Transgrid

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Managing safety and environmental risks on Line 18 (Kangaroo Valley – Dapto)

RIT-T Project Assessment Conclusions Report

Region: Southern

Date of issue: 21 December 2021

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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 18. Publication of this Project Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

Commissioned in 1974, the 43 km single circuit 330 kV transmission line is comprised of 107 steel tower structures between Kangaroo Valley switching station and Dapto 330 kV substation. The section from Kangaroo Valley to Robertson was built in 1974 whilst the remaining section to Dapto substation was built in 1962, previously part of a Yass-Dapto connection. Line 18 forms a key link between the Shoalhaven and Wollongong regions and supports the transmission of electricity from existing generators in southern NSW to the major load centres of Sydney, Newcastle and Wollongong.

The line 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 farmland and Morton National Park – after leaving Dapto, it climbs from the coastal plain up the Illawarra Escarpment.

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 18 and their consequences

Issue	Consequences if not remediated
Corrosion of tower steel members	Steel corrosion, particularly of critical members, can lead to structural failure of tower
Foundation condition buried legs and ground level steel corrosion	Foundation failure
Corroded fasteners	Structural failure
Corroded insulators and conductor attachment fittings	Conductor drop
Corrosion of earth wire and earthwire attachment fittings	Public safety risk increase in case of fault
Condition of conductor and earthwire vibration dampers	Accelerated conductor fatigue due to vibration
Condition of conductor spacers	Damaged spacers can lead to conductor clashing
Asbestos paint	Safety risks
Condition of Climbing deterrents	Public safety

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

Identified need: managing safety and environmental risks from corrosion on Line 18

The proposed investment will enable Transgrid to manage safety and environmental risks on Line 18. 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 18 will continue to deteriorate.

Transgrid calculates that the safety and environmental risk costs associated with the condition deterioration and corrosion of Line 18 are approximately $0.7 million per year and the financial risks are approximately $0.03 million. Condition deterioration of the affected assets due to corrosion would mean an increase in bushfire and safety risks along Line 18 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 risks 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).[1]

Using Transgrid's Risk Assessment Methodology[2], the risks on safety and environment are sufficient such that their mitigation is warranted. The safety and environmental risk costs from corrosion of steel components of the structures, or 'members', insulators and fittings are estimated to be approximately $0.7 million per year.[3]

Under the ALARP test with the application of a gross disproportionate factor[4], the weighted benefits are expected to exceed the cost. Transgrid's analysis concludes that the costs are less than the weighted benefits from mitigating bushfire and safety risks. 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.

Applying the ALARP principle to manage and mitigate bushfire and safety risks, Transgrid determines that its obligations under the New South Wales *Electricity Supply (Safety and Network Management) Regulation 2014* and Transgrid's ENSMS will be met by implementing Option 1 by 2022/23. Under this principle, risks are mitigated unless it is possible to demonstrate that the costs involved in further reducing the risk would be grossly disproportionate to the benefits gained. Using the ALARP principle, all scenarios under Option 1 are NPV positive.

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.

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

[2] Appendix B provides an overview of the risk assessment methodology adopted by Transgrid.

[3] 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.

[4] In accordance with the framework for applying the ALARP principle, a disproportionality factor of 6 has been applied to risk cost figures. The values of the disproportionality factors 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 in this PSCR 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.

Submissions received in response to Project Specification Consultation Report

Transgrid published a Project Specification Consultation Report (PSCR) on 28 May 2021 and invited written submissions on the material presented within the document. One formal submission was received on the PSCR and with permission from the submitter it is available on Transgrid's website.

The submission covered consideration of the maintenance regime, assessment of the risk costs, and demonstrating the value for money of the investment.

Transgrid values the feedback raised in the submission and has taken it into account in preparing this report.

No material developments since publication of the PSCR

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

The following change has occurred since the PSCR which has not made an impact on the preferred option:

- the cost estimate factors for Option 1 have been adjusted to reflect the latest estimated resourcing requirements to implement the preferred option. This resulted in an increase to the total cost estimate from $8.66m to $8.83m.
- financial risk costs have been included in the analysis in response to the submission received.

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

Transgrid considers refurbishing Line 18 is the only credible option

Transgrid put forward for consideration one technically and commercially feasible option[5]: refurbishing the existing line by remediating or replacing the identified components. This option (Option 1) involves the refurbishment of Line 18 including replacement of asset components, earthwire, foundation repairs and remediation of steelwork.

The primary driver for the identified need is to mitigate bushfire and safety risks associated with condition issues on Line 18 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 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 2020/21 dollars.

Table E-2 Options considered

Option	Description	Capital costs ($m 2020/21)	Operating costs ($ per year)	Remarks
Option 1	**Line refurbishment**	**8.83 (+/- 25%)**	**25,000**	**Most economical and preferred option**

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

Option 2	Line dismantling	~12.8	0	Not progressed due to technical infeasibility. Dismantling Line 18 will reduce the supply capability from the Southern network to Greater Sydney significantly, which may lead to reliability of supply issues.
Option 3	New transmission line from Kangaroo Valley switching station to Dapto substation	> 100	Not considered	Due to significant costs of this option, a new 330 kV transmission line from Kangaroo Valley switching station to Dapto 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 18 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 $8.83 million +/- 25 per cent. Routine operating and maintenance costs relating to planned checks by Transgrid field crew are approximately $25,000 per year – similar to the cost under the base case. Transgrid calculates that the avoided risk cost by undertaking Option 1 is approximately $0.60 million[6] per year.

This preferred option, Option 1, is found to have positive net benefits only for the high benefit scenario at $5.1 million. Using the ALARP principle, where disproportionality factors have been applied on the bushfire and safety risks, the benefits from the risk reduction outweigh the costs under all scenarios for Option 1 and on a weighted basis will deliver $29.7 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 18.

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 be completed in in 2022/23.

All works will be completed in accordance with the relevant standards by 2023 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.

[6] $3.4 million per year including the ALARP disproportionality factor.

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 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 May 2021.

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[7] due to:

- the estimated capital cost of the proposed preferred option being less than $43 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[8] 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 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 24 January 2022 (30 days after publication of this PACR[9]). 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 18 PACR'.

[7] 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.

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

[9] 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 18, a single circuit 330 kV transmission line between Kangaroo Valley and Dapto.

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)[10].

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[11] 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 $43 million[12];
- 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[13] 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.

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

[11] See Appendix A for the National Electricity Rules requirements.

