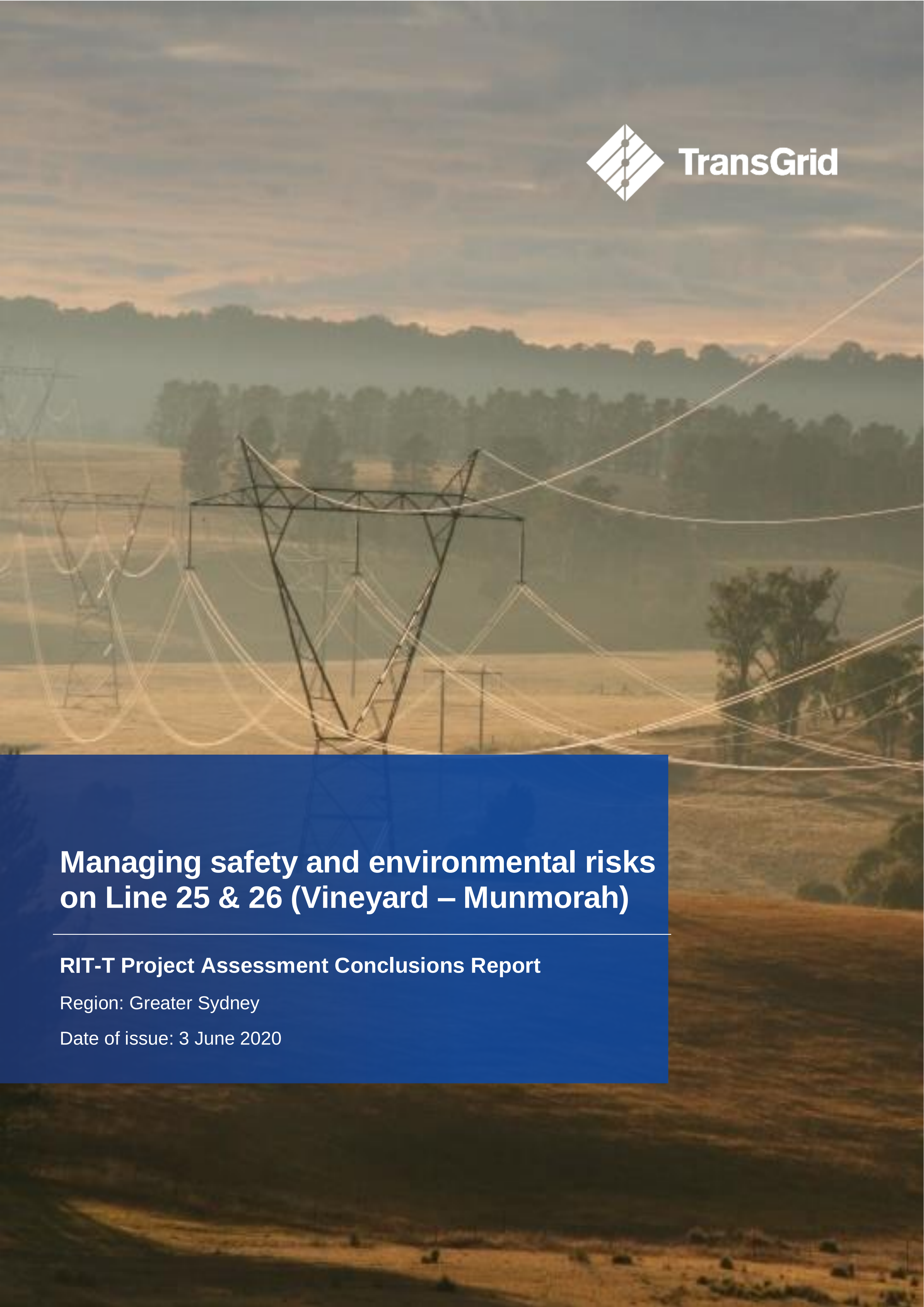

TransGrid

Managing safety and environmental risks on Line 25 & 26 (Vineyard – Munmorah)

RIT-T Project Assessment Conclusions Report

Region: Greater Sydney

Date of issue: 3 June 2020

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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 25 and Line 26. Publication of this Project Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

The transmission lines are part of the network that connects more than 4,000 MW of existing generators north of Sydney (Central Coast, Upper Hunter and northern NSW) and the major load centre of Sydney. They 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.

Lines 25 and Line 26 are two key 330 kV transmission lines from the Central Coast to Sydney. Spanning a route of 109 km, Line 25 connects Eraring substation on the Central Coast and Vineyard substation on the Greater Sydney network. Line 26 spans 123 km and runs between Munmorah substation on the Central Coast and Sydney West substation on the Greater Sydney network.

This RIT-T relates to single circuit section of Line 26, as well as the double circuit section of Line 25 and Line 26 between transmission Structure 11 and the Vineyard substation.

The route of the single circuit section of Line 26 runs between Munmorah and Vales Point, with the 7 km route constructed in 1962 and consists of 24 structures. This part of Line 26 traverses land that is in close proximity to the ocean, lakes and power stations. The double circuit section between transmission Structure 11 and Vineyard substation was constructed in 1965, with the 93km route encompassing 262 structures. This portion of Line 25 and Line 26 traverses National Parks, heavily timbered ridgetops, rural areas and suburban areas as it enters the Sydney basin. There are also several major road and rail crossings, as well as numerous local road crossings, along the length of the route.

Corrosion-related issues that will impact the safe and reliable operation of the network have been found on Line 25 and Line 26. The condition issues raise a number of risks associated with asset failure, including safety and environmental (bushfire) risks.

Table E-1 Condition issues along Line 25 & 26 and their consequences – single circuit and double circuit

Issue	Consequences if not remediated
Corrosion of tower steel members	Steel corrosion, particularly of critical members, can lead to structural failure of tower
Buried concrete foundations	Accelerated corrosion of critical member
Corrosion of earth straps	Earthing safety hazard
Corroded fasteners	Structural failure
Corroded insulators	Conductor drop
Corroded conductor attachment fittings	Conductor drop
Corrosion of earthwire attachment fittings	Conductor drop
Conductor dampers	Accelerated conductor fatigue due to vibration
Corroded ladder and step bolts	Field crew injury or fatality

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

Identified need: managing safety and environmental risks from corrosion on Line 25 and Line 26

The proposed investment will enable TransGrid to manage safety and environmental risks on Line 25 and Line 26. 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 25 and Line 26 will continue to deteriorate.

