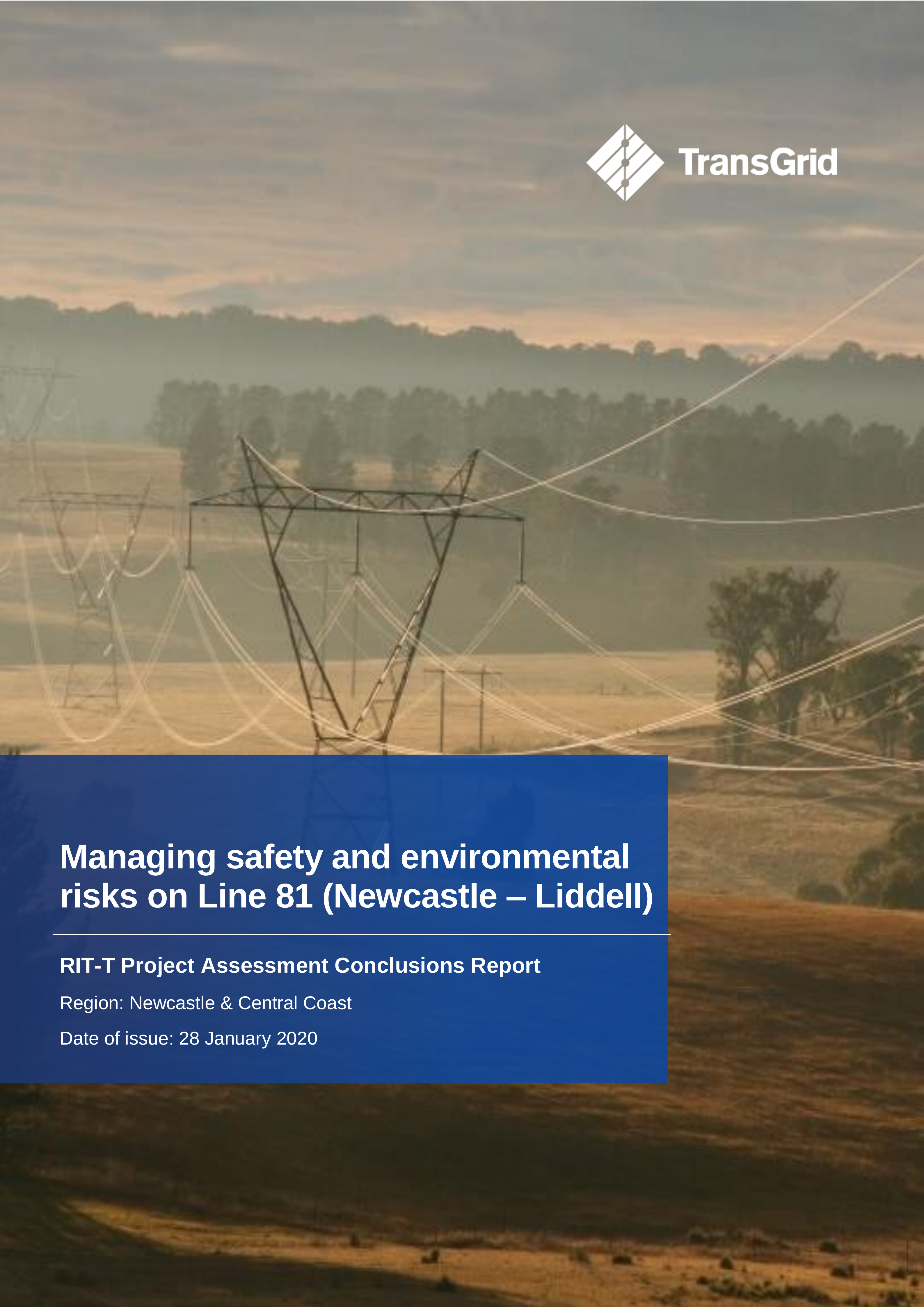


Managing safety and environmental risks on Line 81 (Newcastle – Liddell)

RIT-T Project Assessment Conclusions Report

Region: Newcastle & Central Coast

Date of issue: 28 January 2020

Disclaimer

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

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

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

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

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

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

Privacy notice

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

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

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

Executive summary

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 Assessment Conclusions Report (PACR) represents the final 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 per cent 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	Earthing safety hazard
Rusting of tower steel members	Structural failure
Corroded fasteners	Structural failure
Corroded and damaged disc insulators	Conductor drop
Faulty composite insulators	Flashover (line outage) or Conductor drop
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

The proposed investment will enable TransGrid to manage safety and environmental risks on Line 81. A considerable number of the steel tower structures and associated line components on 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.

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 Assessment Methodology[2], the risks on safety and environment are sufficient such that their mitigation is warranted. The safety and environmental risk costs from corrosion of steel components of the structures or 'members', insulators and fittings is estimated to be approximately $350,000 per year.[3]

Under the ALARP test with the application of a gross disproportionate factor[4], the weighted benefits are expected to exceed the cost. TransGrid's analysis concludes that the costs are less than the weighted benefits from mitigating bushfire and safety risks. The proposed investment will enable TransGrid to continue to manage and operate this part of the network to a safety and risk mitigation level of ALARP. Consequently, it is considered a reliability corrective action under the RIT-T.

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

A reliability corrective action differs from a 'market benefits'-driven RIT-T in that the preferred option is permitted to have negative net economic benefits on account of it being required to meet an externally imposed obligation on the network business.

No submissions received in response to Project Specification Consultation Report

TransGrid published a Project Specification Consultation report (PSCR) on 29 October 2019 and invited written submissions on the material presented within the document. No submissions were received in response to the PSCR.