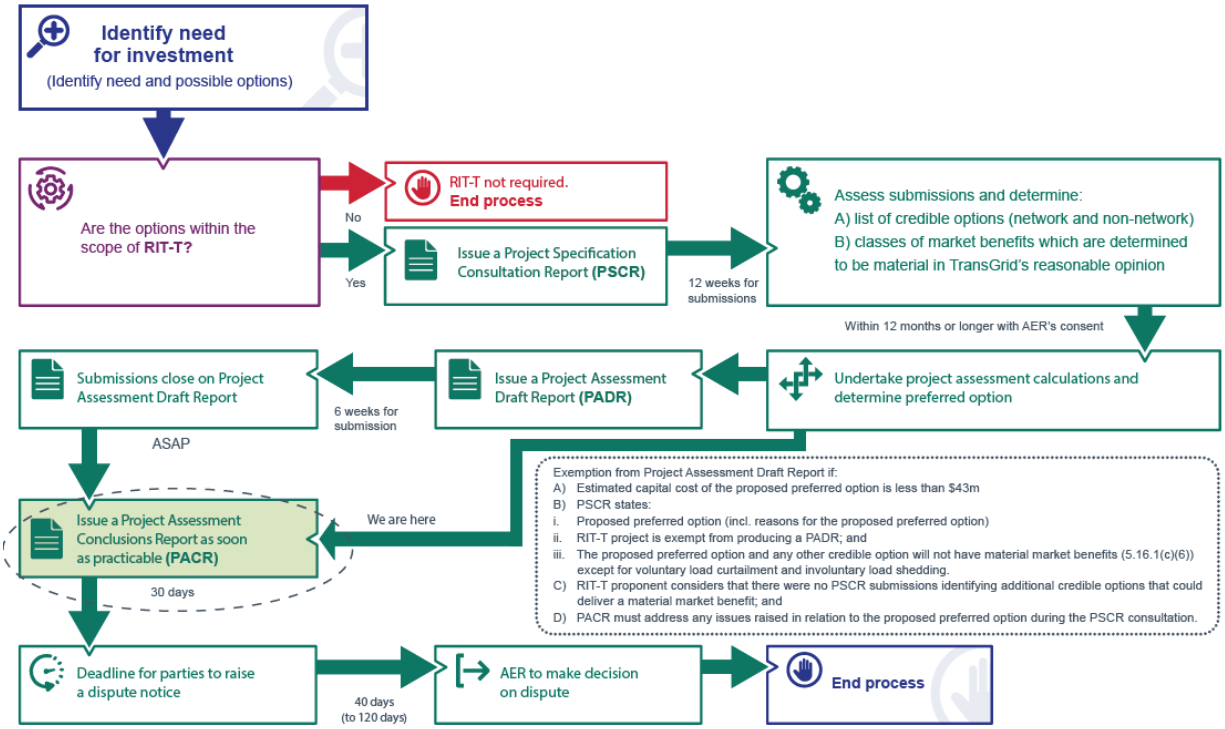
[12] Varied from $35m to $43m based on the AER Final Determination: Cost threshold review November 2018.14. Accessed 20 May 2020 https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/cost-thresholds-review-for-the-regulatory-investment-tests-2018

[13] 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 May 2021. One submission was received in response to the PSCR. With permission from the submitter, the submission is available on Transgrid's website. Transgrid has taken feedback raised in the submission into account in preparing the PACR.

Figure 1-1 This PACR is the third stage of the RIT-T process[14]



Parties wishing to raise a dispute notice with the AER may do so prior to 24 January 2022 (30 days after publication of this PACR[15]). 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 18 PACR'.

[14] 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

[15] 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 Southern NSW network and existing electricity supply arrangements.

2.1. Background to the identified need

The transmission line referred to throughout this PACR was commissioned in 1974. It has two sections. The section from Dapto to Robertson was originally built in 1961 as a Yass - Dapto transmission line.

In 1974, a new transmission line was built from Kangaroo Valley to Avon and rearranged with the existing Yass – Dapto lines (No's 4 and 5) at Robertson. These lines were eventually turned into Marulan substation on its commissioning in the early 1980's.

The current arrangement of the circuits between Dapto and Marulan is shown in Figure 2 1 below.

