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Managing risk on Line 23

RIT-T Project Assessment Conclusions Report

Issue date: 8 August 2023

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Executive summary

We are applying the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating safety, environmental (bushfire) and financial (high reactive maintenance) risks caused by the deteriorating condition of some components on the 330 kV line running between the Vales Point and Munmorah substations on the Central Coast ('Line 23'). Publication of this Project Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

Line 23 is a single-circuit 330 kV, steel tower transmission line with a route length of 7 km that was constructed in 1965. Line 23 is comprised of 24 structures:

- 12 suspension towers;
- 11 tension towers; and
- 1 wood pole suspension structure.

The line is a key link in the Central Coast transmission network and its route traverses rural areas near the Vales Point and Colongra power stations around Lake Macquarie.

Condition information has identified that majority of the structures on Line 23 either have condition issues, or the components on them have condition issues. Affected components include the conductor, conductor fittings, corona rings, earth wire (and its fittings) and porcelain insulators. These structures and components require refurbishment to address asset health and maintain appropriate risk levels across the network.

Many of the condition issues on Line 23 are due to corrosion. Corrosion greatly increases the likelihood of conductor drops and presents consequent safety and bushfire risk to our personnel and the public, as well as resulting in reactive maintenance costs to repair the failed elements. The bushfire risks are exacerbated for the line in question as they traverse substantial sections of bushland, much of which surrounds rural residential areas. Line 23 also crosses the Pacific Highway at Doyalson, which raises the safety risks.

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

Identified need: managing risks on Line 23 transmission line

If action is not taken, the condition of the line is expected to expose us and our customers to increasing levels of risk going forward, as the likelihood of failure increases. There are significant safety and bushfire risks under the 'do nothing' base case, as well as higher expected costs associated with reactive maintenance that may be required under emergency conditions ('financial risks').

The proposed investment will enable us to manage safety, environmental and financial risks on Line 23.

Options considered under this RIT-T have been assessed relative to a base case. Under the base case, no proactive capital investment is made and the condition of the line will continue to deteriorate.

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

We manage and mitigate risks to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with our obligations under the *New South Wales Electricity Supply (Safety and Network Management) Regulation 2014* and our Electricity Network Safety Management System (ENSMS).[1]

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

No submissions received in response to the Project Specification Consultation Report

We published a Project Specification Consultation Report (PSCR) on 14 March 2023 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. In addition, no material changes have occurred since the PSCR that have made an impact on the preferred option.

Credible options considered

We consider there are two credible options that would meet the identified need from a technical, commercial, and project delivery perspective.[2] These are summarised in Table E-1

Table E-1 Summary of credible options, $2021/22

Option	Description	Capital costs, $m	Operating costs (per year), $
Option 1	Replace suspension structures that have priority condition issues and remediate all line components on tension structures	12.3	10,120
Option 2	Replace all suspension structures and remediate all line components on tension structures	13.4	10,120

Both options are not expected to affect annual routine operating costs (i.e., the amounts shown above are the same as under the base case) since they do not affect the frequency of inspections. They do however affect the reactive maintenance costs relative to the base case (which are reflected in reduced 'financial risk costs').

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

We do 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

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

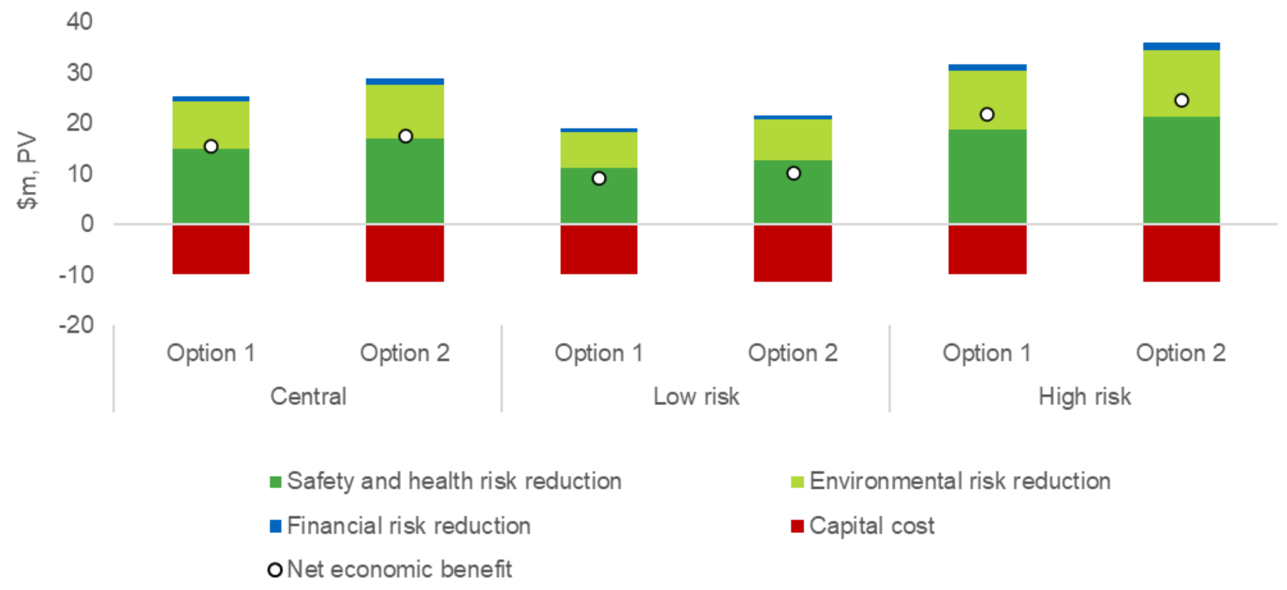
2 As per clause 5.15.2(a) of the NER.

(bushfire) risk posed as a result of corrosion-related asset deterioration. In addition, we did not receive any submissions from proponents of these solutions in response to the PSCR.