TransGrid calculates that the safety and environmental risk costs associated with the condition deterioration and corrosion of Line 25 and Line 26 are approximately $7.5m per year. Further condition deterioration of the affected assets due to corrosion would mean an increase in bushfire and safety risks along Line 25 and Line 26 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. The lines traverse farmlands and national parks, increasing the risk of bushfire from a conductor drop. The consequence of the bushfire is further magnified by its proximity to the urban areas on the outskirts of Sydney and the Central Coast.

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)[1].

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 Assessment Draft Report

TransGrid published a Project Assessment Draft Report (PADR) on 22 January 2020 and invited written submissions on the material presented within the document.

In the PADR TransGrid put forward for consideration one technically and commercially feasible option. Option 1 involves the refurbishment of Line 25 and Line 26 including replacement of asset components, and remediation of steelwork and foundations.

The Project Specification Consultation Report (PSCR) for this RIT-T was published in October 2018 and presented an initial cost estimate for refurbishing Line 25 and Line 26 which was primarily based on a desktop assessment of the activity required to refurbish the line. TransGrid undertook detailed inspections of the asset involving extensive climbing of every structure to further develop the scope. The inspections determined the quantum and extent of the condition issues has increased from TransGrid's initial outline noted in the PSCR.

As a result of the condition of the asset being further deteriorated than expected, the associated estimates proposed to remediate it were revised to factor in:

> increase in identified condition issues and the associated required scope of works

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

> revision of pricing rates to reflect the latest market conditions

The revised estimate for capital expenditure and updated risk cost benefit for Option 1 was outlined in the PADR.

No submissions were received in response to the PADR.

No developments since publication of the PADR

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

Option 1, refurbishment of Line 25 and Line 26 including replacement of asset components, and remediation of steelwork and foundations, remains the preferred option at this stage of the RIT-T process.

TransGrid considers refurbishing Line 25 and Line 26 is the only credible option

TransGrid put forward for consideration one technically and commercially feasible option: refurbishing the existing line by remediating or replacing the identified components. This option (Option 1) involves the refurbishment of Line 25 and Line 26 including replacement of asset components, earthwire, remediation of steelwork and foundations[2].

The primary driver for the identified need is to mitigate bushfire and safety risks associated with condition issues on Line 25 and Line 26 caused by corrosion. Three other options to address the need were considered but were not progressed further as they were not commercially viable when assessed against the preferred option.

This RIT-T may include assets in areas which have recently experienced bushfire events. The impact of these bushfires may affect some of the costs associated with the works outlined in this document. TransGrid will not be able to determine the extent of the impact or the effect on those costs until further inspection work is undertaken. The options are summarised in the table below.

TransGrid expects coronavirus (COVID-19) to impact its suppliers and disrupt their supply chains. TransGrid has preliminary advice that this is already occurring, 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 2019/20 dollars.

Table E-2 Options considered

Option	Description	Capital costs ($m 2019/20)	Operating costs ($ 2019/20 per year)	Remarks
Option 1	**Refurbishment of Line 25 and Line 26**	**~23 (+/- 25%)**	**~280,000**	**Most economical and preferred option**
Option 2	Staged delivery of Option 1 over multiple years	Not costed	Not considered	There are cost efficiencies associated with replacing all identified components under a single combined project, as opposed to staging it across multiple years. In addition, delaying the replacement of any

[2] This RIT-T does not include removal of asbestos paint using solvents. This work will be undertaken outside of this RIT-T.

				components comes with a greater expected risk value. The combination of greater costs and less expected benefits (in terms of avoided risk costs) makes this option less commercially feasible relative to Option 1. This option was not progressed.
Option 3	Replacement of Line 25 and Line 26	~150 million	Not considered	The capital cost of replacing the entire line is estimated to be significantly higher than Option 1, about $150 million, but is only expected to provide minor additional benefits. In addition, not all the structures and components that make up Line 25 and 26 require remediation or replacement in coming years. This option was not progressed.
Option 4	Decommissioning and dismantling of Line 25 and Line 26	~ Between 19 and 38 (depending on access and clearing costs)	Not considered	To manage the risks to workers' safety, public safety, properties, and environment, Line 25 and Line 26, if decommissioned, must be dismantled. This requires: > physical disconnection of the line from the 330 kV switchbays at Vales Point and Sydney West substations > dismantling of line structures, fittings, and conductors > rehabilitation of the easement IPART Reliability standard requires redundancy category 2 ("N-1") for Vineyard Bulk Supply Point (BSP). If both Line 25 and Line 26 are decommissioned, the redundancy level at Vineyard BSP will be reduced to "N". This option was considered not technically feasible and was not progressed.

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

The PADR noted that non-network options are not considered to be commercially and technically feasible to assist with meeting the identified need for this RIT-T. This is because non-network options will not mitigate the safety and environmental risk posed as a result of corrosion-related asset deterioration.

Conclusion: refurbishment of Line 25 and Line 26 is optimal

The optimal commercially and technically feasible option presented in the PSCR – the refurbishment of Line 25 and Line 26 replacement of asset components, and remediation of steelwork and foundations – remains 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.

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, is found to have positive net benefits under all scenarios investigated and on a weighted basis will deliver approximately $58 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 25 and Line 26.

The estimated capital expenditure associated with this option is $23 million +/- 25 per cent. Routine operating and maintenance costs relating to planned checks by TransGrid field crew are approximately $280,000 per year – similar to the cost under the base case. TransGrid calculates that the avoided risk costs by undertaking Option 1 is approximately $7.1 million per year.

The works will be undertaken between 2018/19 and 2021/22. Planning and procurement (including completion of the RIT-T) commenced in 2018/19 and is due to conclude in 2019/20. Project delivery and construction will occur in 2020/21 and 2021/22. All works will be completed in accordance with the relevant standards by 2021/22 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.

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) and Project Assessment Draft Report (PADR) published in October 2018 and January 2020, respectively. No submissions were received in response to the PSCR or the PADR.

Parties wishing to raise a dispute notice with the AER may do so prior to 3 July 2020 (30 days after publication of this PACR). Any dispute notices raised during this period[3] 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 25 & Line 26 PACR'.

[3] Additional days have been included 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 environmental and safety risks caused by the deteriorating condition of Line 25 and 26.

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).[4]

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[5] is to:

> Describe the identified need
> Describe and assess credible options to meet the identified need
> Describe the option assessment approach used
> Provide details of the proposed preferred option to meet the identified need.

1.2 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. No submissions were received in response to the PSCR or the PADR.

Parties wishing to raise a dispute notice with the AER may do so prior to 3 July 2020 (30 days after publication of this PACR). Any dispute notices raised during this period[6] will be addressed by the AER within 40 to 120 days, after which the formal RIT-T process will conclude.

