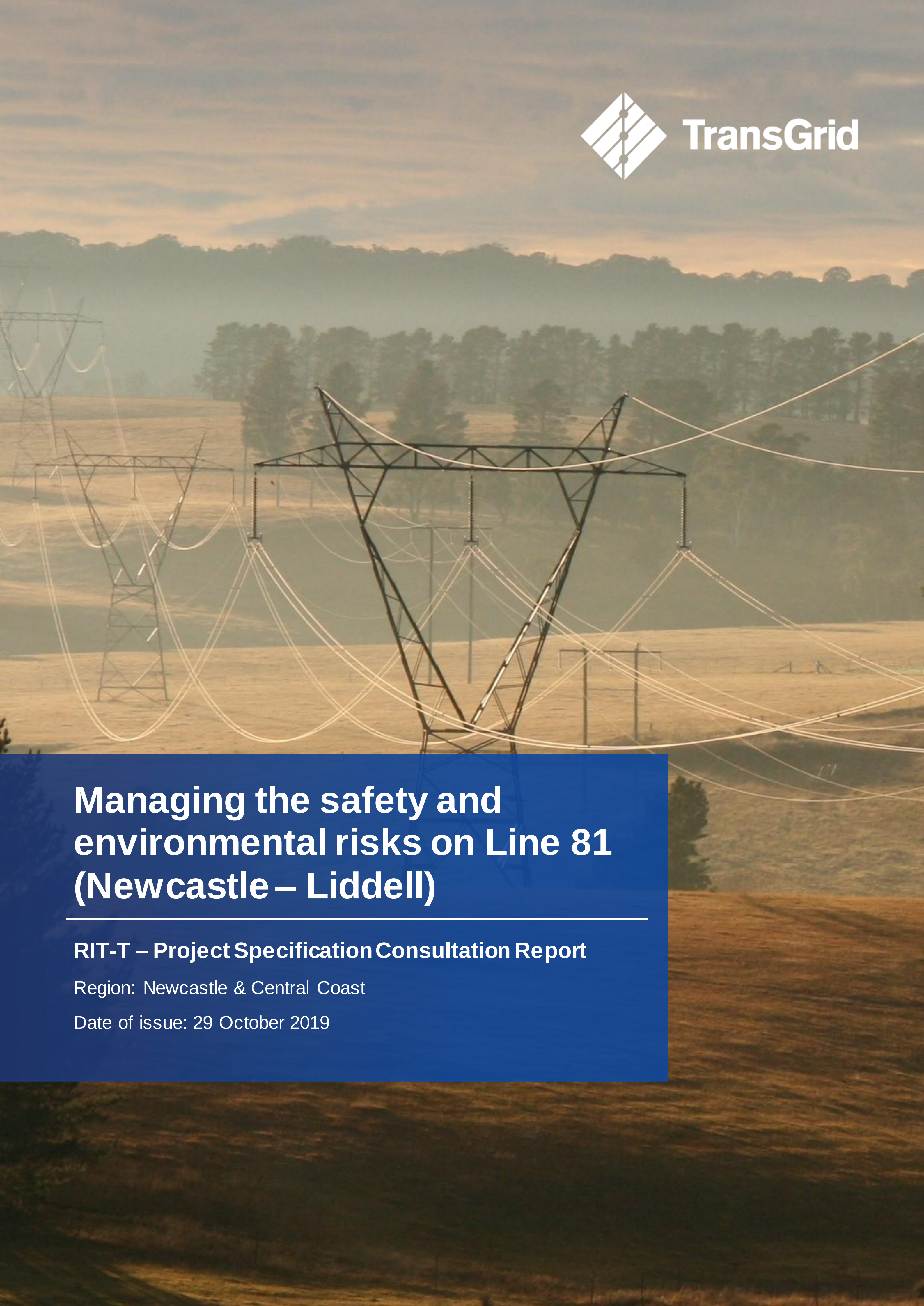

TransGrid

Managing the safety and environmental risks on Line 81 (Newcastle – Liddell)

RIT-T – Project Specification Consultation Report

Region: Newcastle & Central Coast

Date of issue: 29 October 2019

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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 81. Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

Constructed in 1964, Line 81 is a 330 kV transmission line which spans approximately 100km between Newcastle substation and Liddell 330 kV switching station. The transmission line is comprised of 288 steel tower structures and forms part of the network that provides a key link between approximately 4,400 MW of existing generation in the Hunter Valley and Newcastle.

Line 81 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.

As coal mines in the area expanded, portions of Line 81 were realigned with approximately 24% of the structures being constructed after 1986. Consequently, those post-1986 structures are not affected by corrosion to the same degree as the earlier towers.

A significant proportion of the pre-1986 steel transmission structures of Line 81 are impacted by various levels of deterioration and corrosion. The affected components include tower steelwork, foundations and earthing, insulators, conductor fittings, earthwire and associated fittings. This greatly increases the likelihood of transmission structure failures, conductor drop, and subsequent bushfire and safety risks.

Table E-1 Condition issues along Line 81 and their consequences

Issue	Impact
Ground line corrosion of steel at footing	Steel corrosion of critical member, can lead to structural failure of tower
Buried concrete foundations	Accelerated corrosion of critical member
Corrosion of earth strap	Possible transfer potential, earth current and voltage gradient issues, can lead to serious injury or possible fatality
Rusting of tower steel members	Structural failure
Corroded fasteners	Structural failure
Corroded and damaged disc insulators	Conductor drop
Faulty composite insulators	Flashover (line outage)
Corroded earthwire and fittings	Conductor drop
Conductor dampers	Accelerated fatigue of conductor due to vibration
Earthwire dampers	Accelerated fatigue of conductor due to vibration

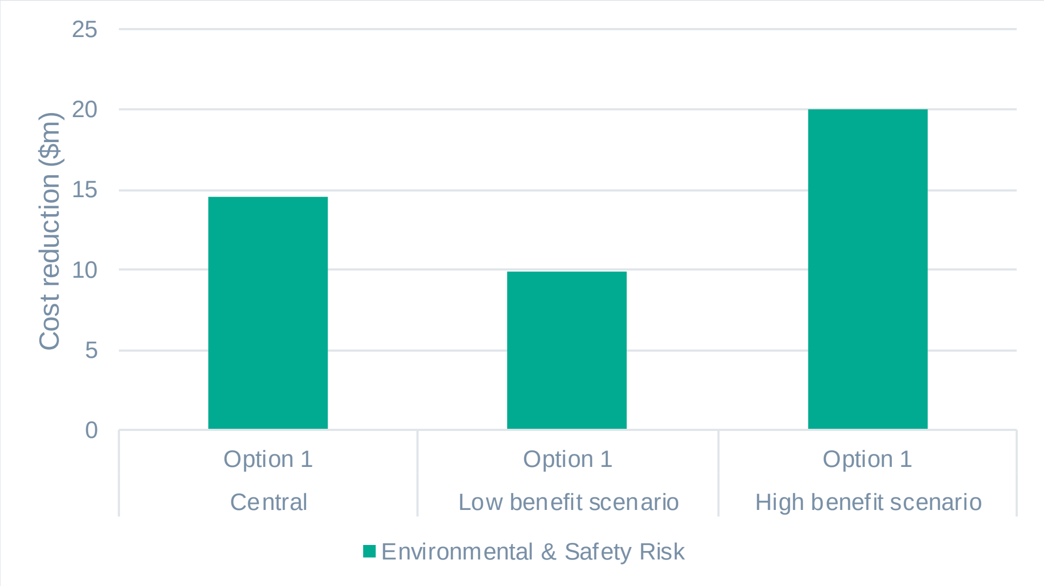
As the asset condition deteriorates over time, the likelihood of failure and subsequent risks may increase should these issues not be addressed.