Conclusion: replacement of all suspension structures and remediation of all line components is optimal

Under all scenarios, the costs of mitigating the risks under both options are found to be significantly outweighed by the expected benefit of avoiding the risks. Option 2 is the preferred option with the estimated net benefits of Option 2 being 12 per cent greater than Option 1 on a weighted basis.

Figure E-1 Net economic benefits ($m, PV)



Option 2 (replacing all suspension structures and remediate all line components on tension structures) is therefore the preferred option to meet the identified need for this RIT-T. Moving forward with this option is the most prudent and economically efficient solution to manage and mitigate safety and environmental risk to ALARP. Consequently, it will ensure our obligations under the *New South Wales Electricity Supply (Safety and Network Management) Regulation 2014* and our Electricity Network Safety Management System (ENSMS) are met.

The estimated capital expenditure associated with this option is $13.4 million +/- 25 per cent. Routine operating and maintenance costs relating to planned checks by our field crew are estimated at approximately $10,120 per year (which is the same as under the base case and the other option considered). We calculate that the avoided risk cost by undertaking Option 2 ranges from approximately $1.2 million per year to $6.5 million per year in real terms over the assessment period.

Option 2 is found to have positive net benefits under all scenarios investigated and, on a weighted basis, will deliver $17.4 million in net economic benefits.

The required works for Option 2 would be undertaken between 2022/23 and 2024/25. All works will be completed in accordance with the relevant standards by 2025/26 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.

Next steps

This PACR represents the final step of the consultation process in relation to the application of the Regulatory Investment Test for Transmission (RIT-T) process undertaken by Transgrid.

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

- the estimated capital cost of the preferred option being less than $46 million;
- the PSCR stating:
  - the proposed preferred option, together with the reasons for the proposed preferred option;
  - the RIT-T is exempt from producing a PADR; and
  - the proposed preferred option and any other credible options will not have a material market benefit for the classes of market benefit specified in clause 5.15A.2(b)(4), with the exception of market benefits arising from changes in voluntary and involuntary load shedding;
- no PSCR submissions identifying additional credible options that could deliver a material market benefit; and
- the PACR addressing any issues raised in relation to the proposed preferred option during the PSCR consultation (noting that no issues have been raised).

Parties wishing to raise a dispute notice with the AER may do so prior to 8 September 2023 (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 RIT-T can be obtained from Transgrid's Regulation team via regulatory.consultation@transgrid.com.au. In the subject field, please reference 'Line 23 PACR'.

Contents

1. Introduction

This Project Assessment Conclusions Report (PACR) represents the final step in the application of the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating the risks caused by the deteriorating condition of certain components of the 330 kV line running between Vales Point and Munmorah substations on the Central Coast ('Line 23').

We manage and mitigate bushfire and safety risk to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with our obligations under the *New South Wales Electricity Supply (Safety and Network Management) Regulation 2014* and our Electricity Network Safety Management System (ENSMS).

This RIT-T therefore examines options for addressing the asset condition issues so that network safety continues to meet a risk mitigation level of ALARP. Consequently, it is considered a reliability corrective action under the RIT-T.

1.1. Purpose of this report

The purpose of this PACR[3] is to:

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

Overall, this report provides transparency into the planning considerations for investment options to ensure continuing reliable supply to our customers. A key purpose of this PACR is to provide interested stakeholders the opportunity to review the analysis and assumptions and have certainty and confidence that the preferred option has been robustly identified as optimal.

1.2. No submissions received in response to the Project Specification Consultation Report and there have been no material developments

We published a Project Specification Consultation Report (PSCR) on 14 March 2023 and invited written submissions on the material presented within the document. No submissions were received in response to the PSCR.

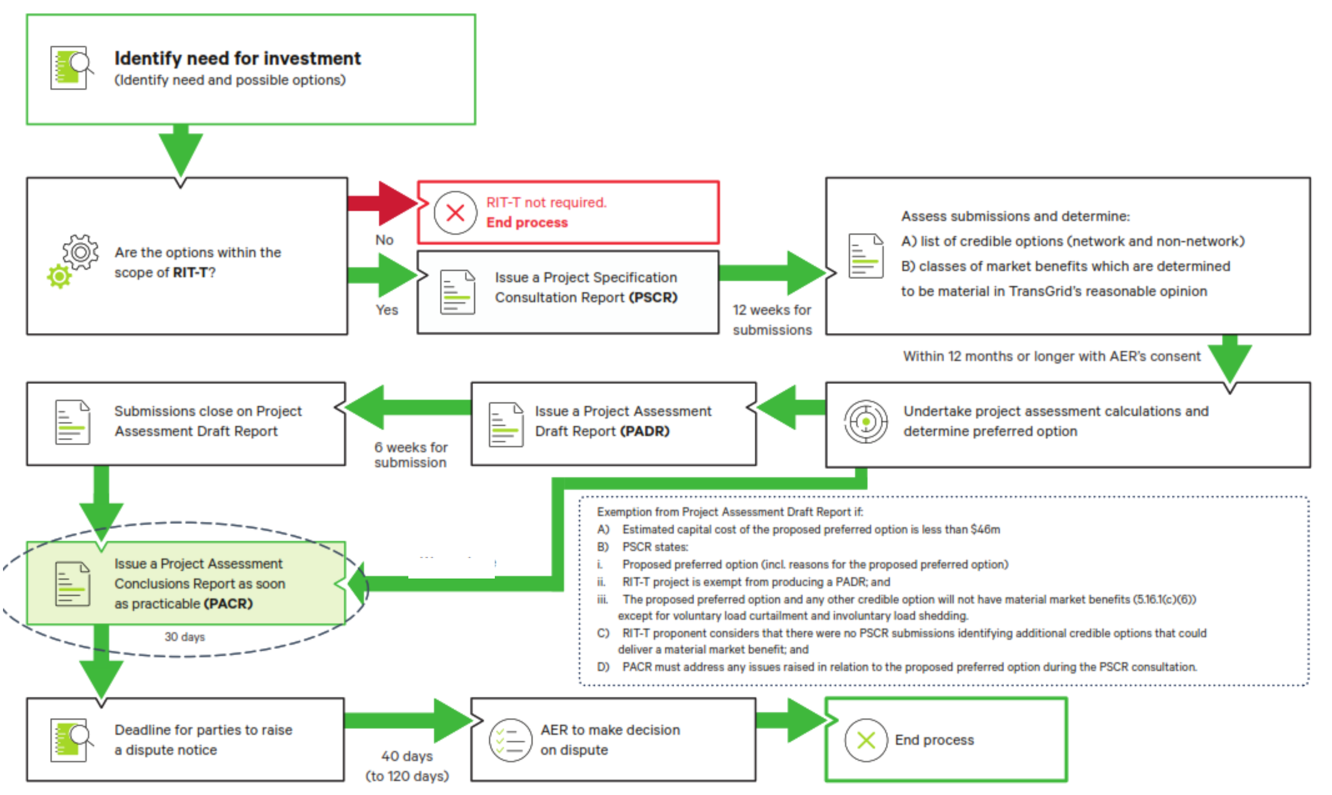
In addition, no additional credible options were identified during the consultation period following publication of the PSCR. No other material changes have occurred since the PSCR that have made an impact on the preferred option.