Figure 2-1 Current arrangements of Line 18

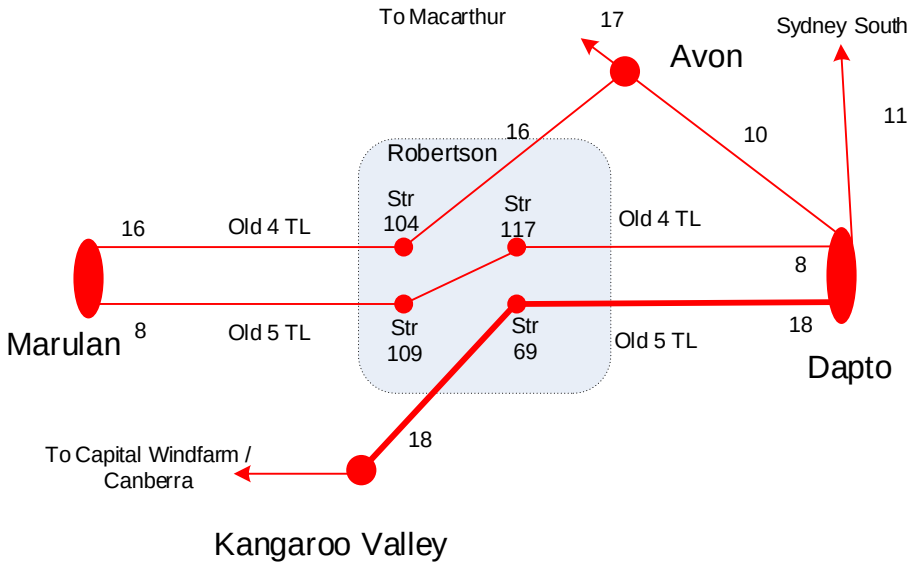
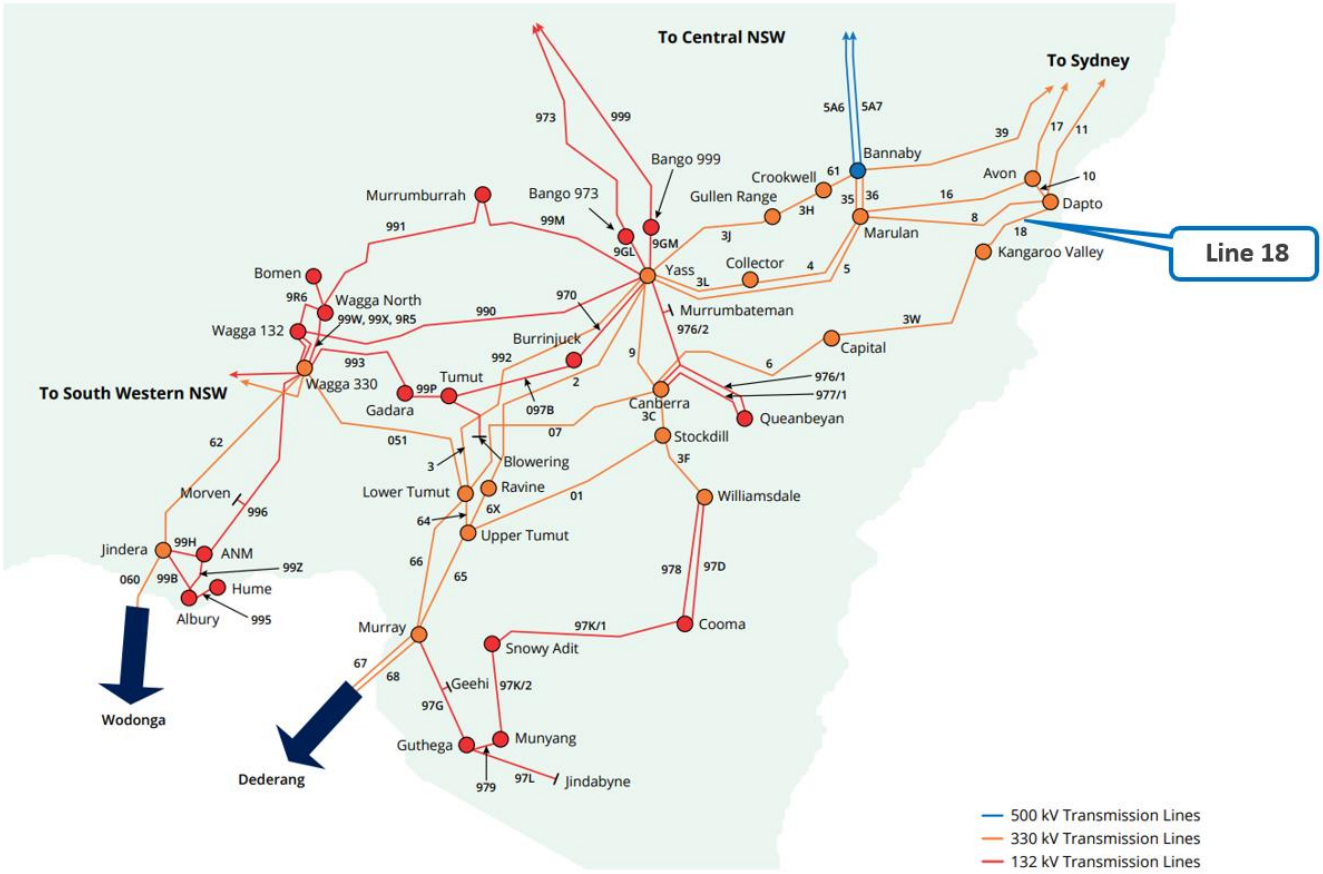


Figure 2-2 Location of Line 18 on Transgrid's network



Line 18 forms a key link between the Shoalhaven and Wollongong regions and supports the transmission of electricity from existing generators in southern NSW to the major load centres of Sydney, Newcastle and Wollongong.

The transmission line mainly traverses farmland and Morton National Park – after leaving Dapto, it climbs from the coastal plain up the Illawarra Escarpment.

It will continue to play a central role in supporting the flow of energy between regions 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.

A condition assessment performed by Transgrid in March 2016 identified a number of issues with Line 18. Further condition inspections were performed in late 2019 identified that a significant proportion of the steel transmission structures are impacted by various levels of deterioration and corrosion. The affected components include tower steelwork, foundations and earthing, insulators, conductor fittings, earthwire and vibration dampers, and increases the likelihood of transmission structure failures, conductor drop, and subsequent bushfire and safety risks.

Figure 2-3 – Figure 2-5 below demonstrate examples of the condition of various components of Line 18.