No material developments since publication of the PSCR

No additional credible options were identified during the consultation period following publication of the PSCR. TransGrid has updated the estimate for capital expenditure that was published in the PSCR to reflect a reduction in the construction component which has been reduced by $15,000. Option 1, refurbishing Line 81 remains the preferred option at this stage of the RIT-T process.

---

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

2 Appendix B provides an overview of the risk assessment methodology adopted by TransGrid.

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

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

Refurbishing Line 81 remains the most prudent and economically efficient option to manage safety and environmental risks to ALARP

In the PSCR 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 81 including replacement of line components, tower steel member replacement, remediation of tower steelwork and foundations. No submissions were received in response to this PSCR and no additional credible options have been identified.

The primary driver for the identified need is to mitigate bushfire and safety risks associated with condition issues on Line 81, mainly caused by corrosion. One other option to address the need was considered but was not progressed further as it was not commercially viable when assessed against the preferred option.

This RIT-T may include assets in areas which are currently experiencing ongoing 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.

All costs presented in this PACR are in 2019/20 dollars.

Table E-2 Options considered

Option	Description	Capital costs ($m)	Operating costs ($ per year)	Remarks
Option 1	**Line refurbishment**	**7.8 (± 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

The PSCR 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 81 is optimal

The optimal commercially and technically feasible option presented in the PSCR – Option 1 (refurbishment of Line 81) – remains the preferred option to meet the identified need. Option 1 can be implemented in sufficient time to meet the identified need by 2022/23, and is therefore the preferred option presented in this PACR.

The estimated capital expenditure associated with this option is $7.8 million ± 25 per cent. Routine operating and maintenance costs are approximately $65,000 per year, similar to the cost under the base case. TransGrid calculates that the avoided risk costs by undertaking Option 1 is approximately $197k per year.

This preferred option, Option 1, whilst having negative net benefits under most scenarios investigated, still falls within the risk benefit threshold once the ALARP disproportionality factors are considered. TransGrid notes that the low net economic scenario which delivers a negative benefit is comprised of an extreme combination of low safety and environmental risks estimates and high capital costs.

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, the costs of mitigating the bushfire risks is less than the disproportionate risk benefit[5] expected from refurbishing Line 81.

Moving forward with this option is the most prudent and economically efficient solution to manage and mitigate bushfire and safety risk to the As Low As Reasonably Practical (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 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.

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

Next steps

This PACR represents the third step in a formal Regulatory Investment Test for Transmission (RIT-T) process undertaken by TransGrid. It follows a Project Specification Consultation Report (PSCR) released in October 2019. The second step, production of a Project Assessment Draft Report (PADR), was not required as the investment in relation to the preferred option is exempt from this part of the RIT-T process under NER clause 5.16.4(z1).Production of a PADR is not required[6] due to:

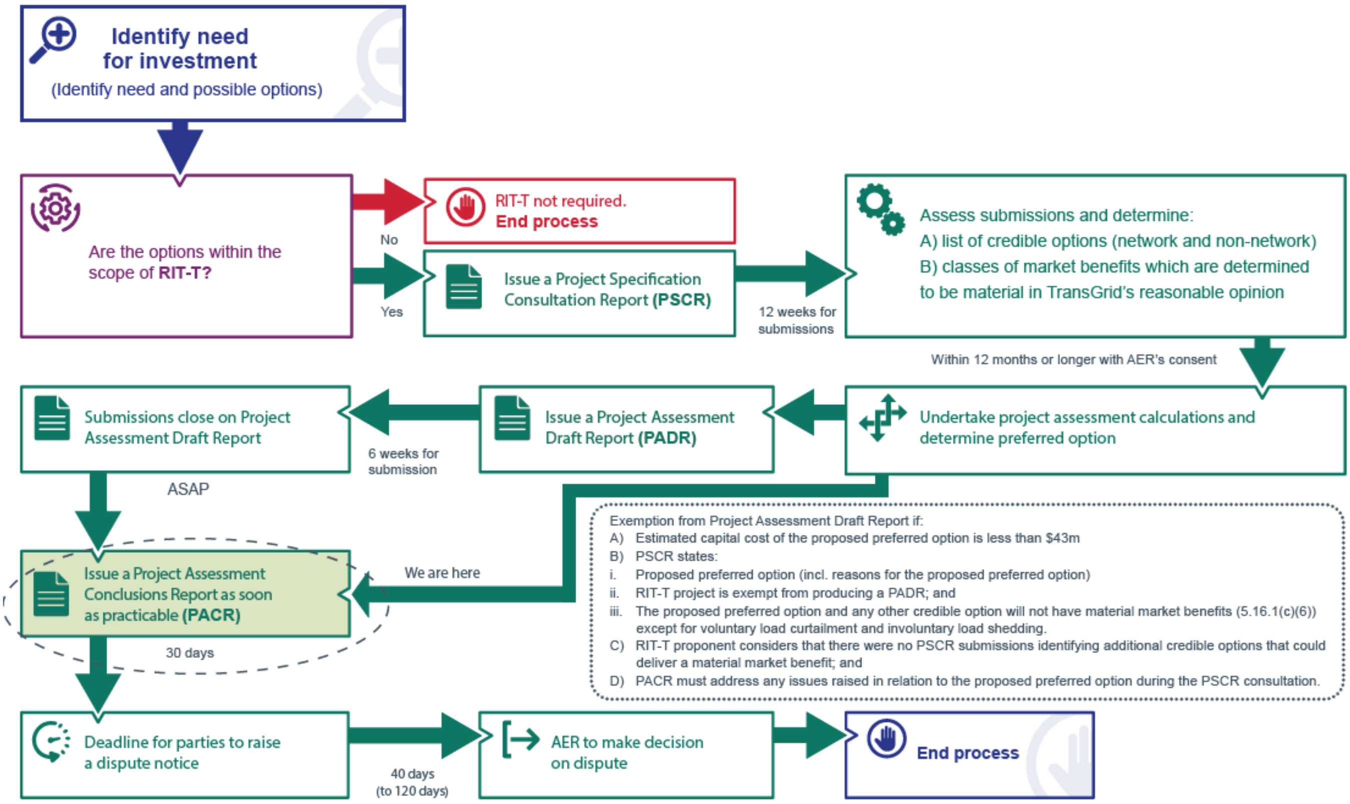
> the estimated capital cost of the preferred option being less than $43 million;
> the TNSP identifies in its PSCR its proposed preferred option, together with its reasons for the preferred option and notes that the proposed investment has the benefit of the clause 5.16.4(z1) exemption; and
> if the 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 benefit specified in clause 5.16.1(c)(4), with the exception of market benefits arising from changes in voluntary and involuntary load shedding.
> This PACR represents the third and final stage of the consultation process in relation to the application of the RIT-T.