1.3. Next steps

This PACR represents the final step of the consultation process in relation to the application of the RIT-T process undertaken by Transgrid.

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

Figure 1-1 This PACR is the final stage of the RIT-T process[4]



Parties wishing to raise a dispute notice with the AER may do so prior to 8 September 2023 (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 RIT-T can be obtained from Transgrid's Regulation team via regulatory.consultation@transgrid.com.au . In the subject field, please reference 'Line 23 PACR'.

[4] Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.

2. The identified need

This section outlines the identified need for this RIT-T, as well as the assumptions and data underpinning it. It first sets out background information related to Line 23.

2.1. Background to the identified need

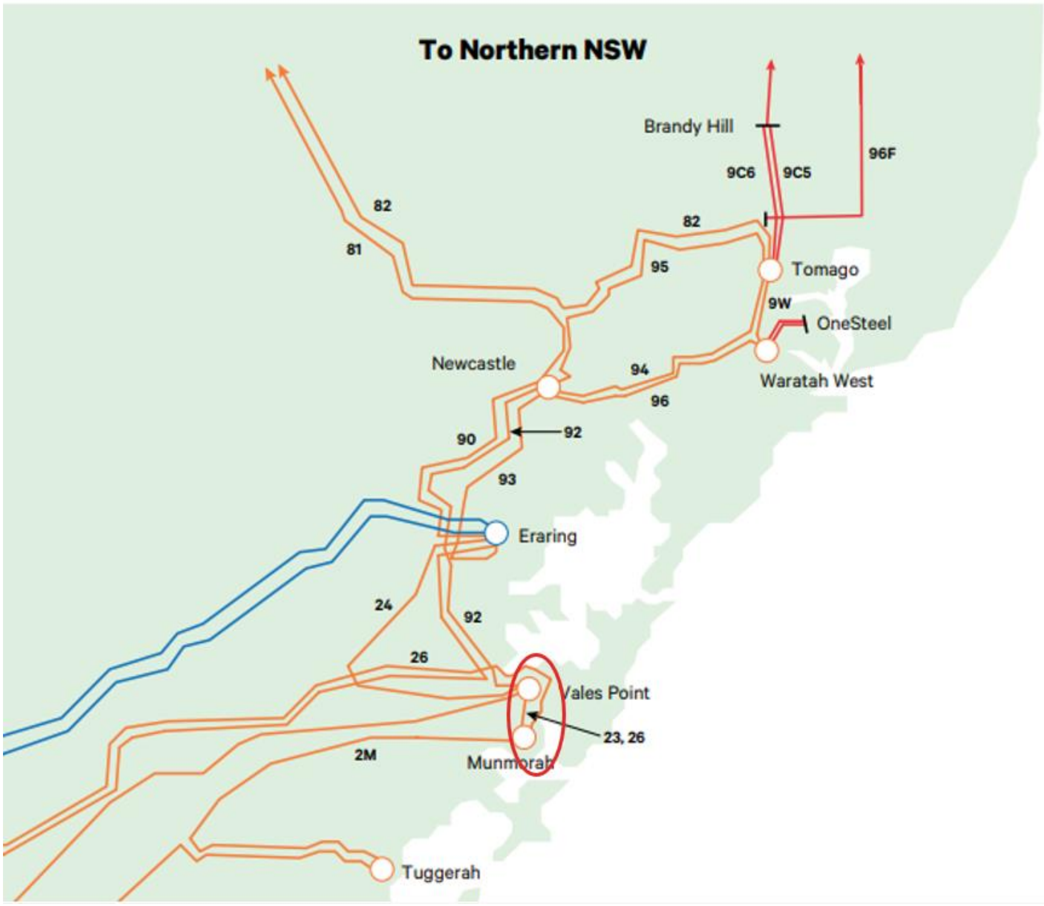
Line 23 is a 330 kV, steel tower transmission line that connects the Munmorah and Vales Point substations with a route length of 7 km. Constructed in 1965, there are 24 structures on this single circuit line:

- 12 suspension towers;
- 11 tension towers; and
- 1 wood pole suspension structure.

Line 23 is a key link in the Central Coast region, and its route traverses rural areas near the Vales Point and Colongra power stations near Lake Macquarie. It also crosses the Pacific Highway at Doyalson North.

Figure depicts the location of Line 23 in our Central Coast network.

Figure 2-1 Location of Line 23



Line 23 will continue to play a central role in supporting the flow of energy to take advantage of naturally-diverse weather patterns, and in the safe and reliable operation of the power system throughout and after the transition to a low-carbon electricity future.