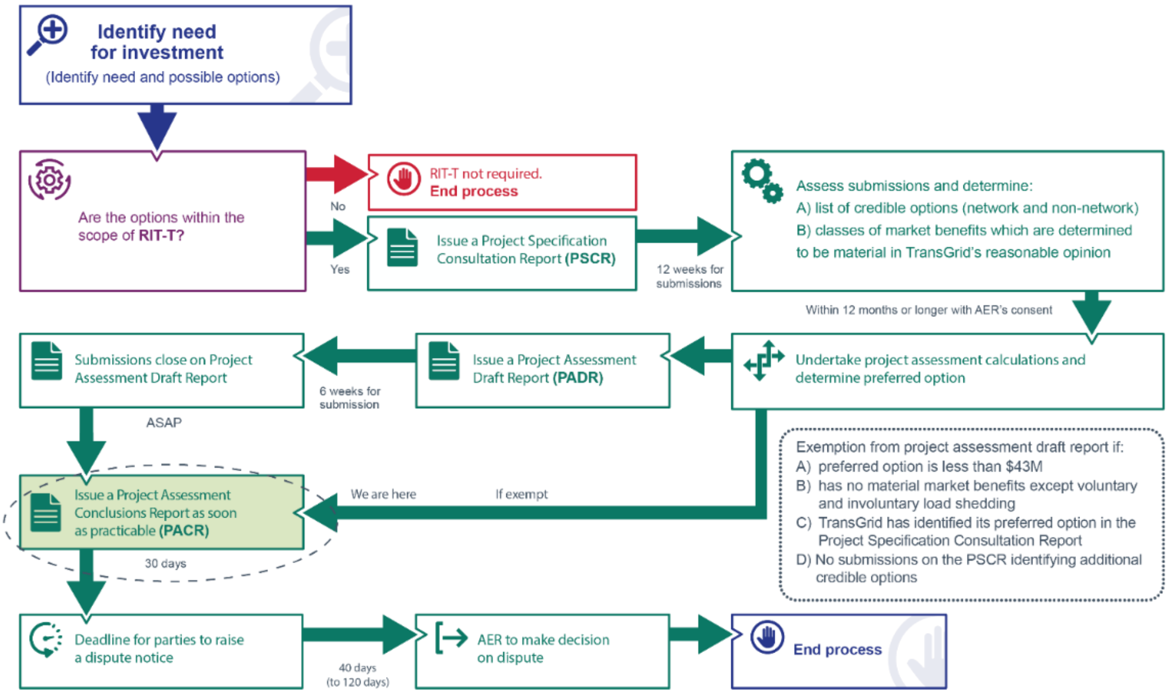
Further details on the RIT-T can be obtained from TransGrid's Regulation team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Line 25 & Line 26 PACR'.

4 TransGrid's ENSMS follows the International Organization for Standardization's ISO31000 risk management framework which requires following hierarchy of hazard mitigation approach.

5 See Appendix A for the National Electricity Rules requirements.

6 Additional days have been included to cover public holidays.

Figure 1-1 This PACR is the third stage of the RIT-T process[7]



[7] Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.65. Accessed 6 May 2020. https://www.aemc.gov.au/sites/default/files/content/89fbf559-2275-4672-b6ef-c2574eb7ce05/Final-rule-determination.pdf

2. The identified need

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

2.1 Background to the identified need

Line 25 and Line 26 are two key 330 kV transmission lines from the Central Coast to Sydney forming part of the network that connects more than 4,000 MW of existing generators north of Sydney (Central Coast, Upper Hunter and northern NSW) and the major load centre of Sydney.

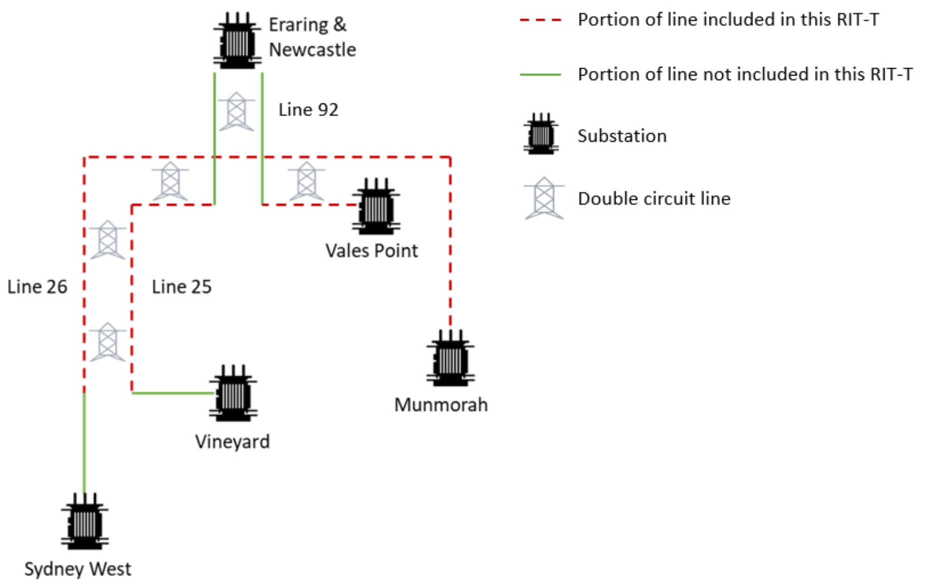
Spanning a route of 109 km, Line 25 connects Eraring substation on the Central Coast and Vineyard substation on the Greater Sydney network. Line 26 runs between Munmorah substation on the Central Coast and Sydney West substation on the Greater Sydney network and spans 123 km.

Lines 25 and 26 run together as a double circuit transmission line for the majority of their routes, providing a key link between the Central Coast and Sydney. A single group of steel tower structures supports the section of the route that is shared by both transmission lines.

The route of the single circuit section of Line 26 runs between Munmorah and Vales Point substations. Constructed in 1962, this part of the line spans a route of 7 km and consists of 24 structures. It traverses land that is in close proximity to the ocean, lakes and power stations.