This PACR represents the third and final stage of the consultation process in relation to the application of the RIT-T.

[5] Risk benefit including gross disproportionate factor

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

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



Parties wishing to raise a dispute notice with the AER may do so prior to 26 February 2020 (30 days after publication of this PACR). Any dispute notices raised during this period will be addressed by the AER within 40 to 120 days, after which the formal RIT-T process will conclude.

Further details on the project can be obtained from TransGrid's Regulation team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Line 81 PACR'.

7 Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.65. Accessed 19 November 2019. https://www.aemc.gov.au/sites/default/files/content/89fbf559-2275-4672-b6ef-c2574eb7ce05/Final-rule-determination.pdf

Contents

List of Tables

List of Figures

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 Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

Line 81 provides a key link between approximately 4,400 MW[8] 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.

Corrosion-related issues that will impact the safe and reliable operation of the network have been found on Line 81. The condition issues raise a number of risks associated with asset failure, including safety and environmental (bushfire) risks.

The Project Specification Consultation Report (PSCR) released in October 2019 set out the:

> reasons TransGrid proposed that action be taken

> credible options TransGrid considered to address the identified need.

No submissions were received in response to the PSCR.

1.1 Purpose of this report

The purpose of this PACR[9] is to:

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

8 Total generation for Liddell Power Station and Bayswater Power Station.

9 See Appendix A for the National Electricity Rules requirements.

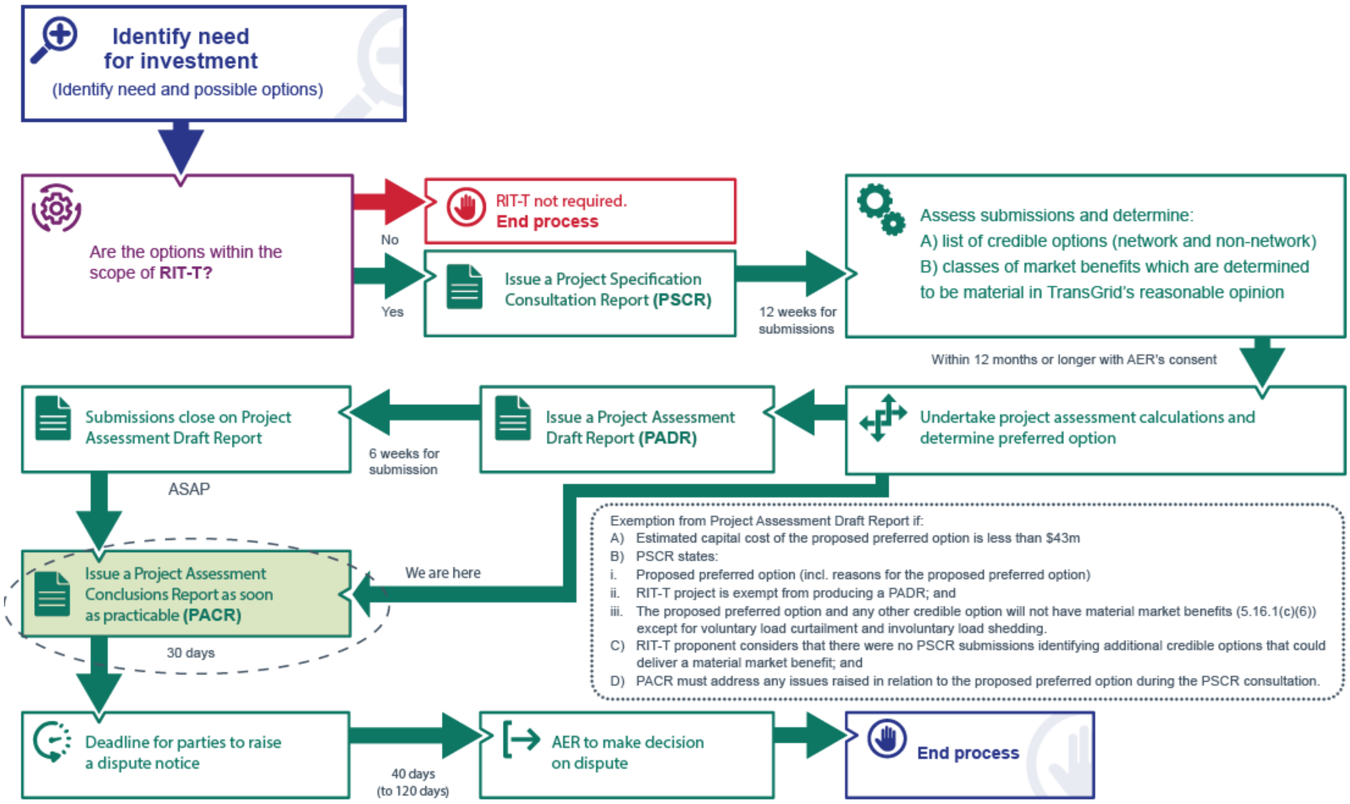
1.2 Next steps

This PACR represents the third step in a formal Regulatory Investment Test for Transmission (RIT-T) process undertaken by TransGrid. It follows a Project Specification Consultation Report (PSCR) released in October 2019. The second step, production of a Project Assessment Draft Report (PADR), was not required as the investment in relation to the preferred option is exempt from this part of the RIT-T process under 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.

