions in the central scenario are varied individually. Option 1 delivers positive benefits under all scenarios. The figures below illustrate that while the results are most sensitive to the safety and environmental risk costs estimates and the discount rate, it is still reasonable to make investments to mitigate the risk.

Figure 6-3 Sensitivities



6.5. Meeting relevant regulatory obligations

Transgrid considers that the sensitivity assessment discussed in section 6.4 demonstrates that planning for any commissioning later than 2022/23 would be inconsistent with the ALARP obligations under the New South Wales Electricity Supply (Safety and Network Management) Regulation 2014. In particular, due to higher risk cost associated with safety and environmental risk, there would be lower expected net market benefits (greater net market cost) if the replacement works were delayed.

Transgrid manages and mitigates bushfire and safety risk to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with Transgrid's obligations under the New South Wales Electricity Supply (Safety and Network Management) Regulation 2014 and Transgrid's Electricity Network Safety Management System (ENSMS).[28]

Under the ALARP test a gross disproportionate factor[29] would typically be applied. Applying the factor in this case would only further enhance support for Option 1 as the outcome of the weighted NPV analysis already demonstrates that the benefits are positive. Transgrid's analysis concluded that the costs are less than the

[28] Transgrid's ENSMS follows the International Organization for Standardization's ISO31000 risk management framework which requires following hierarchy of hazard mitigation approach.

[29] In accordance with the framework for applying the ALARP principle, a disproportionality factor of 6 is typically applied to risk cost figures. The values of the disproportionality factors applied by Transgrid were determined through a review of practises and legal interpretations across multiple industries, with particular reference to the works of the UK Health and Safety Executive. The methodology used to determine the disproportionality factors is in line with the principles and examples presented in the AER Replacement Planning Guidelines and is consistent with Transgrid's Revised Revenue Proposal 2018/19- 2022/23.

weighted benefits from mitigating bushfire and safety risks. Accordingly, Transgrid has not repeated the assessment with the disproportionality factor multipliers.

The proposed investment will enable Transgrid to continue to manage and operate this part of the network to a safety and risk mitigation level of ALARP. Consequently, it is considered a reliability corrective action under the RIT-T. A reliability corrective action differs from a 'market benefits'-driven RIT-T in that the preferred option is permitted to have negative net economic benefits on account of it being required to meet an externally imposed obligation on the network business.

7. Final conclusion on the preferred option

The optimal commercially and technically feasible option presented in this PACR – Option 1 (line refurbishment) – remains the preferred option to meet the identified need. Option 1 can be implemented in sufficient time to meet the identified need by 2022/23, and is therefore the preferred option presented in this PACR.

Moving forward with this option is the most prudent and economically efficient solution to manage and mitigate safety and environmental risk to ALARP. Consequently, it will ensure Transgrid's obligations under the New South Wales Electricity Supply (Safety and Network Management) Regulation 2014 and Transgrid's Electricity Network Safety Management System (ENSMS) are met.

The estimated capital expenditure associated with this option is $8.9 million +/- 25 per cent. Routine operating and maintenance costs relating to planned checks by Transgrid field crew are approximately $10,000 per year – similar to the cost under the base case. Transgrid calculates that the avoided risk cost by undertaking Option 1 is approximately $8.8 million per year. Further, a reduction in reactive corrective maintenance costs is also expected. This has not been included in the NPV analysis.

This preferred option, Option 1, is found to have positive net benefits under all scenarios investigated and on a weighted basis will deliver approximately $101.2 million in net economic benefits. Transgrid also conducted sensitivity analysis on the net economic benefit to investigate the robustness of the conclusion to key assumptions. Transgrid finds that under all sensitivities, positive net benefits are expected from refurbishing Line 24.

The works will be undertaken between 2021/22 and 2022/23. Planning and procurement (including completion of the RIT-T) commenced in 2021/22, while project delivery and construction will occur in 2022/23.

All works will be completed in accordance with the relevant standards by 2022/23 with minimal modification to the wider transmission assets. Necessary outages of affected line(s) in service will be planned appropriately in order to complete the works with minimal impact on the network.

Option 1 is the preferred option in accordance with NER clause 5.16.1(b) because it is the credible option that maximises the net present value of the net economic benefit to all those who produce, consume and transport electricity in the market. The analysis undertaken and the identification of Option 1 as the preferred option satisfies the RIT-T.

Appendix A Compliance checklist

This appendix sets out a checklist which demonstrates the compliance of this PACR with the requirements of the National Electricity Rules version 182.