As part of our ongoing routine asset monitoring maintenance, we have identified that many of the components of Line 23 are corroded and/or at the end of their lives, including the conductor, conductor fittings, corona rings, earth wire (and its fittings) and porcelain insulators.

Corrosion greatly increases the likelihood of conductor drops and presents consequent safety and bushfire risk to our personnel and the public. While this is the case for any corroded elements of the transmission network, the bushfire risks are exacerbated for Line 23 as the line traverses substantial sections of bushland, much of which surrounds rural residential areas. As noted above, Line 23 also crosses the Pacific highway at Doyalson and so has heightened safety consequences.

Line 23 traverses bushland areas that were subject to bushfires in 2013. The line also traverses rural residential areas in Doyalson North, Chain Valley Bay, and Kingfisher Shores which increases how often the public interact with our infrastructure. This highlights the high criticality of the line and the need to manage the risks associated with asset failure.

Detailed analysis of asset condition information has identified that 23 of the 24 structures on Line 23 either have condition issues, or the components on them have condition issues, which require refurbishment to address asset health and maintain appropriate risk levels across the network.

Of the 24 structures on Line 23, all 12 suspension towers have been identified as having condition issues, primarily related to corrosion. Of these, eight of the towers have been identified has having priority condition issues; that is, the tower has one or more members that have been identified as having a condition issue with the worst possible rating. This greatly increases the likelihood of transmission structure failures, conductor drop, and subsequent bushfire and safety risks.

Figure illustrates the two key sets of towers on Line 23 with condition issues.

Figure 2-2 Line 23 tension tower (lefthand side) and suspension tower (righthand side)

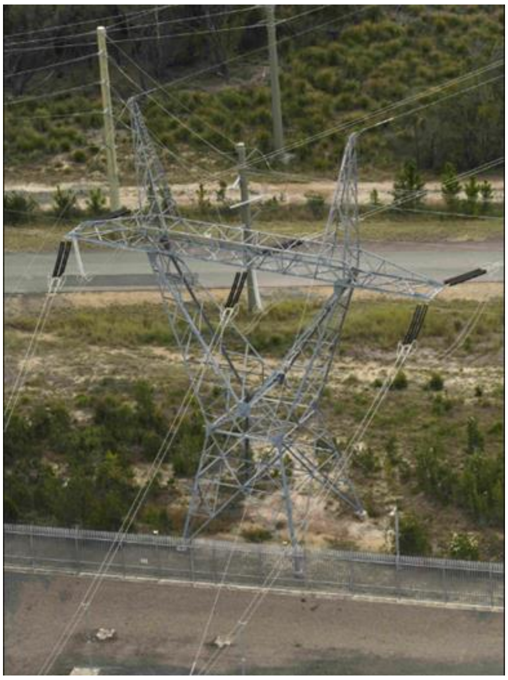


Figure and Figure below provide illustrative examples of the condition of various components of the suspension towers.

Figure 2-3 Corroded tower members

Figure 2-4 Corroded bolt and buts of spacers

No condition issues have been identified on the Line 23 tension towers as these have recently been refurbished. However, condition issues have been identified on components of the line linked to these tension towers (mostly where the components have reached the end of their serviceable lives).

Figure and Figure below demonstrate examples of the condition of various components of the tension towers.

Figure 2-5 ‘Hotspots’[5] in the palm joint of conductors

[5] ‘Hotspots’ refer to conductor/earthwire connections which have degraded and now have a high electrical resistance, leading to high relative temperatures at these connections which can lead to conductor failure.

Figure 2-6 Hotspots' in the earth peak

There is one non-standard wood pole structure on Line 23, originally designed to assist in any future line re-arrangements at the substation. When considering the structure's health, criticality, consequence of failure and reduced resilience to bushfire, we consider it prudent to have this structure replaced with a concrete or steel structure (and have included this replacement in both options).[6] This also aligns with the standard design for this type of structure used across Transgrid's network.

2.2. Description of the identified need

The proposed investment will enable us to manage safety and environmental risks on Line 23. Options considered under this RIT-T have been assessed relative to a base case. Under the base case, no proactive capital investment is made and the condition of Line 23 will continue to deteriorate.

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

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

The proposed investment will enable us 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

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6 We note that the nominal life of a hardwood pole is 63 years and the assumed install date of this pole is 1963 (sixty years ago). This particular pole is also a single pole guyed structure so is considered a higher risk structure. It is located within bushfire prone land and so its failure would lead to high bushfire consequence (and we note that wood pole structures are less resilient to bushfire).

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

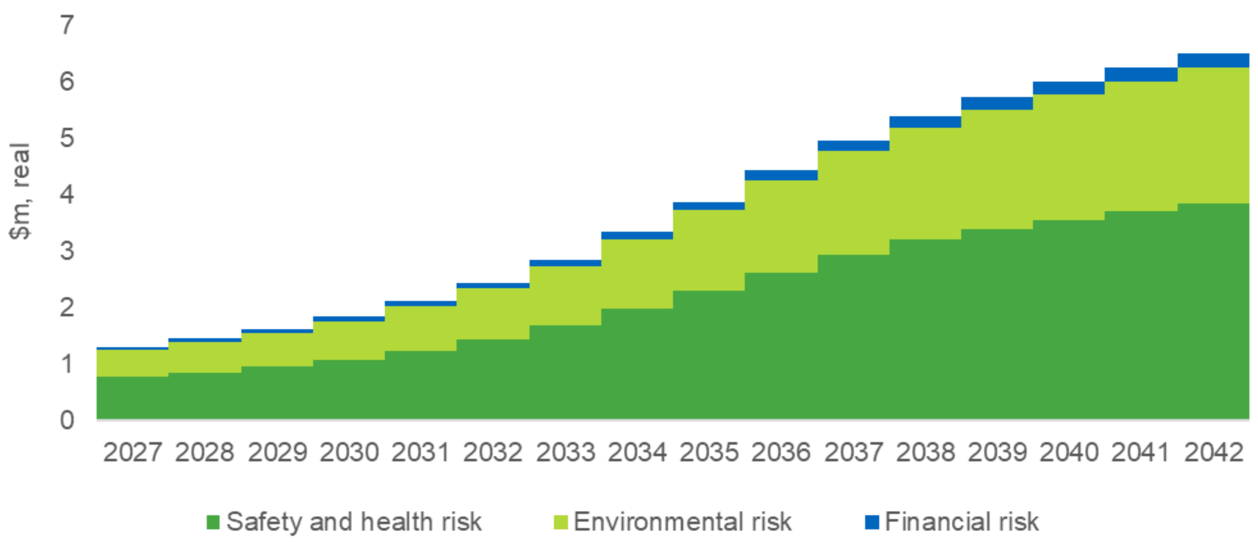
option is permitted to have negative net economic benefits on account of it being required to meet an externally imposed obligation on the network business.