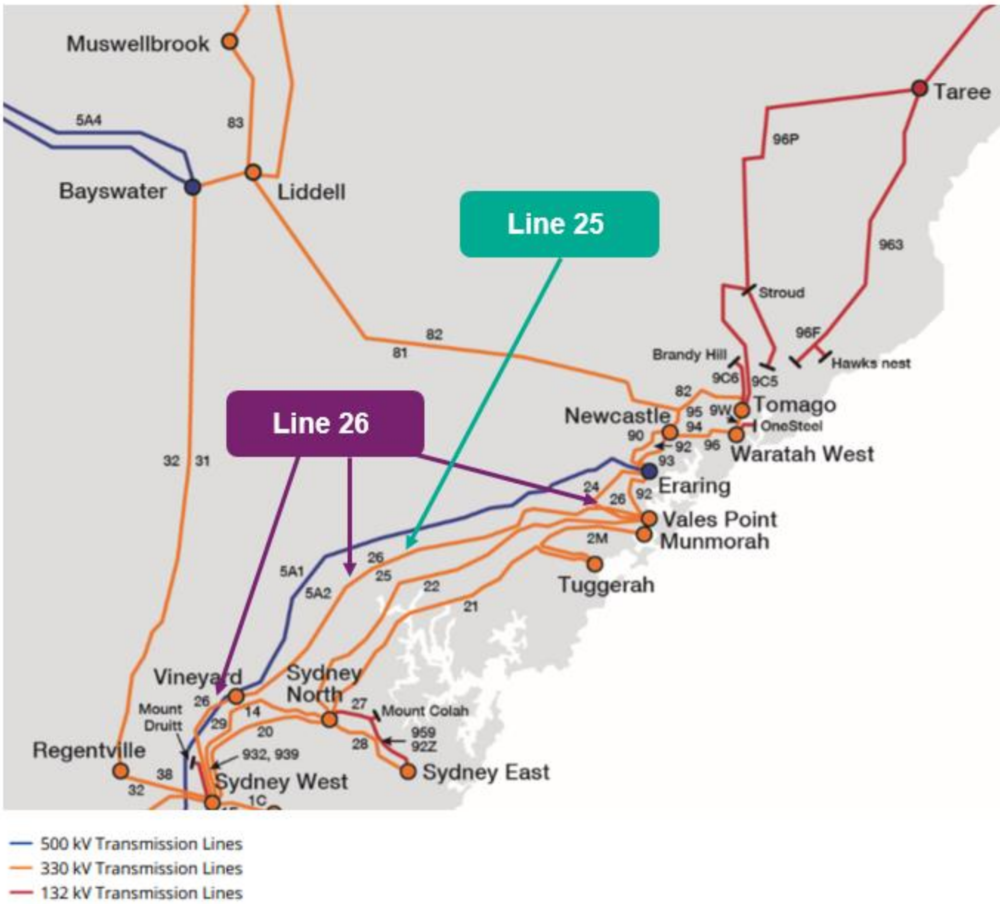
Constructed in 1965, the section of the route that is shared by Lines 25 and 26 spans 93 km and encompasses 262 structures. This RIT-T process is being undertaken to address the identified need due to deterioration of the shared section of the route. Figure 2-1 provides an overview of Line 25 and Line 26 to show the portion of the lines included in this RIT-T.

Figure 2-1 High-level overview of Line 25 and Line 26



This shared section of Line 25 and Line 26 traverses national parks, heavily timbered ridgetops, rural areas and suburban areas as it enters the Sydney basin. There are also several major road and rail crossings, as well as numerous local road crossings, along the length of the route. Figure 2-2 depicts the location of Line 25 and Line 26 to the right of the 500 kV lines from Eraring to Kemps Creek.

Figure 2-2 Location of Line 25 and Line 26 on TransGrid's Greater Sydney network



A condition assessment performed by TransGrid in January 2016 identified several issues with Line 25 and Line 26. Corrosion-related issues are the biggest factor contributing to deterioration and require rectification in order for TransGrid to continue to safely and reliably operate the assets. Some of the other issues found were:

- corrosion of tower steel members
- buried concrete foundations
- corroded insulators
- corroded earth straps
- corroded fasteners
- corroded conductor attachment fittings
- corrosion of earth wire attachment fittings
- conductor dampers
- earthwire dampers.

Figure 2-3 and Figure 2-4 below demonstrate examples of the condition of various components of Line 25 and Line 26.

Figure 2-3 Examples of corroded components of Line 25 and Line 26: earthwire and conductor fittings

Figure 2-4 Examples of corroded components of Line 25 and Line 26: transmission tower steelwork and legs

2.2 Description of the identified need

The proposed investment will enable TransGrid to manage safety and environmental risks on Line 25 and Line 26. 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 25 and Line 26 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 25 and Line 26. 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 TransGrid field crew members who may be working on or near the assets, nearby residents and members of the public. As the line traverses farmlands and national parks, the risk of bushfire from a conductor is increased due to its proximity to the urban areas on the outskirts of Sydney and the Central Coast.

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).[8]

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 methodology to qualify and valuate the risks and consequences of increased 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 Assessment Methodology revealed that the key asset condition issues, summarised in **Error! Reference source not found.**, suggest accelerated deterioration of the affected assets which will result in an increase in line failure rates.

Table 2-1 Condition issues on Line 25 and Line 26 and their consequences – single circuit and double circuit sections

Issue	Consequences if not remediated
Corrosion of tower steel members	Steel corrosion, particularly of critical members, can lead to structural failure of tower
Buried concrete foundations	Accelerated corrosion of critical member
Corrosion of earth straps	Earthing safety hazard
Corroded fasteners	Structural failure
Corroded insulators	Conductor drop

8 TransGrid's ENSMS follows the International Organization for Standardization's ISO31000 risk management framework which requires following hierarchy of hazard mitigation approach.