Identified need: managing safety and environmental risks from corrosion on Line 81

A considerable number of the steel tower structures supporting Line 81 have reached a condition that reflects they are nearing the end of serviceable life. The assets affected by corrosion-related issues pose risk to supply, environment, and safety as a consequence of potential structural failure, conductor drop, and earthing safety hazards. Further deterioration of the condition of these assets increases these risks.

Figure E-1 provides a breakdown of gross benefits estimated to be delivered by the proposed investment. The figure shows almost all of the benefits are derived from avoided risk of bushfires (ie 'environmental risk').

Figure E-1 Components of gross economic benefits, present value ($m 2019/20)



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]

Using TransGrid's risk cost framework, the risks on safety and environment are sufficient such that their mitigation is warranted. The safety and environment risk costs from corrosion of steel components of the structures or 'members', insulators and fittings is estimated to be $350,000 per year.[2]

Under the ALARP test with the application of a gross disproportionate factor[3] 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.

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

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

[3] 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.

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.

Credible options considered

In this PSCR, TransGrid has put forward for consideration credible options that would meet the identified need from a technical, commercial, and project delivery perspective.[4]

These are summarised in the following table.

Table E-2 Summary of the credible options

Option	Description	Capital costs ($m)	Operating and maintenance cost ($ per year)	Remarks
Option 1	Line refurbishment	7.9 (± 25%)	65,000	Most economical and preferred option
Option 2	Line decommissioning and dismantling	27.3 (± 25%)	0	Not progressed due to significant costs

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.

Options addressed under three different scenarios

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.

Table E-3 Summary of the scenarios

Variable / Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Environment and safety risk costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Discount rate	5.9%	7.2%	4.60%

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

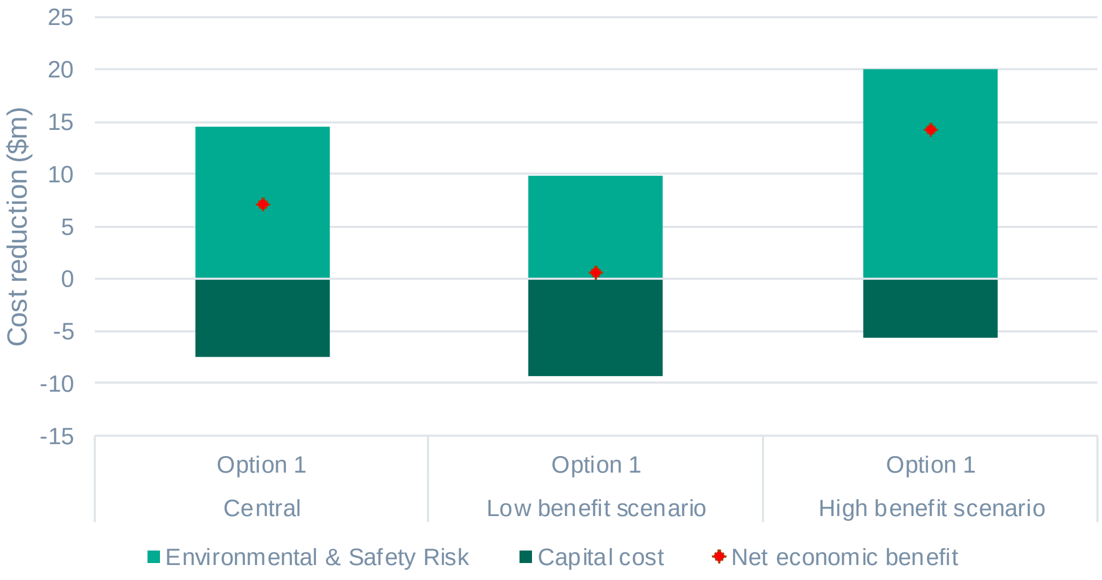
Implementing Option 1 will meet relevant environmental and safety obligations

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 cost 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. This is shown in Figure E-2.

In accordance with the ALARP principle, disproportionality factors have been applied on the risks shown in this figure to just below the level which the community, government and law would consider risk reduction expenditure to be grossly disproportionate.

Figure E-2 As Low as Reasonably Practicable Test, present value ($m 2019/20)



Option 1 reasonably mitigates environmental risk under all sensitivities considered

The figures below illustrate that while the results are most sensitive to the environmental risk cost estimates, it is still reasonable to make investments to mitigate the risk.

Figure E-3 Sensitivities of net present value using the ALARP test

Draft conclusion

The implementation of Option 1, a scope of works involving refurbishment of the line, is the most efficient technically and commercially feasible option at this draft stage of the RIT-T process. 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 PSCR. Moving forward with this option is the most prudent and economically efficient solution to manage and mitigate bushfire risk to the ALARP level.

Option 1 consists of works on:

- insulators
- conductor fittings and vibration dampers
- earthwire fittings and dampers
- earthwire replacement
- replacement of tower members, ladders and nuts & bolts
- tower member painting
- tower earthing
- tower danger signage and climbing deterrents
- remediation of tower foundations

The estimated capital expenditure associated with this option is $7.9 million ± 25%.

The works will be undertaken between 2019/20 and 2020/21. Planning and procurement (including completion of the RIT-T) will occur in 2019/20, while project delivery and construction will occur in 2020/21. All works will be completed in accordance with the relevant standards by 2020/21 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.

Submissions and next steps

The purpose of this PSCR is to set out the reasons TransGrid proposes that action be taken, present the options that address the identified need, outline the technical characteristics that non-network options will need to provide, and allow interested parties to make submissions and provide input to the RIT-T assessment.

TransGrid welcomes written submissions on material contained in this PSCR. Submissions are particularly sought on the credible options presented and from potential proponents of non-network options that could meet the technical requirements set out in this PSCR. Submissions are due on or before 21 January 2020.

Submissions should be emailed to TransGrid's Regulation team via RIT-TConsultations@transgrid.com.au.[5] In the subject field, please reference 'PSCR Line 81 project.'