2.3. Assumptions underpinning the identified need

We adopt a risk cost framework to quantify and evaluate the risks and consequences of increased failure rates. Appendix B provides an overview of our Risk Assessment methodology.

Figure 2-3 summarises the increasing risk costs over the assessment period under the base case.

Figure 2-3 Estimated risk costs



This section describes the assumptions underpinning our assessment of the risk costs, ie, the value of the risk avoided by undertaking investment. The aggregate risk cost under the base case is currently in 2023 is estimated at around $896,256/year and it is expected to increase going forward if action is not taken and the line is left to deteriorate further (reaching approximately $1.8 million/year by 2030 and $6.5 million/year by the end of the 20-year assessment period).

2.3.1. Asset health and the probability of failure

Our asset health modelling aligns with Chapter 5.2 of the AER's asset replacement planning guideline.[8] Condition information for each asset is assessed to generate an Asset Health Index and assets in relatively poor condition, as identified through the asset health index, are candidates for a replacement or refurbishment intervention.

The asset health issues identified on Line 23 is summarised in Table 2-1.

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8 AER, *Industry practice application note – Asset replacement planning*, January 2019 – available at https://www.aer.gov.au/system/files/D19-2978%20-%20AER%20-Industry%20practice%20application%20note%20Asset%20replacement%20planning%20-%2025%20January%202019.pdf

Table 2-1: Asset health issues along Line 23 and their consequences

<table>
<tr><th>Issue</th><th>Consequences if not remediated</th></tr>
<tr><td>Corrosion of conductor fittings</td><td rowspan="5">Bushfire resulting in potential loss of property and/or life
Safety incident resulting in potential injury or death
Line outage with potential network reliability impacts</td></tr>
<tr><td>Corrosion of corona rings</td></tr>
<tr><td>Deteriorated earthwire due to corrosion</td></tr>
<tr><td>Corrosion of earthwire fittings</td></tr>
<tr><td>Porcelain insulators deteriorated and at end of life</td></tr>
<tr><td>Poor connection and bird caging of earthwire bonding</td><td>Safety incident resulting in potential injury or death</td></tr>
</table>

Asset health is used to estimate the remaining life of an asset and forecast the associated probability of failure (PoF) of the asset now and into the future. The future health of an asset (health forecasting) is a function of its current health and any factors causing accelerated (or decelerated) degradation or ‘age shifting’ of one or more of its components. Such moderating factors can represent the cumulative effects arising from continual or discrete exposure to unusual events, external stresses, overloads and faults.

Asset condition information is the primary source of information on the current health of the transmission line and its components. Condition information obtained through routine inspections of transmission lines, such as condition rating of each component, and asset information, such as natural age, location and ideal life expectancy, form the basis for deriving current health.

The PoF is the likelihood that an asset will fail during a given period resulting in a particular adverse event. The probability of each failure mode is calculated using reliability engineering techniques that take into account conditional age (chronological age moderated by asset health), failure and defect history, and industry benchmarking studies. We screen out failures that are not related to end-of-life when quantifying risk for replacement projects because such risks are not addressed by these works.

Defect and condition information for each structure on the line were analysed to assess the level of degradation expected by effective service life. Functional failure statistics were then used by a subject matter expert to estimate the rate of decay, using the relevant corrosion rates from AS 4312 and actual historical asset failure and performance data. Catastrophic PoF curves were then constructed for each line component, represented as a two parameter Weibull equation.

The outputs of the PoF calculation are a PoF time series that provides a mapping between the effective age, discussed above, and the yearly PoF value. This analysis is performed by generating statistical failure curves, normally using Weibull analysis, to determine a PoF time series set for each asset that gives a PoF for each further year of asset life.

2.3.2. Safety risk

This risk refers to the safety consequence to our workforce, contractors and/or members of the public of an asset failure whose failure modes can create harm. The estimated value takes into account the cost associated with a fatality or injury including compensation, loss of productivity, litigation fees, fines and any other related costs.

Our safety model has recently been updated and developed in conjunction with asset management specialist consultancy AMCL[9]. The main changes to the model relate to consequence and likelihood quantifications with our safety risk now considering a range of consequences, from minor injury to fatality, and the likelihood of each based on historical events, human movement data and land use.

Consistent with our ALARP obligations, we apply a disproportionality factor of 'six' to the public safety component and 'three' to the worker safety component of safety risk.

Safety risk is the largest of all risks quantified under the base case for this RIT-T, making up 59 per cent of the total estimated risk cost in present value terms.

2.3.3. Bushfire risk

This risk refers to the consequence to the community of an asset failure that results in a bushfire starting. We have recently undertaken assessment with the University of Melbourne[10] to improve our quantification of bushfire risks across our network, including the moderation of risk costs, using an electricity industry-developed approach.