Figure 2-3 Corroded conductor and earthwire fittings

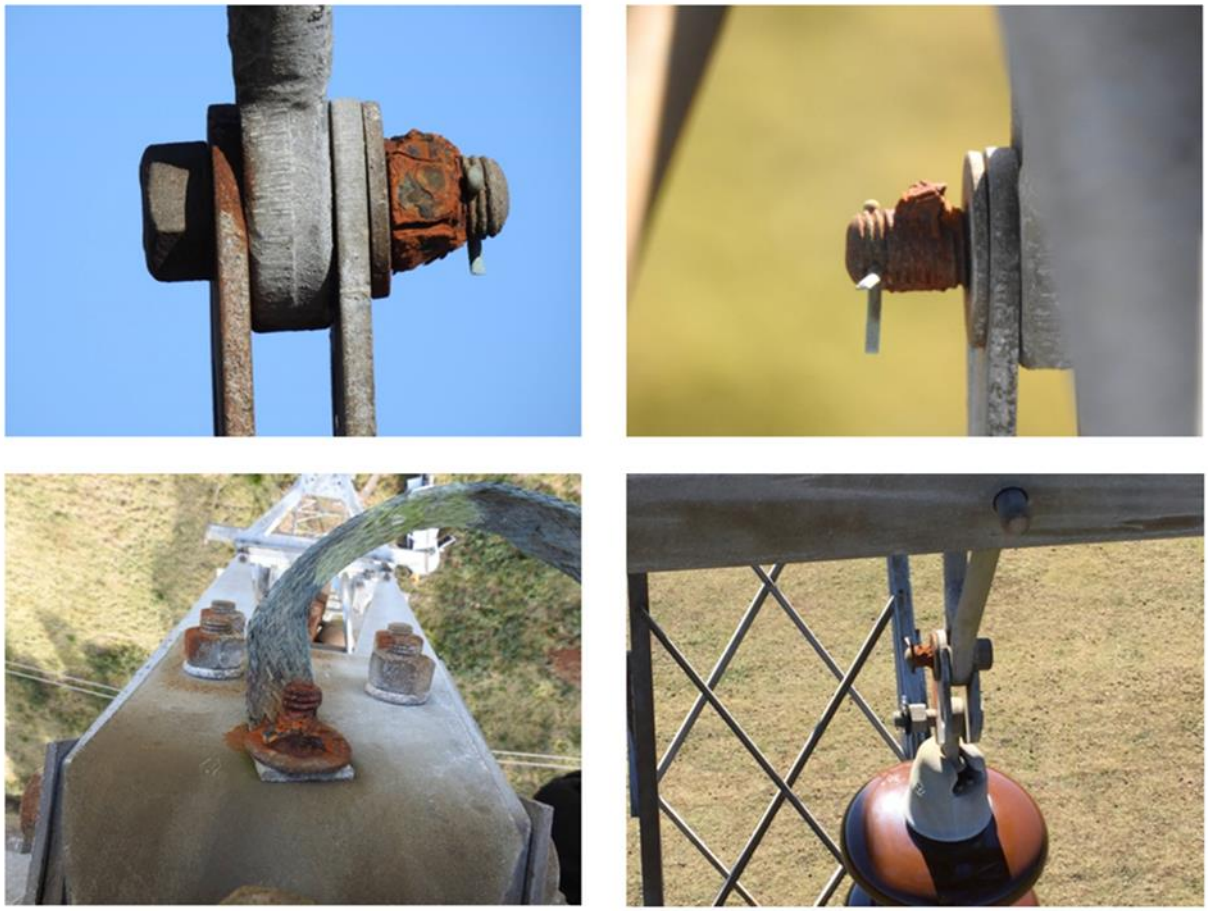


Figure 2-4 Damaged conductor spacers

Figure 2-5 Rust on insulator pins

Figure 2-6 Rust on cross-arm members

2.2. Description of identified need

The proposed investment to will enable Transgrid to manage safety and environmental risks on Line 18. 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 18 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 18 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).[16]

Using Transgrid's Risk Assessment Methodology[17], the risks on safety and environment are sufficient such that their mitigation is warranted. The safety and environmental risk costs from corrosion of steel components of the structures, or 'members', insulators and fittings are estimated to be approximately $0.7 million per year[18]. The financial risk, which is the direct financial consequence arising from the failure of an asset including the cost of reactive replacement and repair, is estimated to be approximately $0.03 million per year.

Applying the ALARP principle to manage and mitigate bushfire and safety risks, Transgrid determines that its obligations under the New South Wales Electricity Supply (Safety and Network Management) Regulation 2014 and Transgrid's ENSMS will be met by implementing Option 1 by 2022/23. Under this principle, risks are mitigated unless it is possible to demonstrate that the costs involved in further reducing the risk would be grossly disproportionate to the benefits gained. Using the ALARP principle, all scenarios under Option 1 are NPV positive.

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

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

[17] Appendix B provides an overview of the risk assessment methodology adopted by Transgrid.

[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.

2.3.1. **Deteriorating asset condition**

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

Table 2-1 Condition issues along Line 18 and their consequences

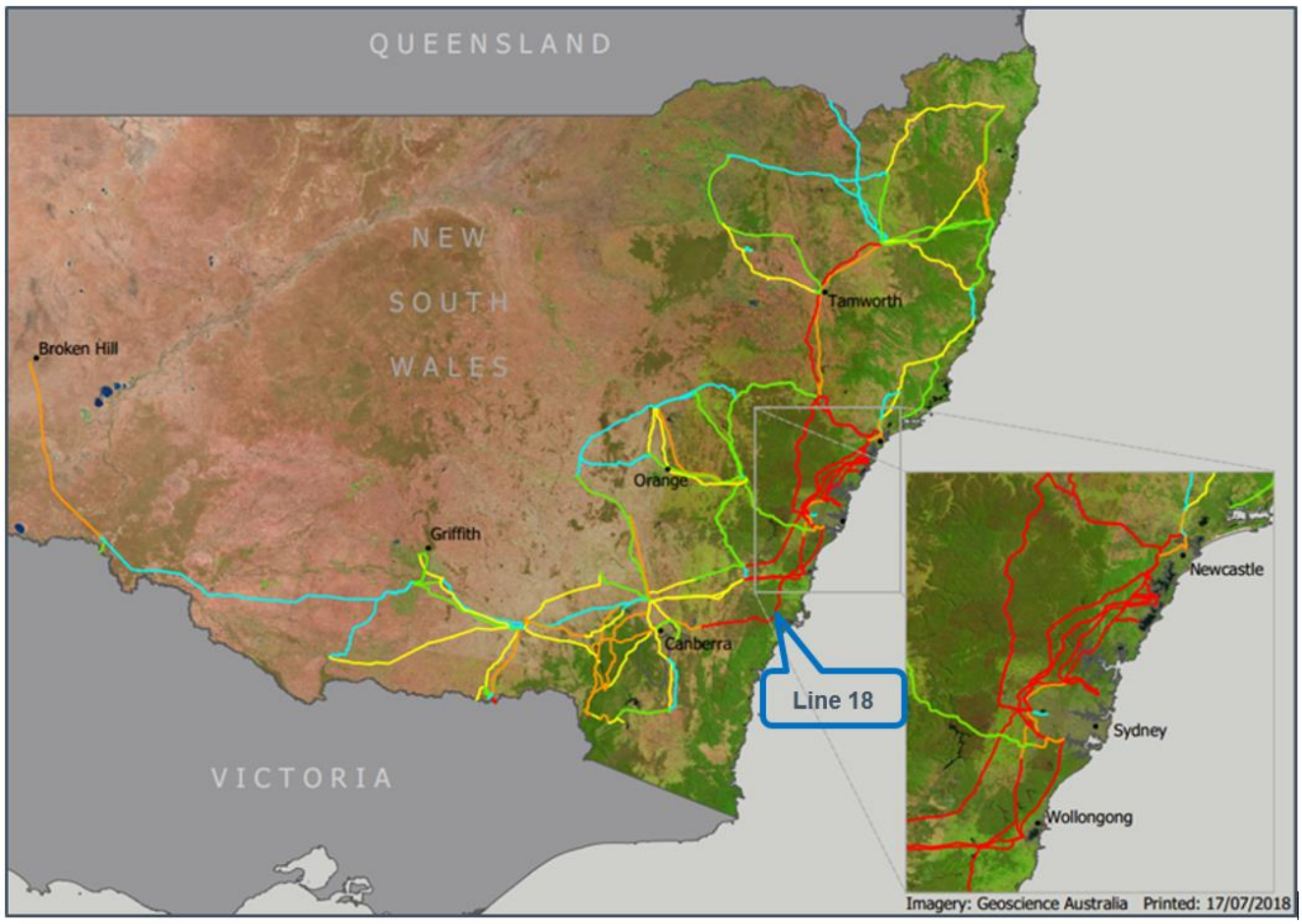
Issue	Proportion of transmission line affected	Consequences if not remediated
Corrosion of tower steel members	12%	Steel corrosion, particularly of critical members, can lead to structural failure of tower
Footing repairs - buried steelwork and ground level corrosion	5%	Foundation failure
Corroded fasteners	5%	Structural failure
Corroded insulators and conductor attachment fittings	75%	Conductor drop
Corrosion of earth wire and earthwire attachment fittings	10%	Public safety risk increase in case of fault
Condition of conductor and earthwire vibration dampers	10%	Accelerated conductor fatigue due to vibration
Condition of conductor spacers	40%	Damaged spacers can lead to conductor clashing
Asbestos paint	3%	Safety risks
Climbing deterrent	2%	Public Safety risks

2.3.2. **Safety and environmental risk costs**

Figure 2-6 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 18 is a high risk line. The transmission line mainly traverses farmland and Morton National Park – after leaving Dapto, it climbs from the coastal plain up the Illawarra Escarpment. The environmental (bushfire) and safety risks associated with this line are considered to be amongst the highest in Transgrid's network.