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 as per NER clause 5.16.4(z1). Production of a PADR is not required due to:

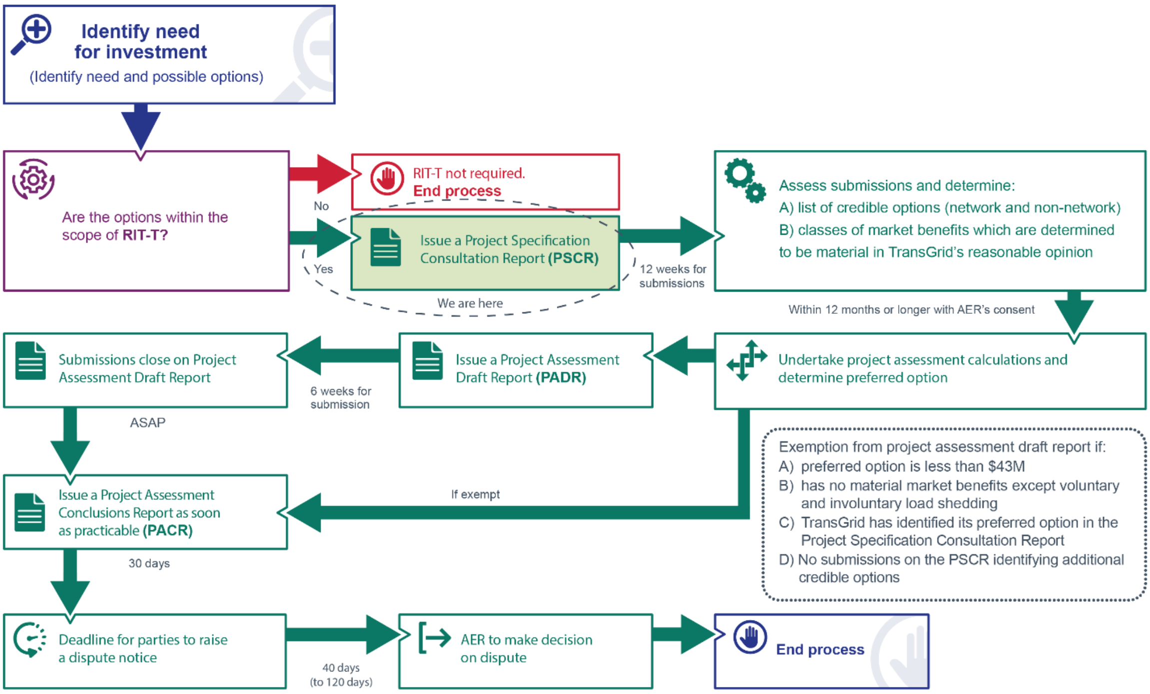
> preferred option being less than $43 million
> no market benefits except voluntary and involuntary load shedding
> preferred option has been identified in the PSCR
> no submissions on the PSCR identifying additional credible options.

Therefore, the next step in this RIT-T, following consideration of submissions received via the 12-week consultation period and any further analysis required, will be publication of a Project Assessment Conclusion Report (PACR). TransGrid anticipates publication of a PACR by 28 February 2020.

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. Accordingly, if TransGrid considers that any additional credible options are identified, TransGrid will produce a PADR which includes a net present value (NPV) assessment of the net economic benefits of each additional credible option.

[5] TransGrid is bound by the Privacy Act 1988 (Cth). In making submissions in response to this consultation process, TransGrid will collect and hold your personal information such as your name, email address, employer and phone number for the purpose of receiving and following up on your submissions. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement. See section 1.2 for more details.

Figure E-4 This PSCR is the first stage of the RIT-T process[6]



6 Australian Energy Regulator, *"Final determination on the 2018 cost thresholds review for the regulatory investment tests."* accessed 15 March 2019. https://www.aer.gov.au/communication/aer-publishes-final-determination-on-the-2018-cost-thresholds-review-for-the-regulatory-investment-tests

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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 81. Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

Line 81 provides a key link between approximately 4,400 MW[7] of existing generation in the Hunter Valley and Newcastle. 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 significant proportion of the steel transmission structures of Line 81 are impacted by various levels of deterioration and corrosion. The affected components include tower steelwork, foundations and earthing, insulators, conductor fittings, earthwire and associated fittings. This greatly increases the likelihood of transmission structure failures, conductor drop, and subsequent bushfire and safety risks.

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

Purpose of this report

The purpose of this PSCR is to:

- set out the reasons why TransGrid proposes that action be undertaken (the 'identified need')
- present the options that TransGrid currently considers to address the identified need
- outline the technical characteristics that non-network options would need to provide, whilst outlining how these options are unlikely to be able to contribute to meeting the identified need for this RIT-T
- allow interested parties to make submissions and provide inputs to the RIT-T assessment.

[7] Total generation for Liddell Power Station and Bayswater Power Station.

2. The identified need

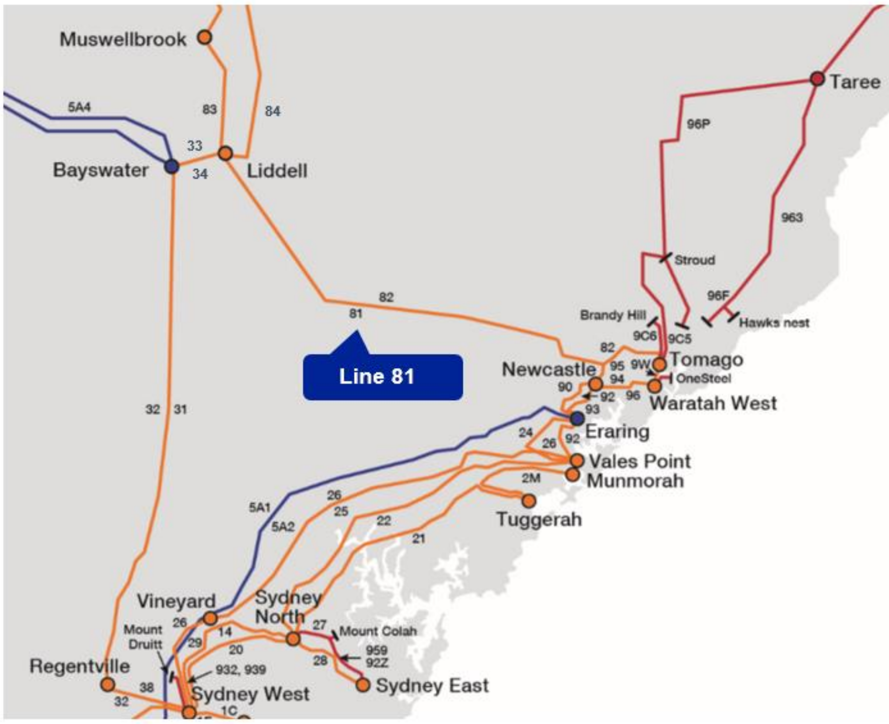
2.1 Background

Line 81 is a 330 kV transmission line built on 288 steel tower structures spanning approximately 100 km between Newcastle substation and Liddell 330 kV switching station.