The bushfire risk model:

- models the potential spread from a fire started at each asset in the network using recognised fire modelling software;
- calculates the consequence based on the number of houses, agricultural and forestry land use (and other infrastructure in the predicted burn area);
- moderates the consequence using a statistical distribution of fire conditions across the year to come up with a most likely consequence to be used in the investment decision;
- moderates this likely consequence by the likelihood of network assets igniting a fire in the event a catastrophic asset failure occurs (i.e., not all asset failures will ignite a fire); and
- further moderates this likely consequence taking into account the expected emergency services response to a fire based on the proximity to population (i.e., locations close to population centres have the highest moderation of likely consequence as the emergency services response is expected to be relatively expeditious).

Consistent with our ALARP obligations, we apply a disproportionality factor of 'six' to the safety component of bushfire risk (ie, loss of life).

Bushfire risk is the second largest of all risks quantified under the base case for this RIT-T, making up approximately 37 per cent of the total estimated risk cost in present value terms.

2.3.4. Financial risk

This risk refers to the direct financial consequence arising from the failure of an asset including the cost of replacement or repair of the asset (reactive maintenance) which may need to be under emergency conditions.

Financial risk is the lowest of all risks quantified under the base case for this RIT-T, making up 4 per cent of the total estimated risk cost in present value terms.

[9] Refer to Network Asset Criticality Framework
[10] Refer to Network Asset Criticality Framework

3. Potential credible options

This section describes the options we have explored to address the need, including the scope of each option and the associated costs.

We consider that there are two feasible options from a technical, commercial, and project delivery perspective that can be implemented in sufficient time to meet the identified need. Four other options were considered but not progressed for reasons for various reasons that are outlined in Table 3-1.

All costs and benefits presented in this PACR are in 2021-22 dollars, unless otherwise stated.

3.1. Base case

The costs and benefits of each option in this PACR are compared against those of a base case.[11] Under this base case, no proactive capital investment is made to remediate the deterioration of the identified assets and Line 23 will continue to operate and be maintained under the current regime.

While the base case is not a situation we plan to encounter, and this RIT-T has been initiated specifically to avoid it, the assessment is required under the RIT-T to use this base case as a common point of reference when estimating the net benefits of each credible option.

The regular maintenance regime will not be able to mitigate the risk of asset failure that will expose us and end-customers to approximately $1.8 million per year in safety, environmental and financial risk costs by 2030, rising to $6.5 million per year by the end of the assessment period.[12] The environmental and safety risk costs are mainly due to the significant consequences of a bushfire event resulting from conductor drop or structure failure and risks associated with compromised earthing. Under the base case, all of these risks will continue to increase.

The annual transmission line routine operating expenditure under the base case is $10,120. We do not expect this to change with any of the investment options being considered, since the options will not change the frequency of planned inspections (however, the reactive maintenance costs do differ and are captured under financial risks).

3.2. Option 1 – Replace suspension structures that have priority condition issues and remediate all line components on tension structures

Option 1 involves:

- replacement of all suspension structures on Line 23 that have been identified as having priority condition issues (9 in total) with concrete or steel pole structures, including the non-standard wood pole structure;
- remediation of all line components that have identified condition issues; and
- replacing all phase conductors and earthwires.

[11] Transgrid notes that the August 2020 AER RIT-T Guidelines (p. 21) 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.

[12] This determination of yearly risk costs is based on our 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 works are estimated to take 24 months to complete. Project completion is assumed in 2025/26.

All works would be completed in accordance with the relevant standards by 2025/26 with minimal modification to the wider transmission assets. Necessary outages of affected line(s) in service would be planned appropriately in order to complete the works with minimal impact on the network.

The estimated capital expenditure associated with this option is $12.3 million.

This option has the lowest estimated risk reduction of the two options due to it being a 'minimal scope' option designed to only address the components that have experienced the greatest deterioration to prevent failure in the short term.

3.3. Option 2 – Replace all suspension structures and remediate all line components on tension structures

Option 2 involves:

- replacement of all suspension structures on Line 23 with concrete or steel pole structures, including the non-standard wood pole structure;
- remediation of all line components on tension structures that have identified condition issues based on the latest Transmission Line Refurbishment Criteria document; and
- replacing all phase conductors and earthwires.

The works are estimated to take 26 months to complete. Project completion is assumed in 2025/26.

All works would be completed in accordance with the relevant standards by 2025/26 with minimal modification to the wider transmission assets. Necessary outages of affected line(s) in service would be planned appropriately in order to complete the works with minimal impact on the network.

The estimated capital expenditure associated with this option is $13.4 million.

This option has a greater estimated risk reduction than Option 1 due to it addressing all identified components with condition issues.

3.4. Options considered but not progressed

Table 3-1 summarises the reasons the following credible options were not progressed further.

Table 3-1 Options considered but not progressed

Description	Reason(s) for not progressing
Increased inspections	The condition issues have already been identified and cannot be rectified through increased inspections. This option is therefore not technically feasible.
Elimination of all associated risk	This can only be achieved through retirement and decommissioning of the associated assets. This option is therefore not technically feasible.
New transmission line	Replacement with a new double circuit 330 kV transmission line would incur significant costs, without a commensurate increase in benefits. This option is therefore not considered commercially feasible.
Non-network solutions	We do not consider non-network options to be commercially and technically feasible to assist with meeting the identified need, as non-network options will not mitigate the safety and environment (bushfire) risks posed as a

	result of corrosion-related asset deterioration. This was outlined in section 4 of the PSCR in more detail.

3.5. No material inter-network impact is expected

We have considered whether the credible option listed above is expected to have material inter-regional impact.[13] A 'material inter-network impact' is defined in the NER as:

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

AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following:[14]

- 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; and
- the investment does not involve either a series capacitor or modification in the vicinity of an existing series capacitor.

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

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

[14] 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 14 May 2020. https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf

4. Materiality of market benefits

This section outlines the categories of market benefits prescribed in the National Electricity Rules (NER) and whether they are considered material for this RIT-T.[15]

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.[16]

The credible options considered in this RIT-T will not address network constraints between competing generating centres and are therefore not expected to result in any change in dispatch outcomes and wholesale market prices. We therefore consider 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; and
- 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 5.15A.2(4) requires that we consider the following classes of market benefits, listed in Table 4-1, arising from each credible option. We consider that none of the classes of market benefits listed are material for this RIT-T assessment for the reasons in Table 4-1.