This PACR represents the third and final stage of the consultation process in relation to the application of the RIT-T.

Figure 1-1 This PACR is the third stage of the RIT-T process[10]



10 Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.65. Accessed 19 November 2019. 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 Newcastle and Central Coast network and existing electricity supply arrangements.

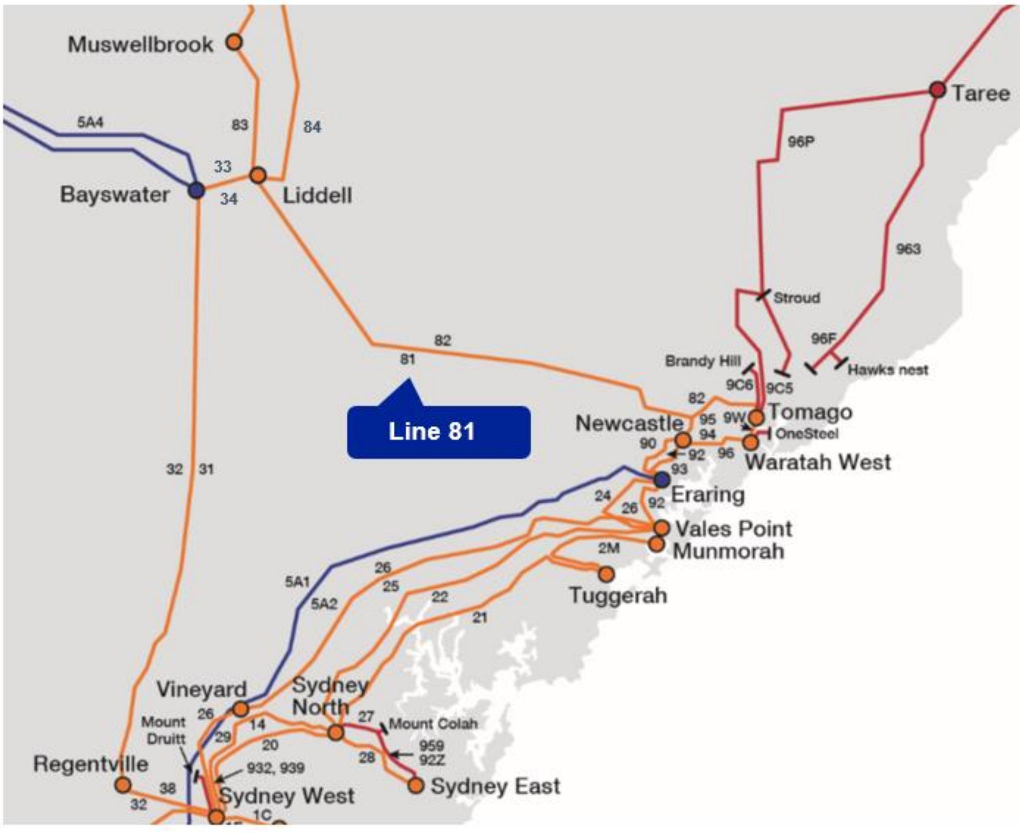
2.1 Background to the identified need

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[11]. 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 Location of Line 81 on TransGrid's Newcastle and Central Coast network



---

11 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

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 were realigned with approximately 25 per cent 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
210	10	4	36	12	16
Number of 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 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 end of life composite insulators

Figure 2-3 - Figure 2-9 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

2.2 Description of the 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 2-10 shows that the majority of costs under the base case are comprised of safety and environmental risk costs.

Figure 2-10 Costs forecast under the base case, present value ($m 2019/20) [12]

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/remediation 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 safety and 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).[13]

Under the ALARP test with the application of a gross disproportionate factor[14], 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.

---

12 See section 5.4 for the assessment approach for the three different scenarios that have been modelled to address uncertainty.

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

14 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.

2.3 Assumptions underpinning the identified need

TransGrid adopts a risk cost framework 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 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