Newcastle is located in the Hunter Region of NSW, approximately 160 km north of Sydney. It has a growing population of 160,919[8]. Newcastle substation is a customer connection point for the Ausgrid 132 kV subsystem serving areas within the Hunter Region including Newcastle and Lake Macquarie.

Liddell switching station is a customer connection point for AGL Macquarie and Ausgrid. It enables the flow of electricity from generators located in the Hunter Valley to Newcastle, and more broadly across the NEM. Both Newcastle and Liddell are key nodes in the Newcastle and Central Coast network. Figure 2-1 depicts the location of Line 81 on TransGrid's network.

Figure 2-1 TransGrid's Newcastle and Central Coast network



Line 81 forms part of the network that provides a key link between approximately 4,400 MW of existing generation in the Hunter Valley and Newcastle. 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.

Despite the planned retirement of Liddell Power Station, Liddell switching station will have 2,600 MW of generation in the vicinity and forms the major link for electricity transmission from Queensland and renewable resources in New England area of Northern NSW.

The majority of Line 81 was constructed in 1968. As coal mines in the area expanded, portions of Line 81

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8 Population in the Local Government Area of Newcastle City Council was 160,919 at the 2016 census and is projected to grow to 195,539 by 2036. Newcastle City Council. "Newcastle 2030- Community Strategic Plan", Newcastle: Newcastle City Council, 2018.7. Accessed 26 September 2019. http://www.newcastle.nsw.gov.au/Newcastle/media/Documents/Engagements/Completed/3119-CSP-Strategy-FINAL-WEB.pdf

were realigned with approximately 24% of the structures being constructed after 1986. Consequently, those post-1986 structures are not affected by corrosion to the same degree as the earlier towers. Figure 2-2 provides a breakdown of the towers along Line 81 by decade of construction.

Figure 2-2 Tower construction date breakdown

Decade of construction	1960s	1970s	1980s	1990s	2000s	2010s
Number of towers	210	10	4	36	12	16

A significant proportion of the pre-1986 steel transmission structures of Line 81 are impacted by various levels of deterioration and corrosion. The affected components include tower steelwork, foundations and earthing, insulators, conductor fittings and vibration dampers. This greatly increases the likelihood of transmission structure failures, conductor drop, and subsequent bushfire and safety risks.

A condition assessment performed by TransGrid in December 2015 identified a number of issues with Line 81. Corrosion-related issues are the biggest factor contributing to deterioration and require rectification for TransGrid to continue to safely and reliably operate the assets. Some of the other issues found were:

> ground line corrosion of steel at footing
> buried concrete foundations
> rusting of tower steel members
> corrosion of fasteners
> corrosion of earth strap
> corrosion of overhead earthwire and earthwire fittings
> corrosion and damage to disc insulators, and faulty composite insulators
> site establishment and access

Figures 2-3 – 2-10 below demonstrate examples of the condition of various components of Line 81.

Figure 2-3 Corrosion affecting tower foundation at ground level

Figure 2-4 Corrosion affecting conductor spacer

Figure 2-5 Corrosion affecting conductor fitting attachments

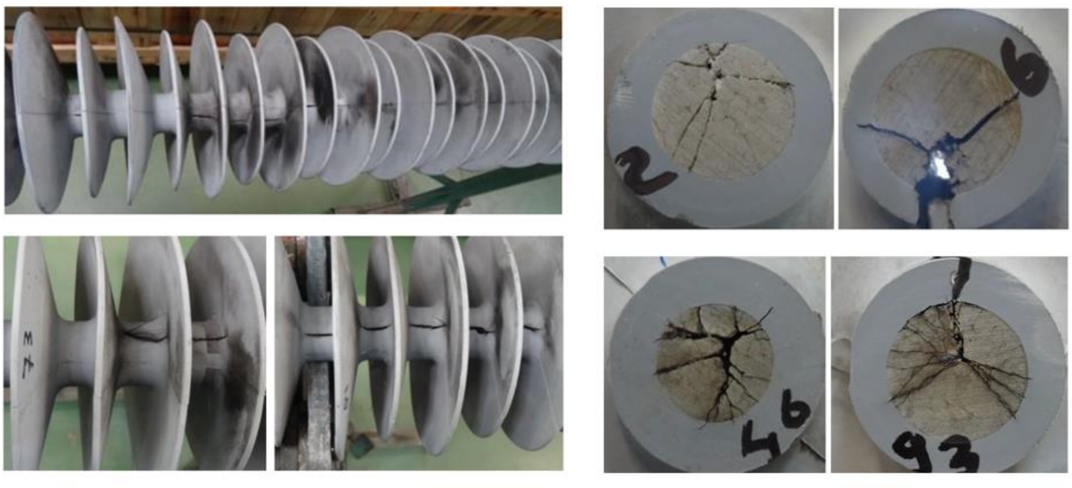
Figure 2-6 Corrosion affecting tower fasteners

Figure 2-7 Corrosion affecting tower members

Figure 2-8 Corrosion affecting earthwire fittings

Figure 2-9 Damaged insulators

Figure 2-10 Circa 2001 longrod insulators



2.2 Description of identified need

TransGrid calculates that the risk costs associated with the condition deterioration and corrosion of Line 81 are approximately $350,000 per year. This cost will increase as the assets further deteriorate and the likelihood of failure increases. Figure 2-11 shows that the majority of costs under the base case are comprised of environmental risk costs.

Figure 2-11 Costs forecast under the base case, present value ($m 2019/20)

One of the most significant elements of concern is excess soil at the tower footings as it accelerates ground line corrosion of steel transmission tower legs. As these are the critical load bearing members of the tower, they cannot be easily remediated if the condition passes a stage where rectification work is not possible.

The galvanising layer of the fasteners and fittings has reached a condition that reflects end of life due to corrosion. This is expected as during the time of manufacture (1960s and 70s, significantly thinner layer of galvanising are applied on these items compared with the steel tower members due to fabrication processes. Fasteners also have no galvanising on the nut thread which explains their poor condition relative to the main tower steelwork.

Corrosion of steel pins on ceramic insulators is also a significant issue. Two insulator strings have previously failed, both in the vicinity of Liddell. The pins on the underside of suspension insulator discs build up pollution and are not adequately washed by rain which leads to an increased rate of corrosion. Detailed climbing inspections have identified increased rusting of both insulator caps and pins. Given the vintage of the insulators, the corrosion condition issues experienced are expected to be prevalent throughout considerable parts of the line. A number of structures had insulators replaced in early 2000's with composite longrods after a number of failures. These new composite insulators have developed a fault leading to severe cracks of the housing and require replacement.

Further deterioration of the condition of the affected assets due largely to corrosion would also mean an increase in bushfire and safety risks. 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 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.

Replacement of the affected components is required to reduce the risk of conductor drop. Risk of conductor/earthwire fatigue is another issue of concern due to damaged conductor/earthwire dampers. Replacement of the affected dampers will enable vibration to be kept to a minimum and minimise the risk of fatigue.

Investment to address the deterioration of the assets along Line 81 due to corrosion is needed to mitigate risks on the environment.