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

Market benefits	Reason
Changes in involuntary load curtailment	Since Line 23 forms part of a meshed network (with an N-1 level of redundancy) required to supply the Central Coast, a failure of one line due to condition issues results in a negligible 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 other network expenditure from any of the options considered.

[15] The NER requires that all classes of market benefits identified in relation to the RIT-T are included in the RIT-T assessment, unless the TNSP can demonstrate that a specific class (or classes) is unlikely to be material in relation to the RIT-T assessment for a specific option – NER clause 5.15A.2(5). See Appendix A for requirements applicable to this document.

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

Market benefits	Reason
Option value	We note 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.[17] We also note 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. We note that no credible option is sufficiently flexible to respond to change or uncertainty for this RIT-T. Specifically, each option is focused on proactively replacing deteriorating assets ahead of when they fail.

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

5. Overview of the assessment approach

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

5.1. Description of the base case

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

We note that this course of action is not expected in practice. However, this approach has been adopted since it is consistent with AER guidance on the base case for RIT-T applications.[18]

5.2. Assessment period and discount rate

A 20 year assessment period from 2022/23 to 2041/42 has been adopted for this RIT-T analysis. This period takes into account the size, complexity and expected asset life of the options.

Where the capital components of the credible options have asset lives extending beyond the end of the assessment period, the NPV modelling includes a terminal value to capture the remaining asset life. This ensures that the capital cost of long-lived options over the assessment period is appropriately captured, and that all options have their costs and benefits assessed over a consistent period, irrespective of option type, technology or asset life. The terminal values are calculated as the undepreciated value of capital costs at the end of the analysis period.

A real, pre-tax discount rate of 5.50 per cent has been adopted as the central assumption for the NPV analysis presented in this PACR, consistent with the assumptions adopted in AEMO's 2022 Integrated System Plan (ISP).[19] The RIT-T requires that sensitivity testing be conducted on the discount rate and that the regulated weighted average cost of capital (WACC) be used as the lower bound. We have therefore tested the sensitivity of the results to a lower bound discount rate of 3.21 per cent.[20] We have also adopted an upper bound discount rate of 7.50 per cent (ie, the upper bound proposed for the 2022 ISP).[19]

5.3. Approach to estimating option costs

We have estimated the capital costs of the options based on the scope of works necessary together with costing experience from previous projects of a similar nature.

[18] We note that the AER RIT-T Guidelines state that the base case is where the RIT–T proponent does not implement a credible option to meet the identified need, but rather continues its 'BAU activities'. The AER define 'BAU activities' as ongoing, economically prudent activities that occur in the absence of a credible option being implemented. Australian Energy Regulator. "Application guidelines Regulatory Investment Test for Transmission - August 2020." Melbourne: Australian Energy Regulator. https://www.aer.gov.au/system/files/AER%20-%20Regulatory%20investment%20test%20for%20transmission%20application%20guidelines%20-%2025%20August%202020.pdf

[19] AEMO, *2022 Integrated System Plan, June 2022*, p 91.

[20] This is equal to WACC (pre-tax, real) in the latest final decision for a transmission business in the NEM, see: https://www.aer.gov.au/system/files/AER%20-%20Transgrid%202023-28%20-%20Final%20Decision%20-%20PTRM%20-%20April%202023.xlsm

The cost estimates are developed using our 'MTWO' cost estimating system. This system utilises historical average costs, updated by the costs of the most recently implemented project with similar scope. All estimates in MTWO are developed to deliver a 'P50' portfolio value for a total program of works (i.e., there is an equal likelihood of over- or under-spending the estimate total).[21]

We estimate that actual costs will be within +/- 25 per cent of the central capital cost estimate. An accuracy of +/-25 per cent for cost estimates is consistent with industry best practice and aligns with the accuracy range of a 'Class 4' estimate, as defined in the Association for the Advancement of Cost Engineering (AACE) classification system.

All cost estimates are prepared in real, 2021-22 dollars based on the information and pricing history available at the time that they were estimated. The cost estimates do not include or forecast any real cost escalation for materials.

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

5.4. Three different scenarios have been modelled to address uncertainty

The RIT-T is focused on identifying the top ranked credible option in terms of expected net benefits. However, uncertainty exists in terms of estimating future inputs and variables (termed future 'states of the world').

To deal with this uncertainty, the NER requires that costs and market benefits for each credible option are estimated under reasonable scenarios and then weighted based on the likelihood of each scenario to determine a weighted ('expected') net benefit. It is this 'expected' net benefit that is used to rank credible options and identify the preferred option.

The credible options have been assessed under three scenarios as part of this PACR assessment, which differ in terms of the key drivers of the estimated net market benefits (ie, the estimated risk costs avoided).

Given that wholesale market benefits are not relevant for this RIT-T, the three scenarios implicitly assume the most likely scenario from the 2022 ISP (ie, the 'Step Change' scenario). The scenarios differ by the assumed level of risk costs, given that these are key parameters that may affect the ranking of the credible options. Risk cost assumptions do not form part of AEMO's ISP assumptions, and have been based on Transgrid's analysis, as discussed in section 2.

How the NPV results are affected by changes to other variables (including the discount rate and capital costs) has been investigated in the sensitivity analysis. We consider this is consistent with the latest AER guidance for RIT-Ts of this type (ie, where wholesale market benefits are not expected to be material).[22,23]

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[21] For further detail on our cost estimating approach refer to section 7 of our Augmentation Expenditure Overview Paper submitted with our 2023-28 Revenue Proposal.

[22] AER, *Application Guidelines Regulatory Investment Test for Transmission*, August 2020, pp. 40-41.