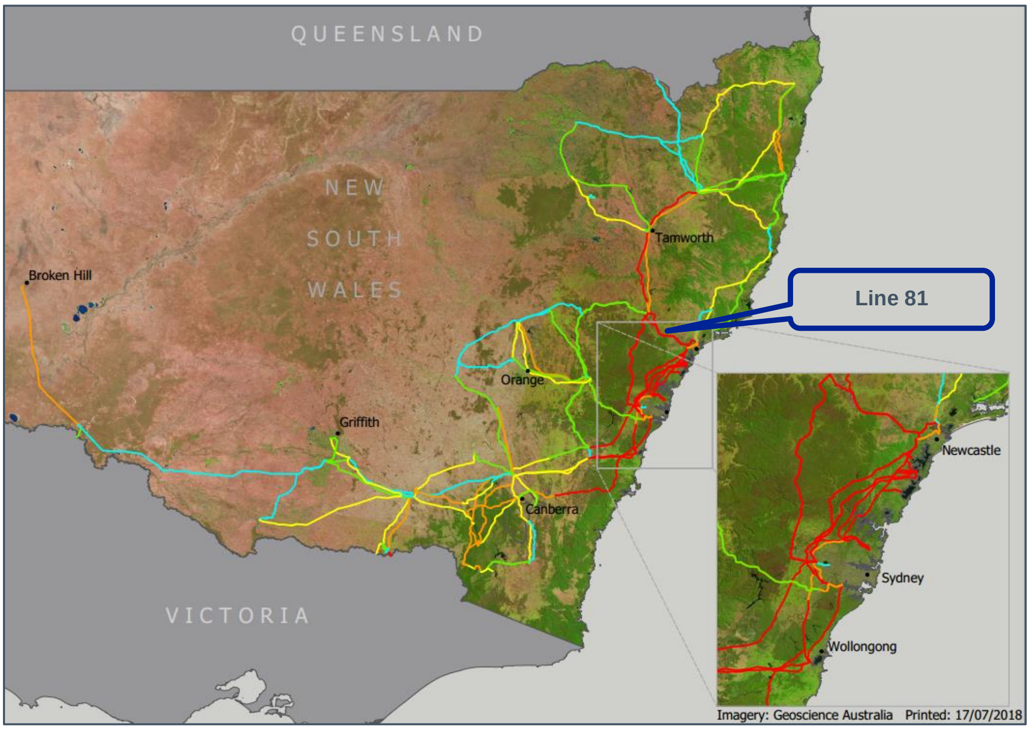
Issue	Cause	Impact
Ground line corrosion of steel at footing	Buried steelwork at footing	Steel corrosion of critical member, can lead to structural failure of tower
Buried concrete foundations	Erosion of soil building up around footings	Accelerated corrosion of critical member
Corrosion of earth strap	Corrosion as buried at footing	Earthing safety hazard
Rusting of tower steel members	Zinc galvanising end of life	Structural failure
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
End of life composite insulators	Cracking, hidden faults.	Flashover (line outage) or Conductor drop
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 Safety and environmental risk costs

Figure 2-11 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 81 is a high risk line. Due to the line's condition and its location near bushland and rural residential areas, the safety and environmental risks associated with this line are considered to be amongst the higher lines in TransGrid's network.

Figure 2-11 TransGrid's line risks heat map



*Line colours on Figure 2-11 represent the level of risk from highest risk to lowest risk respectively: red, orange, yellow, green, and blue.

As stated above, the safety and environmental risk costs is approximately $350,000 per year. This figure is expected to increase over time as the assets continue to deteriorate.

3. Potential credible options

TransGrid considers that there is one feasible option from a technical and project delivery perspective, which is refurbishing Line 81.

This section provides more information on the scope and cost of these options. It also outlines options considered but not progressed and how it is not expected to have a material inter-network impact.

Option 1 described below, remains the preferred option at this final stage of the RIT-T. This option is considered to be both technically and commercially feasible and able to be implemented in sufficient time to meet the identified need. In addition, all works under this option are assumed to be completed in accordance with the relevant standards and components shall be replaced or refurbished with the objective of minimal modification to the wider transmission assets.

This RIT-T may include assets in areas which are currently experiencing ongoing 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.

All costs presented in this PACR are in 2019/20 dollars.

3.1 Base case

The costs and benefits of each option in this PACR were compared against those of a base case[15]. Under this base case, no proactive capital investment is made to remediate the deterioration of Line 81, and the line will continue to operate and be maintained under the current regime. It would be expected that as the line continues to deteriorate, increased reactive corrective maintenance would be required to address defects or asset failures in order to keep the line operating at the required standard.

Routine maintenance costs are approximated at $65,000 per year. The table below provides a breakdown.

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	0.065
Total operating cost	**0.065**

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 safety and environmental risk costs[16].

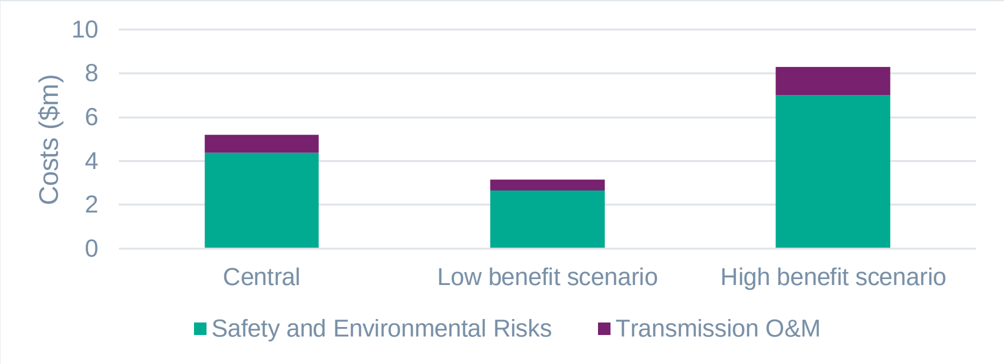
---

[15] 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 1 August 2019. 22. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

[16] 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.

The large safety and 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.

Figure 3-1 Costs forecast under the base case, present value ($m 2019/20)[17]



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 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 product, application of 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 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 and/or member painting
Corrosion of fasteners	> Replacement of fasteners
Corrosion, damage and/or end of life 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

[17] See section 5.45.4 for the assessment approach for the three different scenarios that have been modelled to address uncertainty.

be completed by 2020/21 with minimal modification to the wider transmission assets and in accordance with the relevant standards.

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 $7.8 million ± 25 per cent. The table below provides a breakdown.