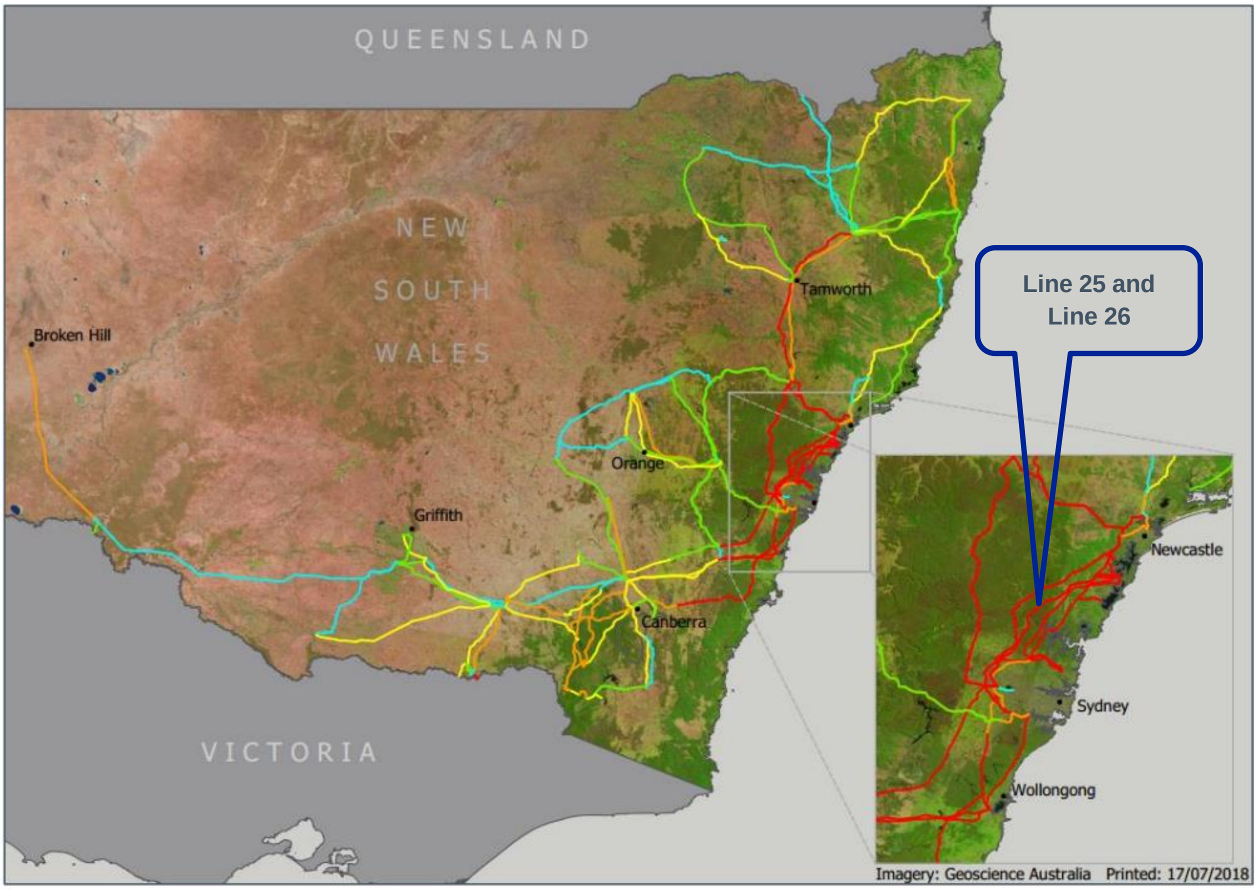
Corroded conductor attachment fittings	Conductor drop
Corrosion of earth wire attachment fittings	Conductor drop
Conductor dampers	Accelerated conductor fatigue due to vibration
Corroded ladder and step bolts	Field crew injury or fatality

2.3.2 Safety and environmental risk costs

Error! Reference source not found. below shows a heat map of transmission line risks. Transmission lines in red have the highest safety and environmental risks. This has been developed based on an assessment of risk factors of specific locations. The figure shows that Line 25 and Line 26 is a high risk line. As Line 25 and Line 26 traverses through farmland and national park areas, structural failure of towers and conductor drop caused by corrosion of steel pose exacerbated significant bushfire and safety risks.

The safety and environmental risks associated with this line are considered to be amongst the highest in TransGrid's network.

Figure 2-5 TransGrid's line risks heat map



*Line colours on Figure 2-5 represent the level of risk from highest risk to lowest risk respectively: red, orange, yellow, green, and blue.

The safety and environmental risk costs from corrosion of steel members of the tower structures are approximately $7.5 million per year.

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 and project delivery perspective, which is refurbishing Line 25 and Line 26.

No submissions were received in response to the PSCR or the PADR and no additional credible options have been identified.

This RIT-T may include assets in areas which have recently experienced bushfire events. The impact of these bushfires may affect some of the costs associated with the works outlined in this document. TransGrid will not be able to determine the extent of the impact or the effect on those costs until further inspection work is undertaken.

TransGrid expects coronavirus (COVID-19) to impact its suppliers and disrupt their supply chains. TransGrid has preliminary advice that this is already occurring, 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 2019/20 dollars.

3.1 Base case

The costs of each option in this PACR were compared against those of a base case[9]. Under this base case, no proactive capital investment is made to remediate the deterioration of Line 25 and Line 26 and the line will continue to operate and be maintained under the current regime.

Annual routine operating and maintenance costs are approximately $280,000. The table below provides a breakdown.

Further, as the line continues to deteriorate, increased reactive corrective maintenance will be required to address defects or asset failures in order to keep the line operating at the required standard.

Table 3-1 Operating expenditure breakdown under the base case ($m 2019/20)

Item	Operating expenditure ($m)
Annualised 5 yearly detailed inspection and easement management costs	0.28
Total operating cost	**0.28**

The regular maintenance regime will not be able to mitigate the risk of structure failure and conductor drop which will expose TransGrid and end-customers to approximately $7.5m annually in safety and environmental risk costs.

9 As per the RIT-T Application Guidelines, the base case provides a clear reference point for comparing the performance of different credible options. Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018. Accessed 6 May 2020. 22. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

The large environmental and safety risk costs are mainly due to the significant consequences of a potential bushfire event resulting from conductor drop and risks associated with compromised earthing. Under the base case, all of these risks will continue to increase as the asset continues to deteriorate.

3.2 Option 1 – Line refurbishment

Option 1 involves the refurbishment of Line 25 and Line 26 to prevent further corrosion to tower steelwork.

Details of the scope of works under this Option 1 are summarised in Table 3-2.

Table 3-2 Option 1 scope of works

Issue	Remediation
Ground line corrosion of steel at footing	> abrasive blast cleaning of steelwork to remove any corrosion > application of coating and concrete encasement to mitigate against future corrosion
Buried concrete foundations	> dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion, application of coating and establishment of drainage channel
Corrosion of earth straps	> replacement of earth straps in line with current standard
Corrosion of tower members	> abrasive blast cleaning of steelwork to remove any corrosion, application of coating > replacement of tower members
Corrosion of tower fasteners	> replacement of fasteners
Corrosion of tower ladders and step bolts	> replacement of tower step bolts and ladders
Insulator pin corrosion – suspension insulators	> replacement with composite long rod insulators and associated fittings
Insulator pin corrosion – tension insulators	> replacement with composite long rod insulators > replacement of tension hot and cold end fittings
Corrosion of conductor fittings	> replacement of conductor fittings, including spacers
Corrosion of earth wire fittings	> replacement of earth wire fittings
Damaged conductor vibration dampers	> replacement of vibration dampers
Damaged of earth wire vibration dampers	> replacement of vibration dampers

The works will be undertaken between 2018/19 and 2020/22. Planning and procurement (including completion of this RIT-T) commenced in 2018/19 and is due to conclude in 2019/20. Project delivery and construction will occur in 2020/21 and 2021/22. All work will be completed by 2021/22. Necessary network asset outages will be implemented to have minimal impact on network capacity.