TransGrid manages and mitigates bushfire and safety risks to ensure they are below 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).[9]

Under the ALARP test with the application of a gross disproportionate factor[10], 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.

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.

2.3.1 Deteriorating asset condition

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

Table 2-1 Condition issues along Line 81 and their consequences

Issue	Cause	Impact
Ground line corrosion of steel at footing	Buried steelwork at footing	Steel corrosion of critical member, can lead to structural failure of tower
Buried concrete foundations	Erosion of soil building up around footings	Accelerated corrosion of critical member
Corrosion of earth strap	Corrosion as buried at footing	Possible transfer potential, earth current and voltage gradient issues, can lead to serious injury or possible fatality
Rusting of tower steel members	Zinc galvanising end of life	Structural failure

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

10 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.

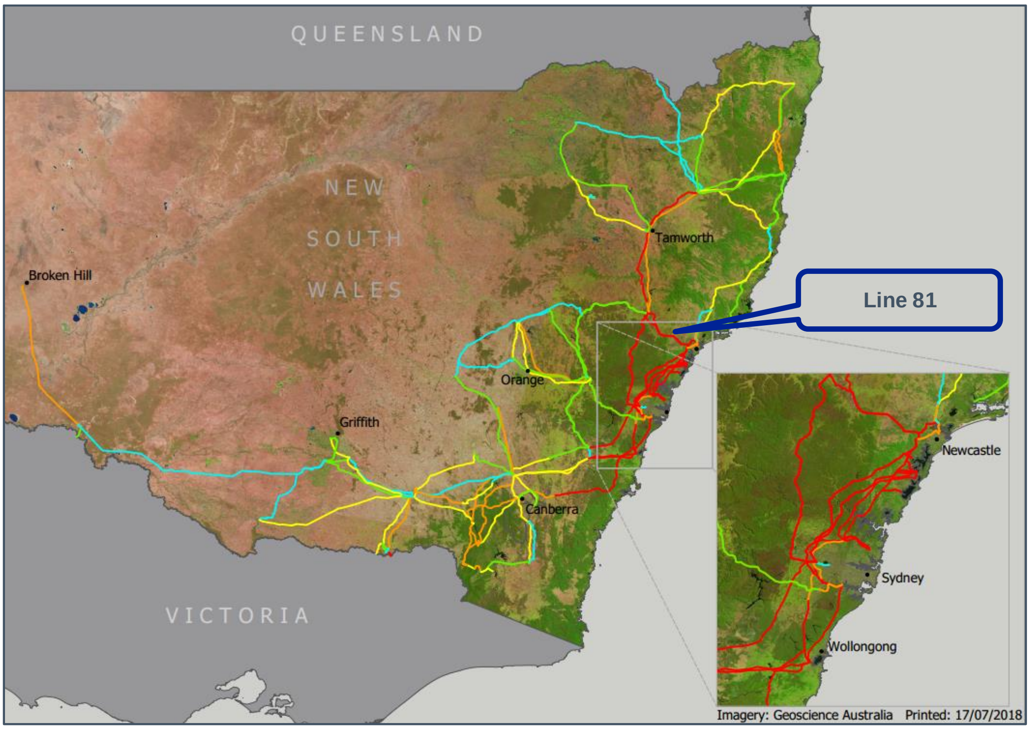
Corroded fasteners	Zinc galvanising end of life	Structural failure
Corroded and damaged disc insulators	Corrosion of steel caps Zinc sleeve protection end of life	Conductor drop
Faulty composite insulators	Cracking, hidden faults.	Flashover (line outage)
Corroded earthwire and fittings	Corrosion of steel earthwire	Conductor drop
Conductor dampers	Damaged	Accelerated fatigue of conductor due to vibration
Earthwire dampers	Damaged	Accelerated fatigue of conductor due to vibration

2.3.2 Environmental risk costs

Figure 2-12 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 81 is a high risk line. Due to the line's condition and its location near bushland and rural residential areas, the environmental and safety risks associated with this line are considered to be amongst the higher lines in TransGrid's network.

Figure 2-12 TransGrid's line risks heat map



*Line colours on Figure 2-12 represent the level of risk from highest risk to lowest risk respectively: red, orange, yellow, green, and blue.

The risk costs from corrosion of steel members of the structures is $350,000 per year, predominantly related to environmental risk (bushfire) This figure is expected to increase over time as the assets continue to deteriorate.

TransGrid's analysis concludes that the costs of mitigating the bushfire risks is more than the benefit of avoiding those risks. After applying disproportionality factors to these costs, the bushfire risk is greater (i.e. Option 1 passes the ALARP test). Categorised as a reliability corrective action under the RIT-T, 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.

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.

3. Options that meet the identified need

TransGrid considers credible network options that would meet the identified need from a technical, commercial, and project delivery perspective.[11]

Option 1 involves refurbishment of the line. All works under all options will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission assets.

In identifying credible options, TransGrid has taken the following factors into account: energy source; technology; ownership; the extent to which the option enables intra-regional or intra-regional trading of electricity; whether it is a network option or a non-network option; whether the credible option is intended to be regulated; whether the credible option has proponent; and any other factor which TransGrid reasonably considered should be taken into account.[12]

3.1 Base case

The costs and benefits of each option in this PSCR are compared against those of a base case. Under this base case, no proactive capital investment is made to remediate the deterioration of Lines 81, and 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 $350,000 per year in environmental risk costs.[13]

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

3.2 Option 1 – Line refurbishment

Option 1 involves the refurbishment of Line 81 to prevent further deterioration and corrosion to tower steelwork. Details of the scope of works under this option are summarised in Table 3-1.

Table 3-1 Option 1 scope of works

Issue	Remediation
Ground line corrosion of steel at footing	> Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion
Buried concrete foundation	> Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel
Corrosion of earth strap	> Replacement of earth straps in line with current standard
Rusting of tower steel members	> Replacement of members

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

12 As per clause 5.15.2(b) of the NER.

13 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.

Corrosion of fasteners	> Replacement of fasteners
Corrosion, damage and/or faulty insulators	> Replacement with composite longrod insulators
Corrosion of earthwire and fittings	> Replacement of steel earthwire and associated fittings
Damaged conductor dampers	> Replacement of Stockbridge vibration dampers
Damaged earthwire dampers	> Replacement of spiral vibration dampers

The works will be undertaken between 2019/20 and 2020/21. Planning and procurement (including completion of the RIT-T) will occur in 2019/20, while project delivery and construction will occur in 2020/21. All works will be completed in accordance with the relevant standards by 2020/21 with minimal modification to the wider transmission assets.

Necessary outages of line(s) in service will be planned appropriately in order to complete the works with minimal impact on the network.

It is estimated that the nominal capital expenditure associated with this option is $7.9 million ±25%. The routine operating and maintenance costs is the same as in the base case.

Following the refurbishment under this option, the risk costs associated with the remediated line are reduced to approximately $150,000 per year.

The biggest risk reductions comes from the environment category due to reduction in the likelihood of conductor drop.