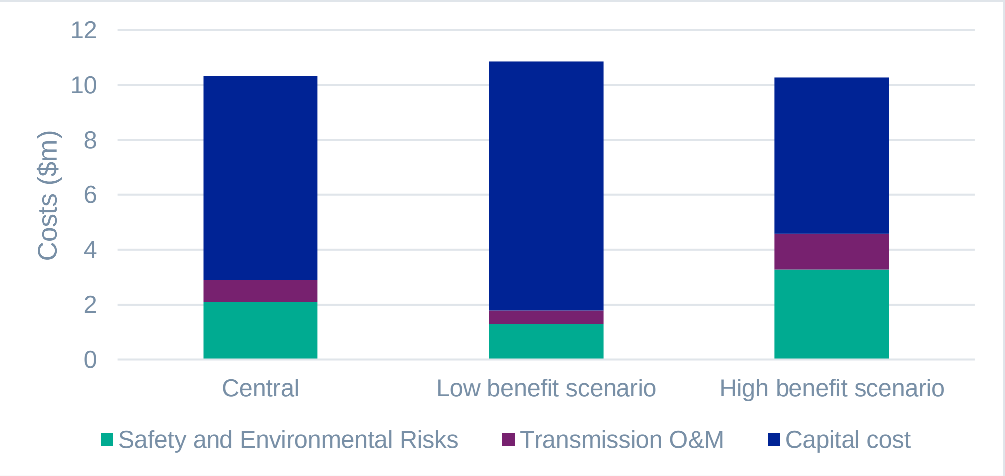
Table 3-3 Capital expenditure breakdown under Option 1 ($m 2019/20)

Item	Capital expenditure ($m)
Transmission tower steelwork remediation	2.3
Insulator and fitting replacement works	3.7
Earthwire replacement	1.8
Total capital cost	**7.8 (+/-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 are 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.

Figure 3-2 Estimated Option 1 costs, present value ($m 2019/20)[18]



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 Option 1.

18 See section 5.4 for the assessment approach for the three different scenarios that have been modelled to address uncertainty.

The table below summarises one other option TransGrid considered as part of this RIT-T. The table also outlines the reasons why Option 2 was not progressed further and has not been explicitly modelled alongside Option 1.

Table 3-4 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[19].

3.4 No material inter-network impact is expected

TransGrid has considered whether the credible options listed above is expected to have material interregional impact.[20] 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:[21]

> 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.

3.5 Non-network options

In the PSCR, 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.

The maximum deferment benefit for Option 1 is valued at approximately $460,000 per year (discount rate 5.90 per cent) compared to the safety and environmental risk costs, approximately $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 safety and bushfire risk related costs. These risk costs

19 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 per cent *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

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

21 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

do not change with the addition of higher levels of non-network options (to the extent where the line is no longer required and decommissioning costs must be considered).

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

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.[22]

4.1 Wholesale electricity market benefits are not material

The AER has recognised that if the credible options considered will not have an impact on the wholesale electricity market, then a number of classes of market benefits will not be material in the RIT-T assessment, and so do not need to be estimated.[23]

TransGrid determines that the credible options 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.

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 network losses. TransGrid considers that none of the classes of market benefits listed are material for this RIT-T assessment for the reasons in Table 5-1.

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

Market benefits	Reason
Changes in involuntary load curtailment	Since Line 81 forms part of a meshed network (N-1 and Modified 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.

22 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.

23 Australian Energy Regulator. "Application guidelines Regulatory Investment Test for Transmission - December 2018." Melbourne: Australian Energy Regulator, 2018.39.Accessed 15 March 2019. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

Market benefits	Reason
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.[24] 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.

[24] Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018. Accessed 15 March 2019.58-59. 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.

5.1 Description of the base case

The costs and benefits of each option in this document are compared against those of a 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 outcome 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. [25]

5.2 General overview of the assessment framework

A 20-year outlook period, from 2019/20 to 2039/40, is 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[26] 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[27].

TransGrid also tested the sensitivity of the results to discount rate assumptions. 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[28], 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 and costing experience from previous projects of a similar nature.

TransGrid estimates that the actual cost is within +/- 25 per cent of the central nominal capital cost.

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

---

[25] 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

[26] 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.

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

[28] 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

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%*
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Safety and environmental risk costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Discount rate	5.90%	8.95%	2.85%

TransGrid considers that the central scenario is most likely since it is 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 a base case. Under the base case, no proactive capital investment is made. Line 81 will not be remediated, the exiting maintenance regime will continue, and the line will continue to operate with an increasing level of risk.

There were no material changes since publication of the PSCR that affect the preference of Option 1.

The analysis presented in the PSCR for this RIT-T was undertaken using an earlier discount rate for the high and low benefit scenario.

All costs presented in this PACR are in 2019/20 dollars.

6.1 Estimated gross benefits

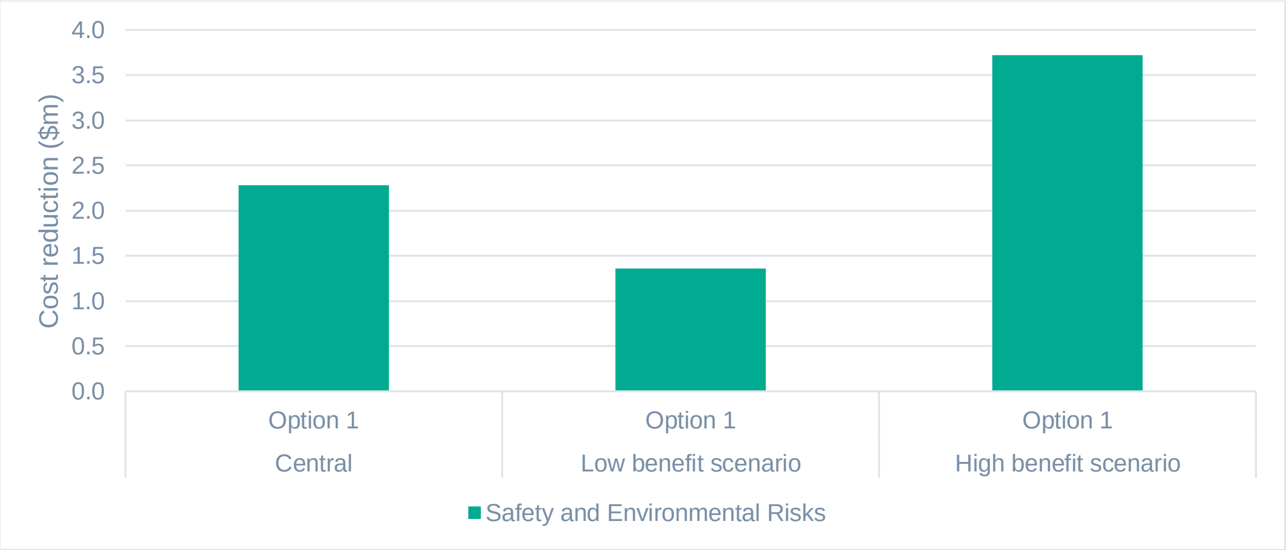
The table below summarises the present value of the gross benefit estimates for each credible option relative to the base case under the three scenarios. There are benefits from avoided costs associated with safety and environmental risks. These expected costs are weighted based on the probability of the event occurring.