The estimated capital expenditure associated with this option is approximately $23 million +/- 25 per cent. The table below provides a breakdown.

Table 3-3 Capital expenditure breakdown under Option 1 ($m 2019/20)

Item	Capital expenditure ($m)
Transmission tower steelwork remediation	13.8
Insulator and fitting replacement works	9.2
Total capital cost	**23.0 (+/-25%)**

Following the remediation of condition issues, it is expected that the level of reactive corrective maintenance needed to keep line operating at the required standard, relative to the base case, would reduce. The routine operating and maintenance costs under Option 1 remain the same as in the base case approximately $280,000 per year as these costs relate to planned routine checks of the line by TransGrid field crew.

TransGrid calculates the annual safety and operational risk costs associated with Line 25-26 under Option 1 to be approximately $400,000.[10]

3.3 Options considered but not progressed

TransGrid also considered whether there are other credible options that would meet the identified need. However, TransGrid considers that the identified need to mitigate safety and environmental risks caused by corrosion cannot be met by solutions other than those outlined under Option 1.

Table 3-4 below summarises three other options TransGrid considered as part of this RIT-T. The table also outlines the reasons why these options were not progressed further and have not been explicitly modelled alongside the options considered.

Table 3-4 Options considered but not progressed

Option	Description	Reason(s) for not progressing
Option 2	Staged delivery of Option 1 over multiple years	There are cost efficiencies associated with replacing all identified components under a single project, as opposed to staging it across multiple years. In addition, delaying the replacement of any components comes with a greater expected risk value. The combination of greater costs and less expected benefits (in terms of avoided risk costs) makes this option less commercially feasible relative to Option 1.
Option 3	Replace Line 25 and Line 26	The capital cost of replacing the entire line is estimated to be significantly higher than Option 1, about $150 million, but is only expected to provide minor additional benefits. In addition, not all the structures and components that make up Line 25 and 26 require remediation or replacement in coming years.

10 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.

Option	Description	Reason(s) for not progressing
Option 4	Decommission and dismantle the lines	To manage the risks to workers' safety, public safety, properties, and environment, Lines 25 and 26, if decommissioned, must be dismantled. This requires: > physical disconnection of the line from the 330 kV switchbays at Vales Point and Sydney West substations > dismantling of line structures, fittings, and conductors > rehabilitation of the easement. The direct decommissioning cost is estimated to be between $19 million to $38 million (depending on access and clearing costs). IPART Reliability standard requires redundancy category 2 ("N-1") for Vineyard Bulk Supply Point (BSP). If both Line 25 and Line 26 are decommissioned, the redundancy level at Vineyard BSP will be reduced to "N". This option is not technically feasible and has not been progressed.

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.[11]

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."*

AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact if it satisfies the following:[12]

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

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 are no material inter-network impacts associated with any of the credible options considered.

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

[12] 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 6 May 2020. https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf

3.5 Non-network options

TransGrid does not consider that non-network solutions can feasibly address, or help to address, the identified need.

In the PSCR and the PADR, TransGrid noted that non-network options are not considered to be technically and commercially feasible to assist with meeting the identified need for this RIT-T.

TransGrid considers that non-network options are unable to contribute to meeting the identified need for this RIT-T based on:

- the fact that the identified need for this investment is not driven by avoiding potential unserved energy so that no amount of demand reduction would defer or avoid the preferred network option – irrespective of the size, nature and location of the non-network option
- any non-network solution for this need is expected to only add to the costs of this option. That is, non-network options would not provide any net benefits.

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

4. Materiality of market benefits

This section outlines the categories of market benefits prescribed in the NER and whether they are considered material for this RIT-T.[13]

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 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.[14]

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 for TransGrid (since there will be no deferral of generation investment)
> changes in ancillary services costs
> 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 in relation to each credible option: differences in the timing of transmission investment; option value; and changes in involuntary load shedding. TransGrid considers that none of the classes of market benefits listed are material for this RIT-T assessment for the reasons in Table 4-1.

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

Market benefits	Reason
Changes in involuntary load shedding	Since Line 25 and Line 26 form part of a meshed network (N-1 and Modified N-2 redundant) required to supply Sydney and surrounding area, a failure due to the corroded assets results to extremely low chance of unserved energy.

13 The NER requires that all classes of market benefit identified in relation to the RIT-T are included in the RIT-T assessment, unless the TNSP can demonstrate that a specific 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.

14 Australian Energy Regulator. "Application guidelines Regulatory Investment Test for Transmission - December 2018." Melbourne: Australian Energy Regulator, 2018.39. Accessed 6 May 2020. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

Market benefits	Reason
Differences in the timing of expenditure	Option 1 is being undertaken to mitigate rising risk due to deteriorating asset condition and as the line is an existing asset, material market benefits will neither be gained nor lost due to timing of expenditure.
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 in the future is likely to change, and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[15] 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 changes in future demand levels are not relevant for this RIT-T, since the need for and timing of the required investment is being driven by asset condition rather than future demand growth. Thus, it is not relevant to consider different future demand scenarios in undertaking the RIT-T analysis. The estimation of any option value benefit would require a significant modelling assessment, which would be disproportionate to any additional option value benefit that may be identified for this specific RIT-T assessment. Therefore, TransGrid has not estimated any additional option value market benefit for this RIT-T assessment.
Changes in network losses	As there is no change to the capacity of the line, the impedance of the line, or the destination of the line under Option 1, there will not be material market benefits associated with changes to network losses.

15 AER, *Final Regulatory Investment Test for Transmission Application Guidelines*, 18 September 2017, pp. 37 & 74. This view was also reiterated in the updated AER RIT-T Guidelines, see: Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018.58-59. Accessed 6 May 2020. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.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 and TransGrid incurs regular and reactive maintenance costs, and bushfire and safety related risks costs that are caused by the corroded equipment resulting in a potential failure, eg conductor drop.

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.[16]

5.2 Assessment period and discount rate

An outlook period of 20 year assessment period from commissioning 2021/22, from 2019/20 to 2041/42, was considered in this analysis. This period takes into account the size, complexity, and expected life of the refurbishment option.