3.3 Options considered but not progressed

Table 3-2 summarises the reasons the following credible options were not progressed further.

Table 3-2 Options considered but not progressed

Option	Description	Reason(s) for not progressing
Option 2	Line decommissioning and dismantling	Due to significant costs (approximately $27 million), line decommissioning and dismantling is not commercially feasible[14].

14 As per the rule of thumb noted in the Energy Networks Australia RIT-T Economic Assessment Handbook, options with a cost of more than 150% *greater* than the cost of the next most expensive option are not commercially feasible. Energy Networks Australia. "*RIT-T Economic Assessment Handbook*". Melbourne: Energy Networks Australia, 2019. 22. Accessed 23 October 2019. https://www.energynetworks.com.au/rit-t-economic-assessment-handbook

3.4 No expected material inter-network impact

TransGrid has considered whether the credible options listed above is expected to have material inter-regional impact.[15] A 'material inter-network impact' is defined in the NER as:

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

AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following:[16]

> 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 the preferred option presented in this PSCR 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.

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

16 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 15 March 2019. https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf.pdf

4. 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.

The maximum deferment benefits for Option 1, the preferred option in this PSCR, is approximately $470,000 per year (discount rate 5.9%) compared to the bushfire risk costs – $350,000 per year. For non-network options to assist, they would need to provide greater net economic benefits than the network option. That is, non-network options would need to reduce the bushfire risk related costs, which do not change with higher levels of non-network options (to the extent where the line is no longer required and decommissioning costs must be considered).

4.1 Required technical characteristics of non-network options

Line 81 forms part of the network supplying Newcastle from the Hunter Valley, which has N-1 and N-2 redundancies, therefore unserved energy is not a key driver for this RIT-T (in fact, it is expected to be immaterial under the base case and consequently has not been estimated).

The objective of this identified need is not load dependent. Therefore, non-network options are unable to technically reduce the safety and risk related costs associated with this need.

Any non-network solution is expected to only add to the costs of this option.

In summary, TransGrid consider that non-network options are unable to contribute to meeting the identified need for this RIT-T – this is based on:

- the fact that 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.

5. 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.[17]

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.[18]

TransGrid determines that the preferred option considered in this RIT-T will not have an impact on the wholesale electricity market, 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.

[17] The NER requires that all categories 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 category (or categories) is unlikely to be material in relation to the RIT-T assessment for a specific option – NER clause 5.16.1(c)(6). Under NER clause 5.16.4(b)(6)(iii), the PSCR should set out the classes of market benefits that the NSP considers are not likely to be material for a particular RIT-T assessment.

[18] Australian Energy Market Operator. *"Power System Security Guidelines, 31 December 2018."* Melbourne: Australian Energy Market Operator, 2018. Accessed 20 March 2019. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715---Power-System-Security-Guidelines.pdf

5.2 No other categories 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.

The same table sets out the reason TransGrid considers these classes of market benefits to be immaterial.

Table 5-1 Reasons non-wholesale market benefit categories are considered immaterial

Market benefits	Reason
Changes in involuntary load curtailment	Since Line 81 forms part of a meshed network (N-1 and N-2 redundant) required to supply Sydney, a failure due to the corroded assets results in an extremely 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.
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.[19] 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 benefit but it would be disproportionate to potential additional benefits for this RIT-T. Therefore, TransGrid has not estimated any additional option value benefit.

[19] Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018. Accessed 15 March 2019. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

6. Overview of the assessment approach

As outlined in section 3.1, all costs and benefits considered were measured against a base case.

The analysis presented in this RIT-T considered a 20-year period, from 2019/20 to 2039/40. TransGrid considers that a 20-year period takes into account the size, complexity and expected service life of the options and provides a reasonable indication of the costs and benefits over a long outlook period. Since the capital components have an asset life greater than 20 years, TransGrid took a terminal value approach to ensure that the capital costs of those assets were appropriately captured in the 20-year assessment period.

TransGrid adopted a central real, pre-tax 'commercial' discount rate of 5.9% 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[20].

TransGrid also tested the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 4.60% equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PSCR[21], and an upper bound discount rate of 7.2% (a symmetrical adjustment upwards) were investigated.

6.1 Approach to estimating project costs

TransGrid has estimated the capital costs of the options by using scope from similar works. TransGrid considers the central capital costs estimates to be within ± 25% of the actual costs.

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

Reactive maintenance costs under the base case considers the:

> level of corrective maintenance required to restore assets to working order following a failure
> probability and expected level of network asset faults.

6.2 Three different scenarios have been modelled to address uncertainty

RIT-T assessments are based on cost-benefit analysis that includes assessment under reasonable scenarios which are designed to test alternate sets of key assumptions and their impact on the ranking and feasibility of options.

TransGrid has considered three alternative scenarios, summarised in Table 6-1, to address uncertainty – namely:

> a low net economic benefits scenario, involving a number of assumptions that gives a lower bound and conservative estimates of net present value of net economic benefits
> a central scenario which consists of assumptions that reflect TransGrid's central set of variable estimates that provides the most likely scenario

20 Available at https://www.energynetworks.com.au/rit-t-economic-assessment-handbook Note the lower bound discount rate of 4.60% is based on the most recent final decision for a TNSP revenue determination which was TasNetworks in April 2019.

21 See TasNetworks' Post-tax Revenue Model (PTRM) for the 2019-24 period, available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/tasnetworks-determination-2019-24/final-decision

- a high net economic benefits scenario that reflects a set of assumptions which have been selected to investigate an upper bound of net economic benefits.

Table 6-1 Summary of the scenarios

Variable / Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Safety and environment risk costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Discount rate	5.9%	7.2%	4.60%

TransGrid considers that the central scenario is most likely since it is based primarily on a set of expected/central assumptions. TransGrid has therefore assigned this scenario a weighting of 50%, with the other two scenarios being weighted equally with 25% each.