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	2.3	1.4	3.7	2.4

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

Figure 6-1 Gross benefits, present value ($m 2019/20)



6.2 Estimated costs

The table below summarises the costs of Option 1, relative to the base case, in present value terms. The cost has been calculated for each of the three reasonable scenarios 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 value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	7.4	9.1	5.7	7.4

6.3 Estimated net economic benefits

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

Table 6-3 Estimated net economic benefits 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	-7.7	-2.0	-5.0

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

6.4 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 to just below the level which the community, government and law would consider risk reduction expenditure to be grossly disproportionate. Figure 6-2 shows the net economic benefit comprised of the risk cost minus the capital cost, with the disproportionality factor applied to the risk costs.

Figure 6-2 As Low as Reasonably Practicable Test, present value ($m 2019/20)

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

6.5 Summary of ALARP Benefit Tests

Table 6-4 summarises the outcomes of the net economic benefit under ALARP tests. Option 1 is preferred under the ALARP principle.

This preferred option is found to have positive net benefits under most scenarios investigated. TransGrid notes that the low net economic scenario which delivers a negative benefit is comprised of an extreme combination of low safety and environmental risks estimates and high capital costs.

Table 6-4 Summary of net economic benefits under ALARP tests, present value ($m 2019/20)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	6.3	-0.9	16.6	7.1

6.6 Sensitivity testing under ALARP

TransGrid has undertaken 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 the key findings is outlined below.

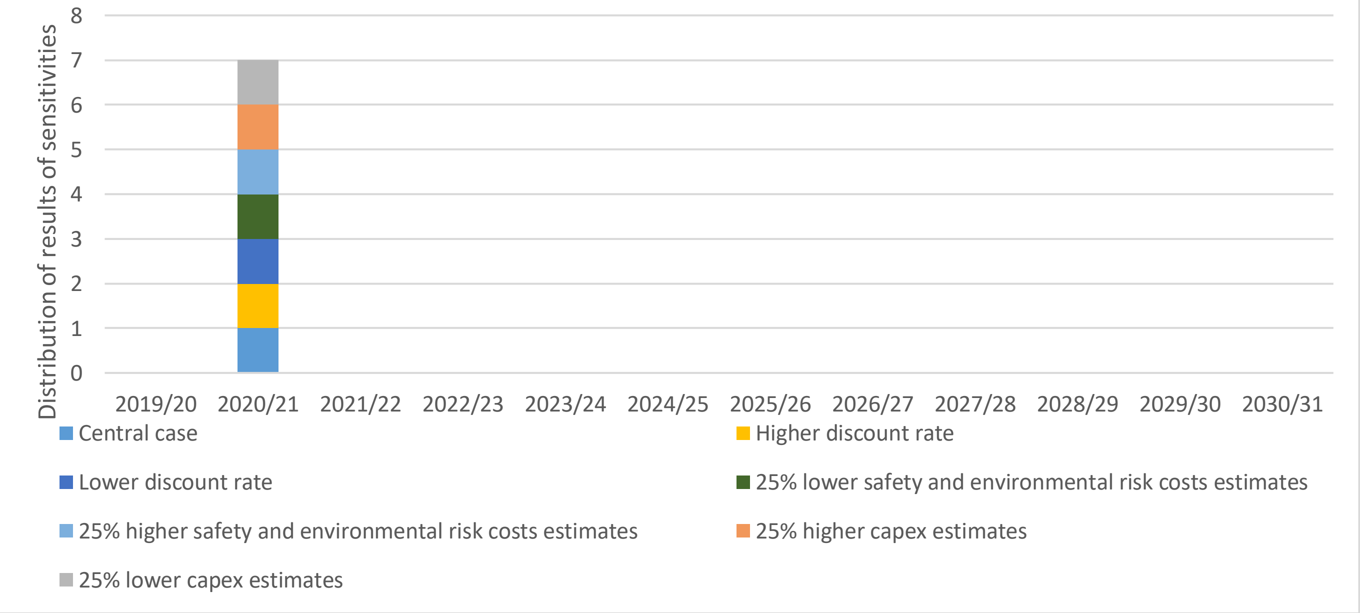
6.6.1 Step 1 – Sensitivity testing of the optimal timing

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 2020/21 for all of the sensitivities investigated.