Figure 2-7 Transgrid's line risks heat map



*Line colours on Figure 2-6 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 $0.7 million per year. This figure will increase over time as the assets continue to deteriorate.

2.3.3. **Financial risk costs**

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. This represents the expected reactive maintenance costs under the base case from the condition issues identified in Table 2-1 should a failure occur, which are approximately $0.03 million per year.

3. Consultation on the PSCR

Transgrid published a Project Specification Consultation Report (PSCR) on 28 May 2021 and invited written submissions on the material presented within the document. One formal submission was received on the PSCR and with permission from the submitter it is available on Transgrid's website.

Transgrid values the feedback raised in the submission and has taken it into account in preparing this PACR. The topics raised and how they have been considered in this PACR is summarised in Table 3-1.

Table 3-1 Summary of consultation comments on PSCR

Consultation comments	PACR consideration
Considering alternative solutions to correct issues before they present a failure risk	Safety is Transgrid's highest priority and routine maintenance inspections are undertaken to assess the condition of assets. We respond to any issues in accordance with our plans and procedures, and at the optimal time, either in the form of maintenance activities and/or as part of refurbishment projects. We have actioned 137 issues on Line 18 over the last 5 years through our maintenance program to maintain safety, however, we are forecasting that a refurbishment of the transmission line is now required to maintain safety into the future as the reactive maintenance costs escalate. The refurbishment of the transmission line aims to intervene at the optimal time, considering both the failure risk and cost of refurbishment.
Demonstrating that the proposed approach represents value for money	Line 18 is experiencing deteriorating condition affecting a significant proportion of the transmission line, which we have now detailed in section 2.3.1. Only these deteriorated items of the transmission line are proposed to be refurbished in a targeted manner. We have identified a credible option to refurbish the asset and assessed that this offers net economic benefits. We have also considered other options such as dismantling or rebuilding the transmission line, but these were deemed technically and/or commercially infeasible. The RIT-T PSCR assessment, and the assessment in this PACR, shows that considering the risk and capital cost, there are net economic benefits as a result of the investment. We are also obligated to reduce network safety risks to As Low As Reasonably Practicable, which is the identified need for this RIT-T.
Routine and corrective maintenance costs considered in the analysis	We included in our RIT-T PSCR assessment the routine maintenance costs, but we did not include the additional benefit of reduced corrective maintenance costs as this would only increase the net benefits provided by refurbishing the transmission line compared to the base case, and not be material to the outcome of the assessment. We have now included in the PACR assessment the expected future reactive maintenance costs as a financial risk cost, described in section 2.3.3.
Asset condition risk calculation inputs and considerations	We assess the probability of failure across many components of the transmission line, including the tower steelwork. The economic assessment in the RIT-T considers the probability of failure, as well as the potential consequence of failure to determine risk cost. In formulating our probability of failure values we consider past performance (including failures) of each asset component as well as the environment influencing that asset, e.g. coastal regions generally have higher corrosion rates. We have included additional details regarding past failures and the probability of failure in Appendix B.

4. 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 4-5.

Transgrid expects coronavirus (COVID-19) 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 2020/21 dollars.

4.1. Base case

The costs and benefits of each option in this PACR are compared against those of a base case[19]. Under this base case, no proactive capital investment is made to remediate the deterioration of Line 18, 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 $0.70 million per year in safety and environmental risk costs and $0.03 million per year in financial risk costs[20]. The main contributor to the environmental and safety risk costs 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.

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

Table 4-1 Operating expenditure breakdown under the base case ($ 2020/21)

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

As we have included finance risk costs associated with reactive maintenance, we have not included reactive corrective maintenance operating expenditure in the base case to avoid any potential 'double counting' of costs and benefits.

[19] 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.

[20] 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.

4.2. Option 1 – Line refurbishment

Option 1 involves the refurbishment of Line 18 to prevent further deterioration and corrosion to tower steelwork. Details of the scope of works under Option 1 are summarised in Table 4-2.

Table 4-2 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
Footing repairs	Repairs to cracked concrete footings; restoration of soil erosion including drainage improvements. Application of corrosion mitigations on buried steelwork grillage footings. Works on tower leg (earthworks and encasements) and tower leg painting.
Corroded fasteners	Replacement of fasteners
Corroded insulators and conductor attachment fittings	Replacement of complete insulator arrangement
Corrosion of earth wire and earthwire attachment fittings	Replacement of earthwire including fittings
Conductor and earthwire vibration dampers	Replacement of vibration dampers
Conductor spacers	Replacement of spacers
Asbestos paint	Safety risks
Site works	Site establishment and access
Climbing deterrents	Replacement of tower anti-climbers and danger signage

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

All works will be completed in accordance with the relevant standards by 2023 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 $8.83 million +/-25%.

Table 4-3 Capital expenditure breakdown under Option 1 ($m 2020/21)

Item	Capital expenditure ($m)
Access & Site Establishment	1.25
Earthwire & Fittings Replacement	2.68
Insulator & Conductor Fittings Replacement	1.07
Tower Grillage Foundation & Asbestos Paint Remediation	0.09
Tower Refurbishment	1.62

Transgrid Labour and Expenses	2.12
Total capital cost	**8.83 (+/- 25%)**

Routine operating and maintenance costs will remain unchanged at approximately $25,000 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.

Table 4-4 Operating expenditure breakdown under Option 1 ($ 2020/21)

Item	Operating expenditure ($)
Annualised routine maintenance activities	25,000
Total operating cost	**25,000 (+/- 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 18 under Option 1 to be approximately $0.13 million and the financial risk costs to be approximately $1,000.[21]

4.3. Options considered but not progressed

Table 4-5 summarises the reasons the following credible options were not progressed further.

Table 4-5 Options considered but not progressed

Option	Description	Reason(s) for not progressing
Option 2	Line dismantling	Dismantling Line 18 is not technically feasible, as it would significantly reduce supply capability from the Southern network to Greater Sydney, which may lead to a supply reliability issue.
Option 3	New transmission line from Kangaroo Valley switching station to Dapto substation	Due to significant costs of this option (> $100 million), a new 330 kV transmission line from Kangaroo Valley switching station to Dapto substation is not commercially feasible.