7. Assessment of credible options

7.1 Estimated gross economic benefits

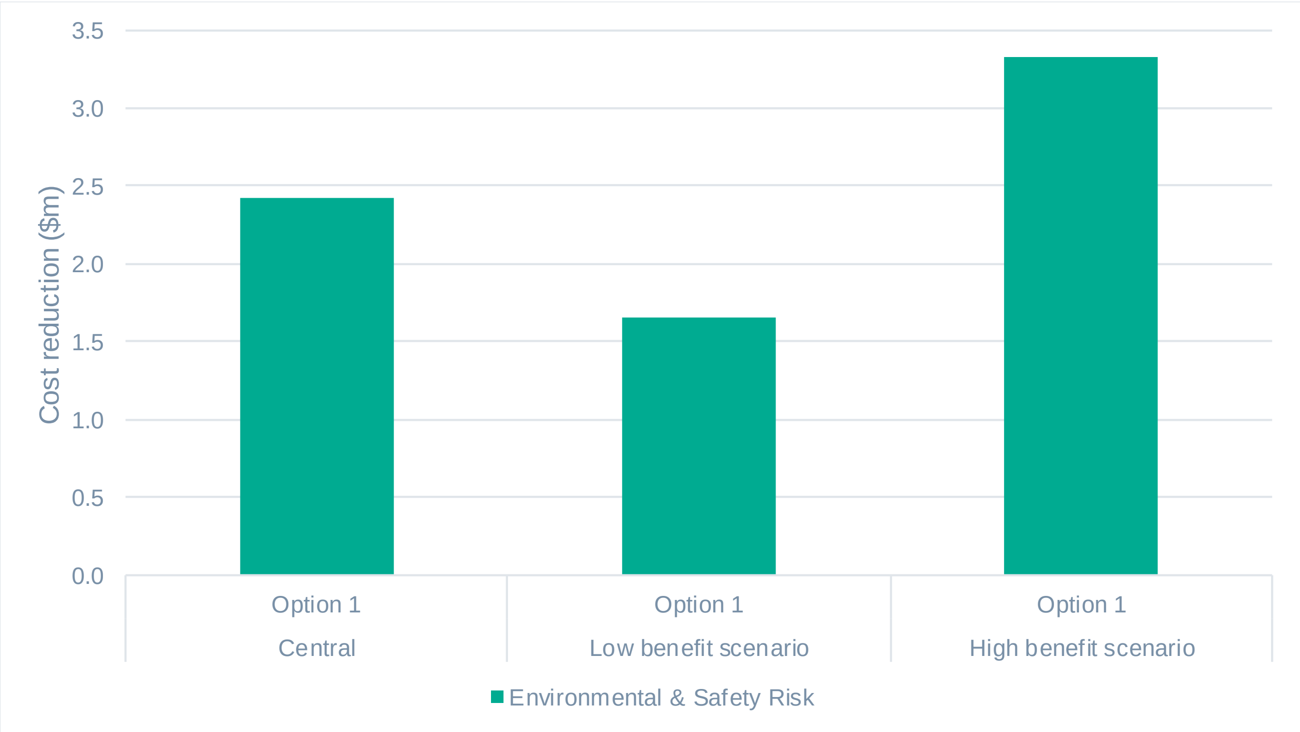
Table 7-1 below summarises the present value of gross economic benefit estimated for each credible option under the three scenarios.

Table 7-1 Gross economic benefits from credible options relative to the base case, present value ($m 2019/20)

Option/scenario	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	2.4	1.7	3.3	2.5

The figure below provides a breakdown of benefits estimated for each credible option.

Figure 7-1 Components of gross economic benefits, present value ($m 2019/20)



7.2 Estimated costs

Table 7-2 summarises the present value of costs of the credible options under the three scenarios relative to the base case.

Table 7-2 Costs of credible options relative to the base case, present value ($m 2019/20)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	7.5	9.3	5.7	7.5

7.3 Estimated net economic benefits

The net economic benefits are the differences between the estimated gross economic benefits less the estimated costs. Table 7-3 summarises the present value of the net economic benefits for each credible option across the three scenarios and the weighted net economic benefits.

Table 7-3 Net economic benefits for Option 1 relative to the base case, present value ($m 2019/20)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	-5.1	-7.6	-2.4	-5.0

Though the net economic benefits are negative, the investments can still be justified as they are intended to mitigate safety and environmental risks using the ALARP principle.

7.4 Meeting relevant regulatory obligations

TransGrid determines that its obligations under the New South Wales *Electricity Supply (Safety and Network Management) Regulation 2014* and TransGrid's Electricity Network Safety Management System (ENSMS) will be met by implementing Option 1 as by applying the ALARP principle, the safety and environmental risks will be mitigated reasonably.

In accordance with the ALARP principle, a disproportionality factor has been applied on the risks shown in this figure to just below the level which the community, government and law would consider risk reduction expenditure to be grossly disproportionate[22].

Figure 7-2 shows that the present value of the net disproportionate benefits under the ALARP principle. Again, for each credible option across the three scenarios and the weighted net economic benefits.

[22] 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.

Figure 7-2 As Low as Reasonably Practicable Test, present value ($m 2019/20)

Under the ALARP principle, all scenarios under Option 1. TransGrid's analysis concludes that the costs of mitigating the bushfire risks is less than the disproportionate risk benefit.

7.5 Summary of Net Economic and ALARP Benefit Tests

Table 7-4 summarises the outcomes of the net economic benefit and ALARP tests. Option 1 is preferred under the ALARP principle.

Table 7-4 Summary of net economic with ALARP benefit tests, present value ($m 2019/20)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	7.0	0.7	14.3	7.2

7.6 Sensitivity testing under ALARP

TransGrid has conducted sensitivity analysis. The figures below illustrate that while the results are most sensitive to the safety and environmental risk costs estimates, it is still reasonable to make investments to mitigate the risk.

Figure 7-3 Sensitivities of net present value using the ALARP test

8. Draft conclusion and exemption from preparing a PADR

A reasonable reduction in environmental risk costs makes Option 1 the preferred option at this draft stage. This option passes the ALARP test for mitigating bushfire risks and consists of works on:

> insulators
> conductor fittings and vibration dampers
> earthwire fittings and dampers
> earthwire replacement
> replacement of tower members, ladders and nuts & bolts
> tower member painting
> tower earthing
> tower danger signage and climbing deterrents
> remediation of tower foundations

Furthermore, Option 1 provides additional benefits from reduction in operating, maintenance, and licensing costs.

The estimated capital costs of Option 1 is $7.9 million. Per annum routine and operating maintenance costs will be approximately less than 1% of the estimated capital costs.

The works will be undertaken between 2019/20 and 2020/21. Planning and procurement (including completion of the RIT-T) will occur in 2019/20, while project delivery and construction will occur in 2020/21. All works will be completed in sufficient time to meet the identified need (by 2022/23) with minimal modification to the wider transmission assets and in accordance with the relevant standards.

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 as per NER clause 5.16.4(z1). Therefore, the next step in this RIT-T, following consideration of submissions received during the 12-week consultation period and any further analysis required, will be publication of a Project Assessment Conclusions Report (PACR). TransGrid anticipates publication of a PACR by 28 February 2020.

TransGrid welcomes written submissions on material contained in this PSCR. Submissions are due on or before 21 January 2020. Submissions should be emailed to TransGrid's Regulation team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'PSCR Line 81 project.'

NER clause 5.16.4(z1) provides for a TNSP to be exempt from producing a PADR for a particular RIT-T application, in the following circumstances:

(a) if the estimated capital cost of the preferred option is less than $43 million;
(b) if the TNSP identifies in its PSCR its proposed preferred option, together with its reasons for the preferred option and notes that the proposed investment has the benefit of the clause 5.16.4(z1) exemption; and
(c) if the TNSP considers that the proposed preferred option and any other credible options in respect of the identified need will not have a material market benefit for the classes of market benefits specified in clause 5.16.1(c)(4), with the exception of market benefits arising from changes in voluntary and involuntary load shedding.