Figure 6-3 Optimal timing of Option 1



6.6.2 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:

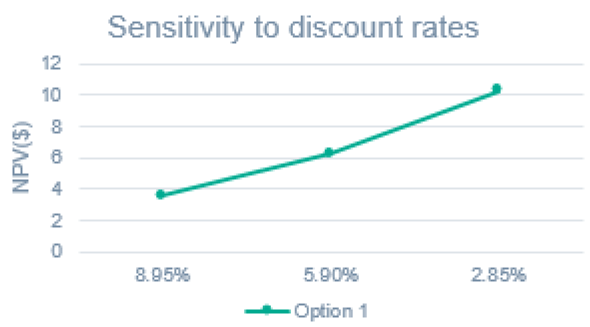
> a 25 per cent increase/decrease in the assumed network capital costs
> lower discount rate of 2.85 per cent as well as a higher rate of 8.95 per cent
> lower (or higher) assumed safety and environmental risk.

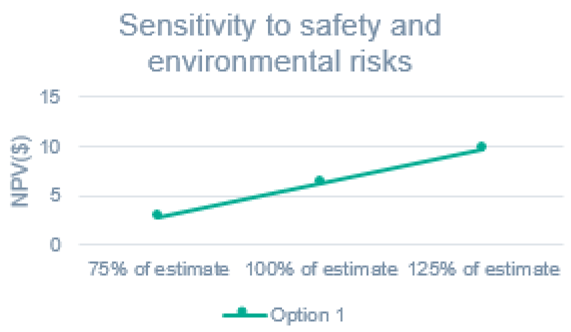
All these sensitivities investigate the consequences of 'getting it wrong' having committed to a certain investment decision.

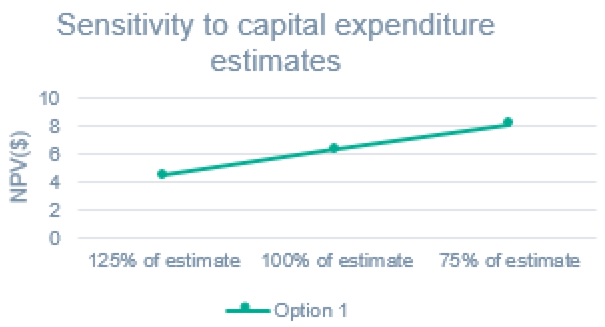
The figures below illustrate the estimated net market benefits for each option if four separate key assumptions in the central scenario are varied individually. Importantly, for all sensitivity tests shown below, the estimated net benefits of Option 1 are found to be positive.

Figure 6-4 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 6-4 Sensitivities of net present value using the ALARP test







7. Final conclusion on the preferred option

The optimal commercially and technically feasible option presented in the PSCR – Option 1 (refurbishment of Line 81) – remains the preferred option to meet the identified need. Option 1 can be implemented in sufficient time to meet the identified need by 2022/23, and is therefore the preferred option presented in this PACR.

The estimated capital expenditure associated with this option is $7.8 million +/- 25 per cent. Routine operating and maintenance costs are approximately $65,000 per year in 2019/20 prices – similar to the cost under the base case. TransGrid calculates that the avoided risk costs by undertaking Option 1 is approximately $197k per year. Further, a reduction in reactive corrective maintenance costs is also expected.

This preferred option, Option 1, whilst having negative net benefits under most scenarios investigated, still falls within the risk benefit threshold once the ALARP disproportionality factors are considered. 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, that the costs of mitigating the bushfire risks is less than the disproportionate risk benefit expected from refurbishing Line 81.

Moving forward with this option is the most prudent and economically efficient solution to manage and mitigate bushfire and safety risk to the As Low As Reasonably Practical (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 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.

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 132.

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.[29]

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:

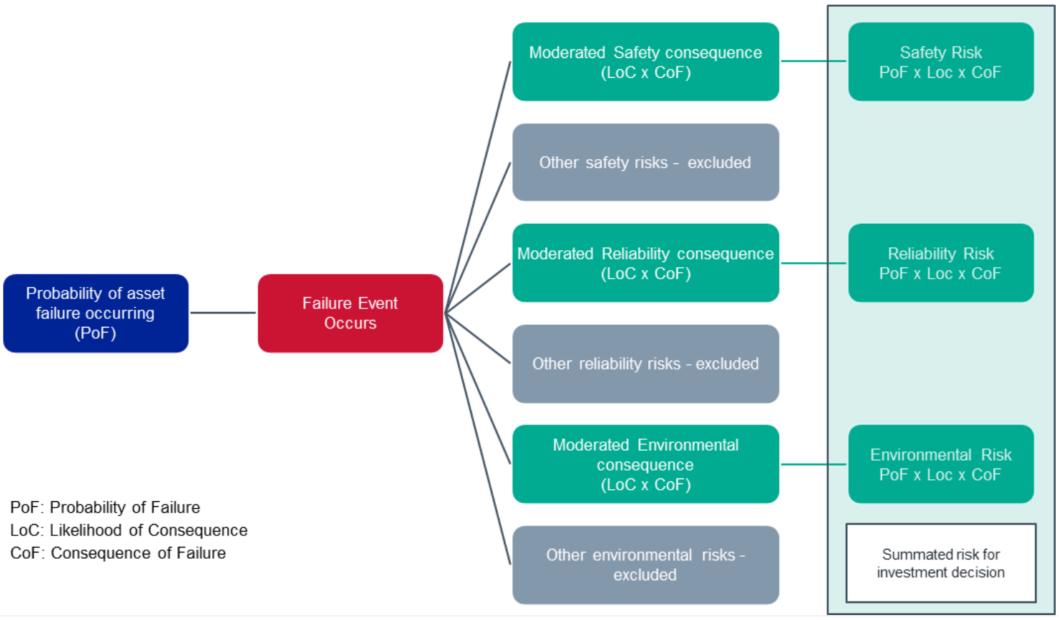
> uses externally verifiable parameters to calculate asset health and failure consequences
> assesses and analyses asset condition to determine remaining life and probability of failure
> applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence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

B.1 Overview 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).

In calculating the PoF, each failure mode that could result in significant impact is considered. For replacement

29 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

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.