4.4. No material inter-network impact is expected

Transgrid has considered whether the credible option listed above is expected to have material inter-regional impact[22]. A 'material inter-network impact' is defined in the NER as:

[21] 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.

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

"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."

AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following[23]:

- 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.

4.5. 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.

[23] 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

5. 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.[24]

5.1. 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.[25]

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.

5.2. 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 5-1, 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 5-1 Reasons non-wholesale electricity market benefits are considered immaterial

Market benefits	Reason
Changes in involuntary load curtailment	Since Line 18 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.

[24] 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.

[25] 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.[26] 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.

[26] 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

6. 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.

6.1. 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.[27]

6.2. Assessment period and discount rate

A 20 year post-commissioning assessment period from 2022/23 to 2041/42 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[28] of 5.90 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 commercial discount rate calculated in the RIT-T Economic Assessment Handbook (Version 2.0) published by Energy Networks Australia (ENA) in October 2020[29]. This is consistent with the discount rate used in the PSCR.

Transgrid also tested 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 document[30], and an upper bound discount rate of 9.57 per cent (a symmetrical adjustment upwards) were used.

6.3. 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.

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[27] 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. https://www.aer.gov.au/system/files/AER%20-%20Regulatory%20investment%20test%20for%20transmission%20application%20guidelines%20-%2025%20August%202020.pdf

[28] 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.

[29] Available at https://www.energynetworks.com.au/resources/fact-sheets/ena-rit-t-handbook-2020/ Note the lower bound discount rate of 2.23 per cent is based on the most recent final decision for a TNSP revenue determination which was Directlink in June 2020.

[30] See 2020-25 Directlink's Post-tax Revenue Model (PTRM) cashflow derived pre-tax real WACC available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/directlink-determination-2020-25/final-decision

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

6.4. 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 6-1 Summary of scenarios

Variable / Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Discount rate	5.90%	9.57%	2.23%
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 (negative 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.

7. 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 2020/21 dollars.

7.1. 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, and
- Reduction in financial risks.

Table 7-1 Estimated gross benefits from credible options relative to the base case, present value ($m 2020/21)

Option/scenario	Central	Low benefit scenario	High benefit scenario	Weighted
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	6.0	3.2	10.9	6.5

7.2. 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 7-2 Costs of credible options relative to the base case, present value ($m 2020/21)

Option/Scenario	Central	Low benefit scenario	High benefit scenario	Weighted
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	8.0	9.5	6.4	8.0

7.3. Estimated net economic benefits

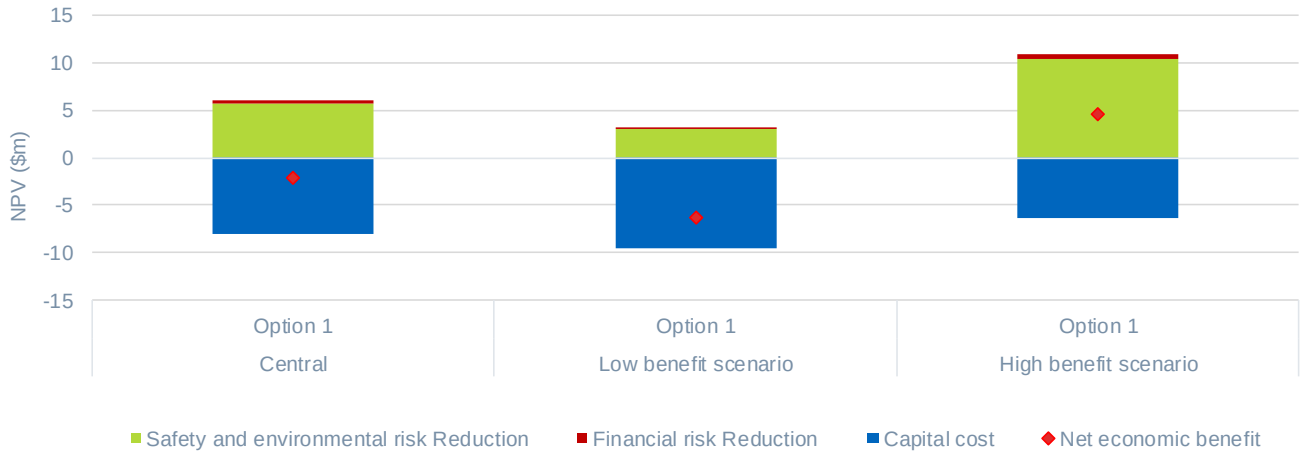
These net economic benefits are the differences between the estimated gross benefits less the estimated costs. The table below summarises the present value of the net economic benefits for each credible option across the three scenarios and the weighted net economic benefits.

Only the high benefit scenario and sensitivities under Option 1 are NPV positive. Table 7-3 shows that the costs of mitigating the bushfire and safety risks for Option 1 in only one of three scenarios is less than the benefit of avoiding those risks. The total weighted net economic benefit assessment is negative.

Table 7-3 Net economic benefits for Option 1 relative to the base case, present value ($m 2020/21)

Option	Central	Low benefit scenario	High benefit scenario	Weighted	Ranking
Scenario weighting	*50%*	*25%*	*25%*		
Option 1	-2.0	-6.3	4.6	-1.5	1

Figure 7-1 Net economic benefits, present value ($m 2020/21)

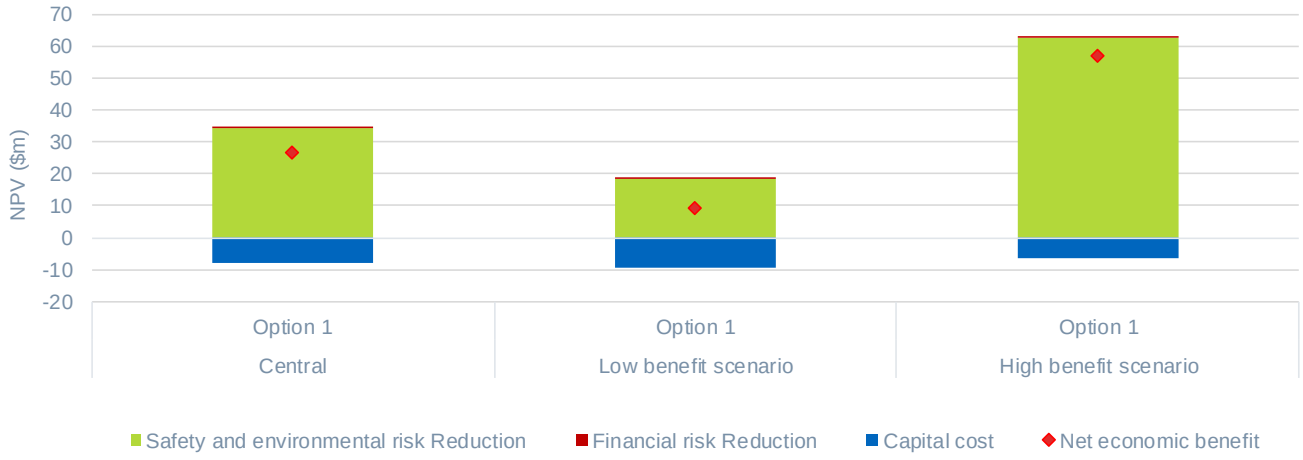


Using the ALARP principle, where disproportionality factors have been applied on the bushfire and safety risks, the benefits from the risk reduction outweigh the costs under all scenarios. This is shown in Table 7-4. It is noted that, in accordance with the ALARP principle, the disproportionality factors have been selected to a level just below where the community, government and law would consider risk reduction expenditure to be grossly disproportionate.