TransGrid considers that the preferred option is exempt from producing a PADR under NER clause 5.16.4(z1).

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.

Accordingly, if TransGrid considers that any additional credible options are identified, TransGrid will produce a PADR which includes an NPV assessment of the net economic benefits of each additional credible option.

Should TransGrid consider that no additional credible options were identified during the consultation period, TransGrid intends to produce a PACR that addresses all submissions received including any issues in relation to the proposed preferred option raised during the consultation period.[23]

[23] As per clause 5.16.4(z2) of the NER.

Appendix A – Compliance checklist

This appendix sets out a compliance checklist which demonstrates the compliance of this PSCR with the requirements of clause 5.16.4(b) of the NER version 124.

Rules clause	Summary of requirements	Relevant section
5.16.4 (b)	A RIT-T proponent must prepare a report (the project specification consultation report), which must include:	–
	(1) a description of the identified need;	2
	(2) the assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, why the RIT-T proponent considers reliability corrective action is necessary);	2
	(3) the technical characteristics of the identified need that a non-network option would be required to deliver, such as: (i) the size of load reduction of additional supply; (ii) location; and (iii) operating profile;	N/A
	(4) if applicable, reference to any discussion on the description of the identified need or the credible options in respect of that identified need in the most recent National Transmission Network Development Plan;	NA
	(5) a description of all credible options of which the RIT-T proponent is aware that address the identified need, which may include, without limitation, alterative transmission options, interconnectors, generation, demand side management, market network services or other network options;	3
	(6) for each credible option identified in accordance with subparagraph (5), information about: (i) the technical characteristics of the credible option; (ii) whether the credible option is reasonably likely to have a material inter-network impact; (iii) the classes of market benefits that the RIT-T proponent considers are likely not to be material in accordance with clause 5.16.1(c)(6), together with reasons of why the RIT-T proponent considers that these classes of market benefit are not likely to be material; (iv) the estimated construction timetable and commissioning date; and (v) to the extent practicable, the total indicative capital and operating and maintenance costs.	3 & 5
5.16.4(z1)	A RIT-T proponent is exempt from paragraphs (j) to (s) if:	8

	1. the estimated capital cost of the proposed preferred option is less than $35 million (as varied in accordance with a cost threshold determination); 2. the relevant Network Service Provider has identified in its project specification consultation report: (i) its proposed preferred option; (ii) its reasons for the proposed preferred option; and (iii) that its RIT-T project has the benefit of this exemption; 3. the RIT-T proponent considers, in accordance with clause 5.16.1(c)(6), that the proposed preferred option 1nd any other credible option in respect of the identified need will not have a material market benefit for the classes of market benefit specified in clause 5.16.1(c)(4) except those classes specified in clauses 5.16.1(c)(4)(ii) and (iii), and has stated this in its project specification consultation report; and 4. the RIT-T proponent forms the view that no submissions were received on the project specification consultation report which identified additional credible options that could deliver a material market benefit.	

Appendix B – Risk cost framework

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.[24]

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:

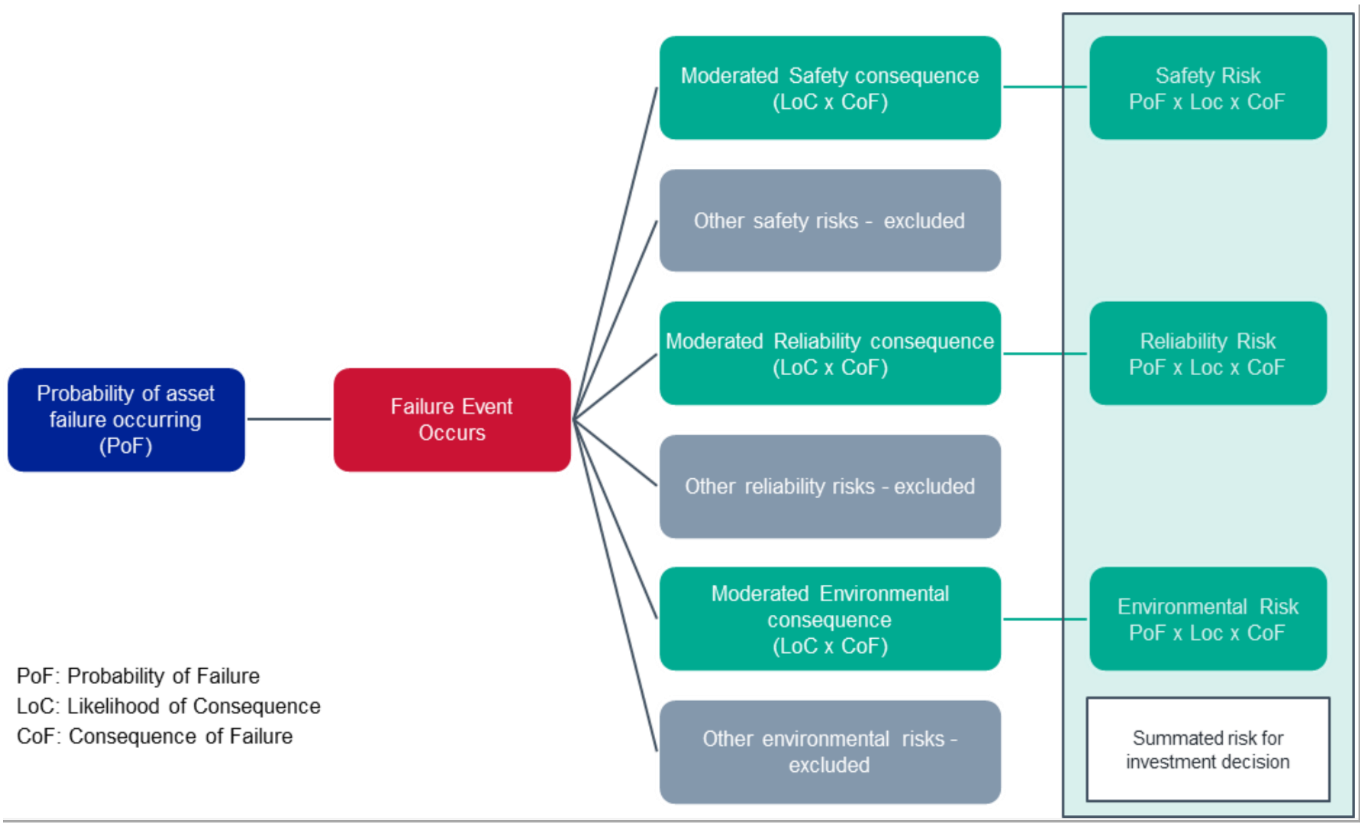
> uses externally verifiable parameters to calculate asset health and failure consequences
> assesses and analyses asset condition to determine remaining life and probability of failure
> applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence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

B.1 Overview of 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.

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



The 'risk costs' are calculated based on the Probability of Failure (PoF), the Consequence of Failure (CoF),

24 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

and the corresponding Likelihood of Consequence (LoC).

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

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