Rules clause	Summary of requirements	Relevant section
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).	NA
5.16.4(k)	The project assessment draft report must include:	–
	(1) a description of each credible option assessed;	3
	(2) a summary of, and commentary on, the submissions to the project specification consultation report;	NA
	(3) a quantification of the costs, including a breakdown of operating and capital expenditure, and classes of material market benefit for each credible option;	3, 4
	(4) a detailed description of the methodologies used in quantifying each class of material market benefit and cost;	5
	(5) reasons why the RIT-T proponent has determined that a class or classes of market benefit are not material;	4
	(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);	3, 4
	(7) the results of a net present value analysis of each credible option and accompanying explanatory statements regarding the results;	6
	(8) the identification of the proposed preferred option;	7
	(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*.	3, 7

Appendix B Risk Assessment Methodology

This appendix summarises the key assumptions and data from the risk assessment methodology that underpin the identified need for this RIT-T and the assessment undertaken for the Revenue Proposal.[30]

As part of preparing its Revenue Proposal for the current regulatory control period, Transgrid developed the Network Asset Risk Assessment Methodology to quantify risk for replacement and refurbishment projects. The risk assessment methodology:

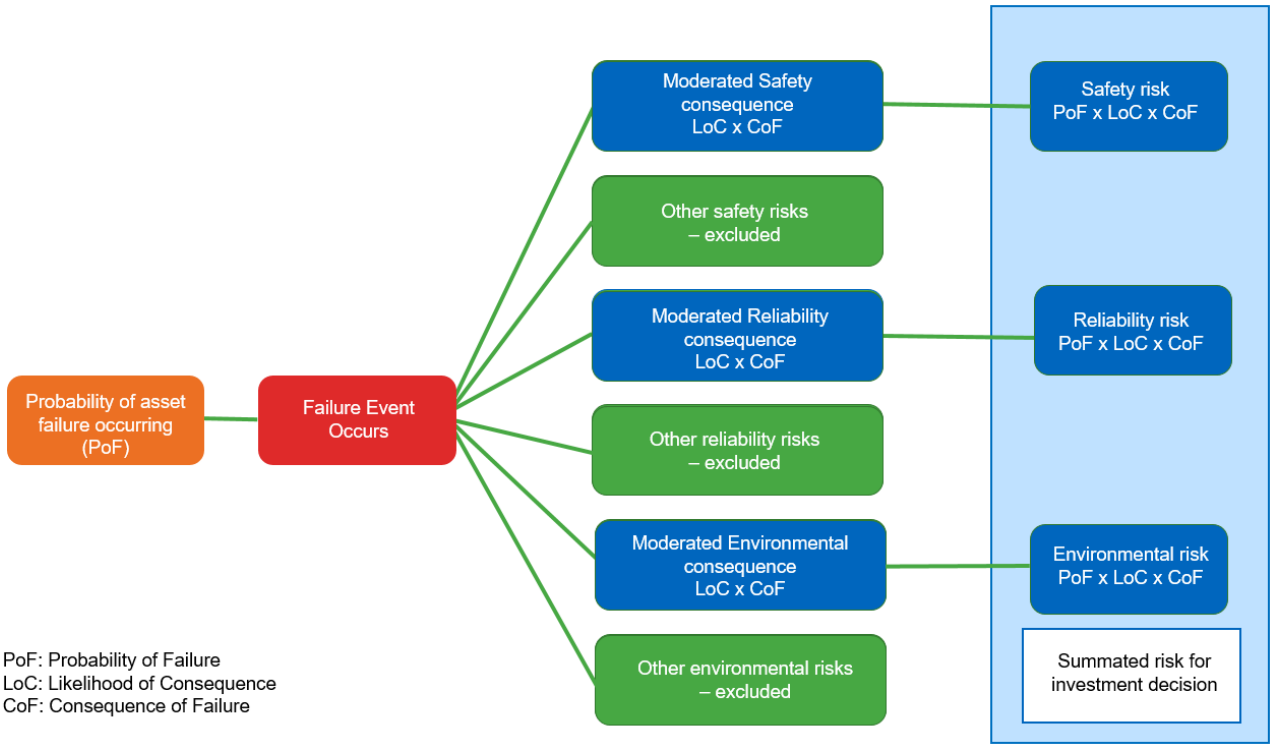
- uses externally verifiable parameters to calculate asset health and failure consequences
- assesses and analyses asset condition to determine remaining life and probability of failure
- applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence in a particular circumstance
- identifies safety and compliance obligations with a linkage to key enterprise risks

B.1 Overview of the risk assessment methodology

A fundamental part of the risk assessment methodology is calculating the 'risk costs' or the monetised impacts of the reliability, safety, environmental and other risks.

The figure below summarises the framework for calculating the 'risk costs', which has been applied on Transgrid's asset portfolio considered to need replacement or refurbishment.

Figure B-1 Overview of Transgrid's 'risk cost' framework



[30] Transgrid. "*Revised Regulatory Proposal 2018/19-2022/23*." Melbourne: Australian Energy Regulator, 2017. 63-69. Accessed 15 March 2019. https://www.aer.gov.au/system/files/TransGrid%20-%20Revised%20Revenue%20Proposal%20-%201%20December%202017.pdf

The ‘risk costs’ are calculated based on the Probability of Failure (PoF), the Consequence of Failure (CoF), and the corresponding Likelihood of Consequence (LoC).

In calculating the PoF, each failure mode that could result in significant impact is considered. For replacement planning, only life-ending failures are used to calculate the risk costs. PoF is calculated for each failure mode base on ‘conditional age’ (health-adjusted chronological age), failure and defect history, and benchmarking studies. For ‘wear out’ failures, a Weibull curve may be fitted; while for random failures, a static failure rate may be used.

In calculating the CoF, LoC and risks, Transgrid uses a moderated ‘worst case’ consequence. This is an accepted approach in risk management and ensures that high impact, low probability (HILP) events are not discounted. The approach excludes the risk costs of low impact, high probability (LIHP) which would results in lower calculated risk.