Table 7-4 Net economic benefits for Option 1 relative to the base case, present value with ALARP applied ($m 2020/21)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value	Ranking
Scenario weighting	*50%*	*25%*	*25%*		
Option 1	26.5	9.0	56.8	29.7	1

Figure 7-2 Net economic benefits, present value with ALARP applied ($m 2020/21)



7.4. 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.

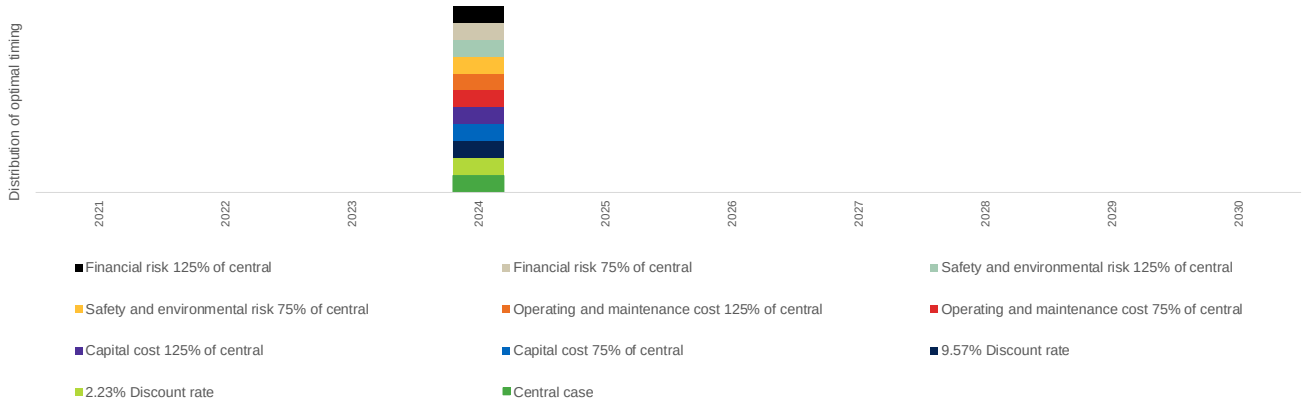
7.4.1. **Step 1 – Sensitivity testing of the optimal timing**

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 2.23 per cent as well as a higher rate of 9.57 per cent
- lower (or higher) assumed operation and maintenance costs
- lower (or higher) assumed safety and environmental risks
- lower (or higher) assumed financial 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 (with benefits realised from 2023/24) for all of the sensitivities investigated.

Figure 6-2 Optimal timing of Option 1



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

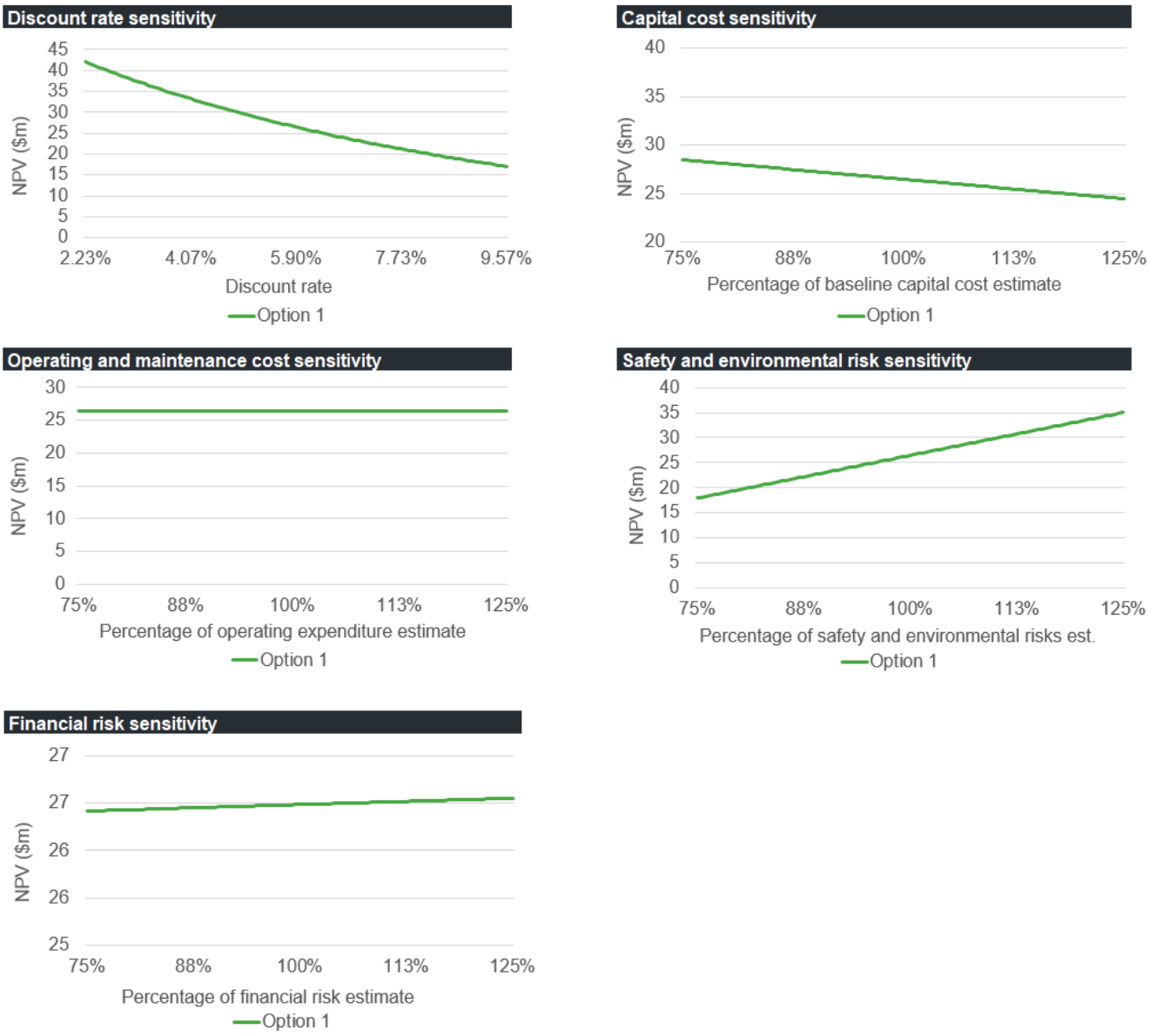
Transgrid has conducted sensitivity analysis on the present value of the net economic benefit, based on having to undertake the project by 2022/23. Specifically, Transgrid has investigated the same sensitivities under this step as in the first step:

- a 25 per cent increase/decrease in the assumed network capital costs
- lower discount rate of 2.23 per cent as well as a higher rate of 9.57 per cent
- lower (or higher) assumed operation and maintenance costs
- lower (or higher) assumed safety and environmental risks
- lower (or higher) assumed financial 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 7-3 Sensitivities



7.5. Meeting relevant regulatory obligations

Transgrid considers that the sensitivity assessment discussed in section 7.4 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).[31]

Under the ALARP test with the application of a gross disproportionate factor[32], the weighted benefits are expected to exceed the cost. Transgrid's analysis concludes that the costs are less than the weighted benefits from mitigating bushfire and safety risks. 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.

Applying the ALARP principle to manage and mitigate bushfire and safety risks, Transgrid determines that its obligations under the New South Wales *Electricity Supply (Safety and Network Management) Regulation 2014* and Transgrid's ENSMS will be met by implementing Option 1 by 2022/23. Under this principle, risks are mitigated unless it is possible to demonstrate that the costs involved in further reducing the risk would be grossly disproportionate to the benefits gained. Using the ALARP principle, all scenarios under Option 1 are positive.

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.

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

[32] In accordance with the framework for applying the ALARP principle, a disproportionality factor of 6 has been applied to risk cost figures. The values of the disproportionality factors 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 in this PSCR 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.

8. 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 $8.83 million +/- 25 per cent. Routine operating and maintenance costs relating to planned checks by Transgrid field crew are approximately $25,000 per year – similar to the cost under the base case. Transgrid calculates that the avoided risk cost by undertaking Option 1 is approximately $0.60 million[33] per year.

This preferred option, Option 1, is found to have positive net benefits only for the high benefit scenario at $4.6 million. Using the ALARP principle, where disproportionality factors have been applied on the bushfire and safety risks, the benefits from the risk reduction outweigh the costs under all scenarios for Option 1 and on a weighted basis will deliver approximately $29.7 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 18.

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

All works will be completed in accordance with the relevant standards by 2023 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.

[33] $3.4 million per year including the ALARP disproportionality factor

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 175.

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

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.[34]

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:

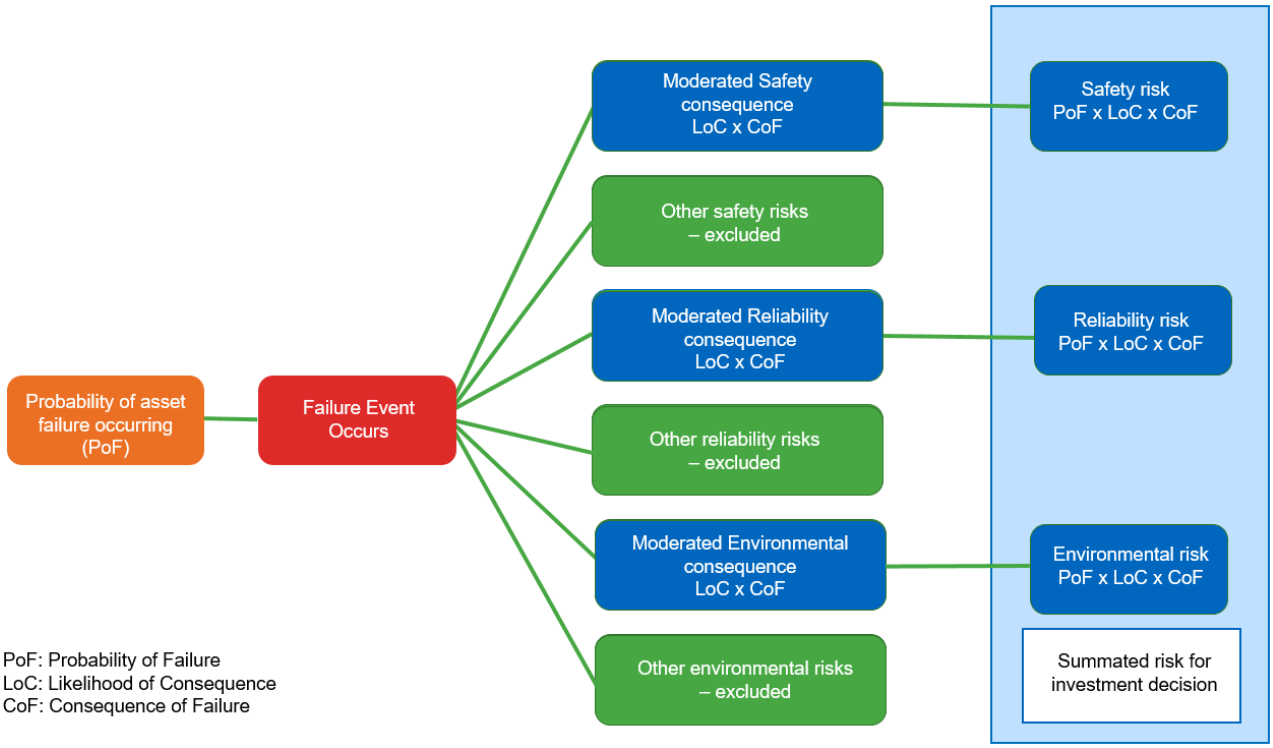
- uses externally verifiable parameters to calculate asset health and failure consequences
- assesses and analyses asset condition to determine remaining life and probability of failure
- applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence 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



[34] 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.

For Line 18, the calculated PoF for each structure location is 0.001122, this equates to annual probability of 0.12 that a failure will occur along Line 18. We have experienced failures on other transmission lines of similar vintage and construction type located in a similar environment which has informed the PoF calculation. The predominant failure mode experienced has been corrosion of the insulator pins leading to insulator mechanical failure and conductor drop. Replacement of insulators and their associated fittings due to corrosion is the substantive issue being addressed in this refurbishment project, as detailed in Section 2.3.1.

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.