TransGrid adopted a central real, pre-tax 'commercial' discount rate[17] 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 published by Energy Networks Australia (ENA) in March 2019.[18]

TransGrid also tested the sensitivity of the results to the discount rate assumption. A lower bound real, pre-tax discount rate of 2.85 per cent equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PACR,[19] and an upper bound discount rate of 8.95 per cent (a symmetrical adjustment upwards) were used.

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.

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16 TransGrid notes that the final updated 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. See: AER, *Regulatory Investment Test for Transmission Application Guidelines,* December 2018. 21

17 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.

18 Available at https://www.energynetworks.com.au/rit-t-economic-assessment-handbook Note the lower bound discount rate of 2.85 per cent is based on the most recent final decision for a TNSP revenue determination which was TasNetworks in April 2019.

19 See 2019-24 TasNetworks' Transmission Post-tax Revenue Model (PTRM) cashflow derived pre-tax real WACC available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/tasnetworks-determination-2019-24/final-decision

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	5.90%	8.95%	2.85%
Costs			
Network capital 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 option.

The assessment compares the costs and benefits of the option to the base case. The benefits of each option are represented by reduction in costs or risks compared to the base case.

There were no changes since publication of the PADR.

All costs presented in this PACR are in 2019/20 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 2019/20)

Option/scenario	Central	Low benefit scenario	High benefit scenario	Weighted
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	73.2	41.1	126.6	78.5

6.2 Estimated costs

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

Table 6-2 Estimated costs of credible options relative to the base case, present value ($m 2019/20)

Option/Scenario	Central	Low benefit scenario	High benefit scenario	Weighted
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	20.6	24.4	16.4	20.5

6.3 Estimated net economic benefits

These net economic benefits are the differences between the estimated gross economic 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.

Table 6-3 shows that Option 1 is found to have positive net benefits for all scenarios investigated. On a weighted basis, Option 1 will deliver approximately $58.0 million in net economic benefits above the base case.

Table 6-3 Estimated net economic benefits relative to the base case, present value ($m 2019/20)

Option/Scenario	Central	Low benefit scenario	High benefit scenario	Weighted
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	52.6	16.7	110.2	58.0

6.4 Sensitivity testing

TransGrid has undertaken a thorough sensitivity testing exercise to understand the robustness of the RIT-T assessment to underlying assumptions about key variables. In particular, TransGrid has undertaken 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.

TransGrid has therefore undertaken sensitivity analysis to first determine the optimal timing of the project, to conclude that a particular year represents the 'most likely' date at which the project will be needed. This analysis of optimal timing is an economic test, and does not consider TransGrid's obligation to manage and mitigate bushfire and safety risks to 'ALARP', which may change the optimal timing.

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 bushfire 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 key variables is outlined below.

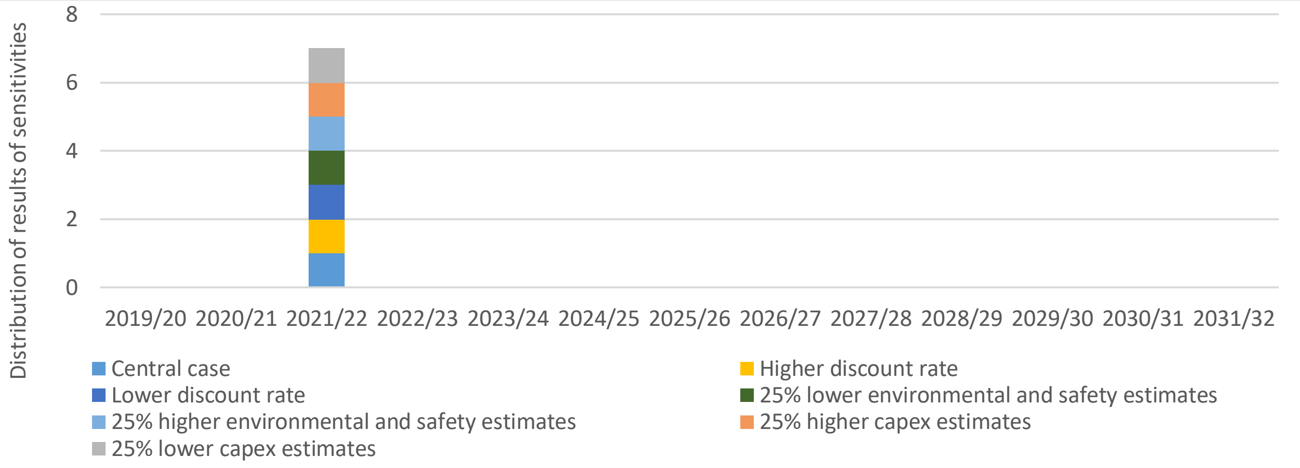
6.4.1 Step 1 – Sensitivity testing of the optimal timing

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 2.85 per cent as well as a higher rate of 8.95 per cent
> lower (or higher) assumed safety and environmental risk.

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 2021/22 for all of the sensitivities investigated.

Figure 6-1 Optimal timing of Option 1



6.4.2 Step 2 – Sensitivity of the overall net benefit

TransGrid has also conducted sensitivity analysis on the overall NPV of the net economic benefit, based on the optimal option timing established in step 1. Specifically, TransGrid has investigated the same sensitivities under this second step as in the first step:

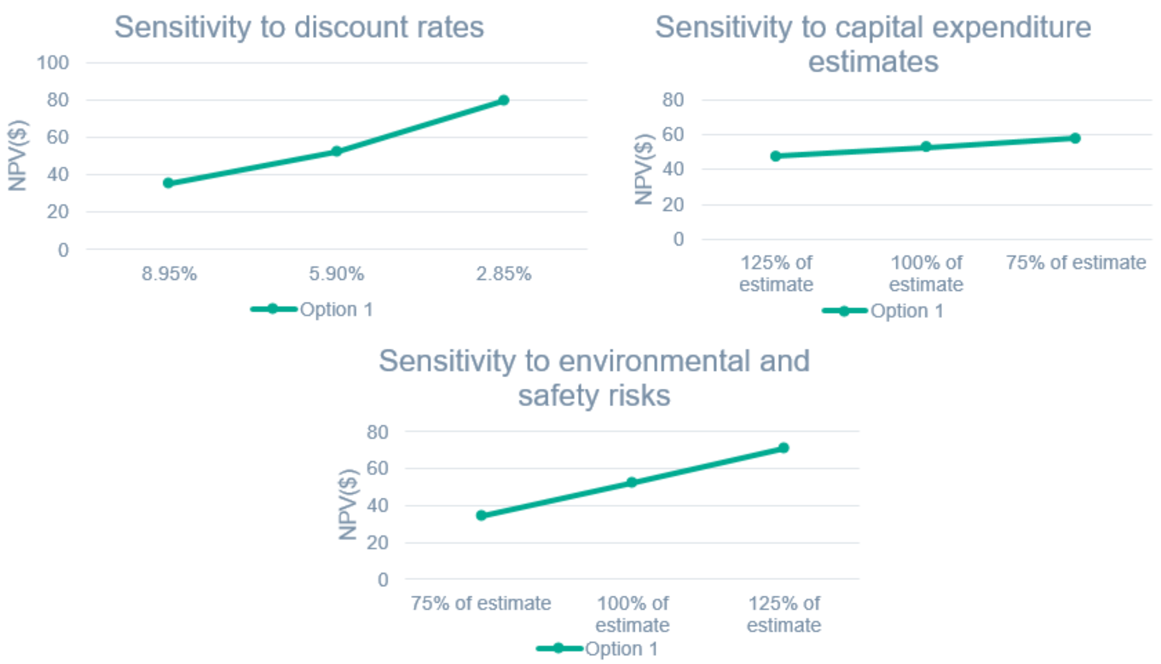
> a 25 per cent increase/decrease in the assumed network capital costs
> lower discount rate of 2.85 per cent as well as a higher rate of 8.95 per cent
> lower (or higher) assumed safety and environmental risk.

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. Importantly, for all sensitivity tests shown below, the estimated net benefits of Option 1 are found to be positive.

Figure 6-2 below illustrates that while the results are most sensitive to the safety and environmental risk cost estimates and discount rates, it is still reasonable to make investments to mitigate low risk costs estimates.

Figure 6-2 Sensitivity testing



6.5 Managing environmental and safety risk

TransGrid considers that the sensitivity assessment discussed in section 6.4 demonstrates that planning for any commissioning later than 2021/22 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).[20]

Under the ALARP test a gross disproportionate factor[21] would typically be applied. Applying the factor in this case would only further enhance support for Option 1 as the outcome of the NPV analysis already demonstrates that the benefits are positive. TransGrid's analysis concluded that the costs are less than the 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.

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

[21] 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.

7. Final conclusion on the preferred option

The optimal commercially and technically feasible option presented in the PACR – the refurbishment of Line 25 and Line 26 replacement of asset components, and remediation of steelwork and foundations – remains the preferred option to meet the identified need.

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, is found to have positive net economic benefits under all scenarios investigated and on a weighted basis will deliver approximately $58.0 million in net economic benefits. TransGrid also conducted sensitivity analysis on the net market benefit to investigate the robustness of the conclusion to key assumptions. TransGrid finds that under all sensitivities, positive net economic benefits are expected from refurbishing Line 25 and Line 26.

Option 1 is the most prudent and economically efficient solution to manage and mitigate safety and environmental risk to ALARP.

The works will be undertaken between 2018/19 and 2021/22. Planning and procurement (including completion of the RIT-T) commenced in 2018/19 and is due to conclude in 2019/20. Project delivery and construction will occur in 2020/21 and 2021/22. All works will be completed in accordance with the relevant standards by 2021/22 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 $23 million +/- 25 per cent. Routine operating and maintenance costs relating to planned checks by TransGrid field crew are approximately $280,000 per year– similar to the cost under the base case. TransGrid calculates that the avoided risk costs by undertaking Option 1 is approximately $7.1 million per year. Further, a reduction in reactive corrective maintenance costs is also expected.

The analysis undertaken and the identification of Option 1 as the preferred option satisfies the RIT-T.

Appendix A – Compliance checklist

This section sets out a checklist which demonstrates the compliance of this PACR with the requirements of the National Electricity Rules version 139.

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
	(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.[22]

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:

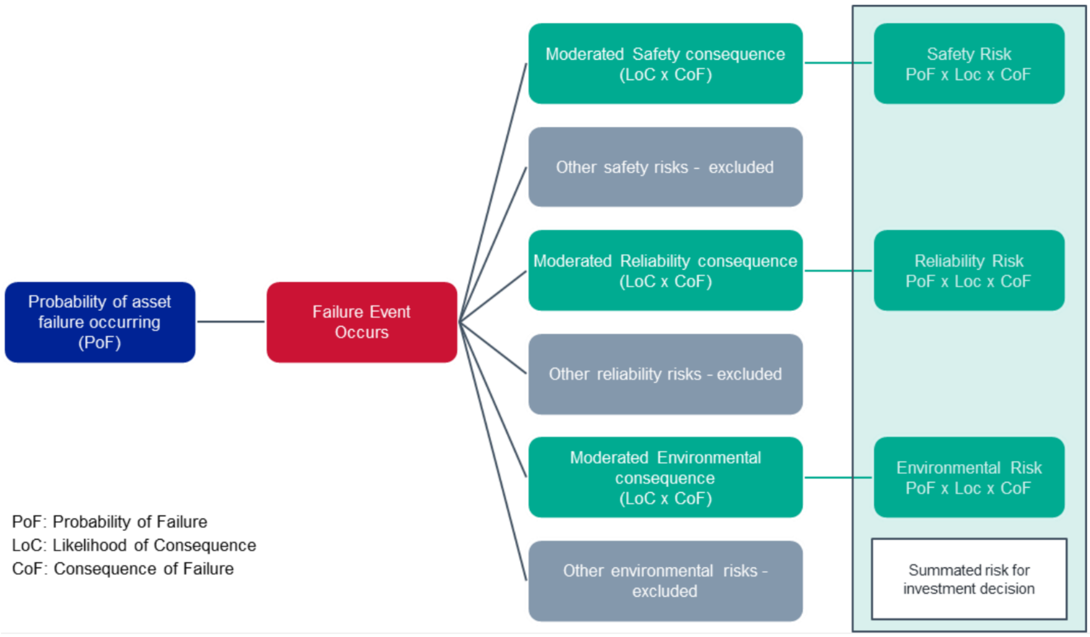
> uses externally verifiable parameters to calculate asset health and failure consequences
> assesses and analyses asset condition to determine remaining life and probability of failure
> applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence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

B.1 Overview of the risks 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 cost', 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



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

22 For additional information on the risk assessment methodology, refer to pages 63-69 of TransGrid's Revised Regulatory Proposal for the period 2018-23, available at: https://www.aer.gov.au/system/files/TransGrid%20-%20Revised%20Revenue%20Proposal%20-%201%20December%202017.pdf

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 based 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 result in lower calculated risk.