[23] We consider the approach to scenarios and sensitivities to be consistent with the AER guidance provided in November 2022 in the context of the disputes of the North West Slopes and Bathurst, Orange and Parkes RIT-Ts. See: AER, *Decision: North West Slopes and Bathurst, Orange and Parkes Determination on dispute - Application of the regulatory investment test for transmission*, November 2022, pp. 18-20 & 31-32, as well as with the AER's RIT-T Guidelines.

Table 5-1 Summary of scenarios

Variable / Scenario	Central	Low risk cost scenario	High risk cost scenario
Scenario weighting	*33%*	*33%*	*33%*
Discount rate	5.50%	5.50%	5.50%
Network capital costs	Base estimate	Base estimate	Base estimate
Operating and maintenance costs	Base estimate	Base estimate	Base estimate
Safety, environmental and financial risk benefit	Base estimate	Base estimate – 25%	Base estimate +25%

We have weighted the three scenarios equally given there is nothing to suggest an alternate weighting would be more appropriate.

5.5. Sensitivity analysis

In addition to the scenario analysis, we have also considered the robustness of the outcome of the cost benefit analysis through undertaking a range of sensitivity testing, focused on the central scenario.

The range of factors tested as part of the sensitivity analysis in this PACR are:

- lower and higher capital costs of the credible options;
- lower and higher estimated safety, environmental and financial risk benefits; and
- alternate commercial discount rate assumptions.

The above list of sensitivities focuses on the key variables that could impact the identified preferred option. The results of the sensitivity tests are set out in section 6.4.

In addition, we have also sought to identify the 'boundary value' for key variables beyond which the outcome of the analysis would change, including the amount by which capital costs would need to increase for the preferred option to no longer be preferred.

6. Assessment of credible options

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

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

6.1. Estimated gross benefits

Table 6-1 below summarises the present value of the gross benefits estimated for each credible option relative to the base case under the three scenarios. The benefits included in this assessment consist only of avoided risk, ie, a reduction in safety, environmental and financial risks.

Table 6-1 Estimated gross benefits from credible options relative to the base case ($m, PV)

Option/scenario	Central	Low risk cost scenario	High risk cost scenario	Weighted
Scenario weighting	*33%*	*33%*	*33%*	
Option 1	25.34	19.01	31.68	25.34
Option 2	28.82	21.62	36.03	28.82

6.2. Estimated costs

Table 6-2 below summarises the costs of the options, relative to the base case, in present value terms. The cost includes the direct capital and routine operating costs of each option, relative to the base case, and is the same for each option in all scenarios given nothing that affects the direct costs is varied between scenarios.

Table 6-2 Costs of credible options relative to the base case ($m, PV)

Option	Cost
Option 1	9.82
Option 2	11.38

6.3. Estimated net economic benefits

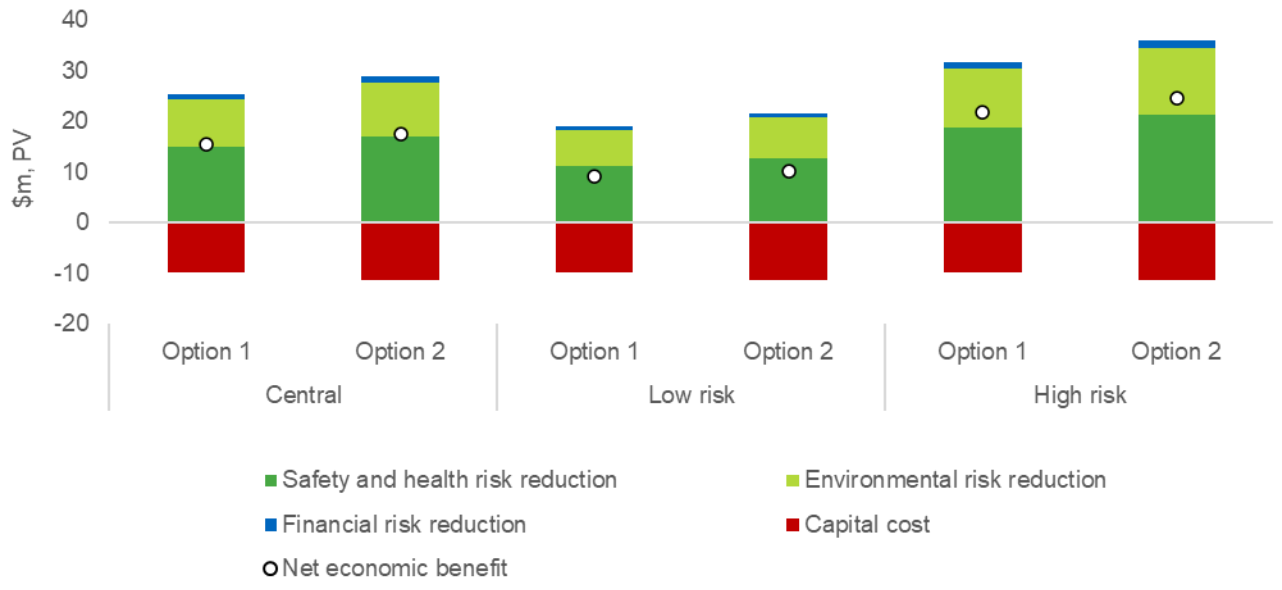
The net economic benefits are the differences between the estimated gross benefits less the estimated costs. Table 6-3 below summarises the present value of the net economic benefits for each credible option across the three scenarios and the weighted net economic benefits.

Table 6-3 Net economic benefits for Option 1 relative to the base case ($m, PV)

Option/scenario	Central	Low risk cost scenario	High risk cost scenario	Weighted
Scenario weighting	*33%*	*33%*	*33%*	
Option 1	15.52	9.19	21.86	15.52
Option 2	17.44	10.23	24.65	17.44

All options are found to have positive net benefits for all scenarios investigated. On a weighted basis, Option 2 is found to deliver the greater net economic benefits at approximately $17.44 million (12 per cent greater than Option 1).

Figure 6-1 Net economic benefits ($m, PV)



6.4. Sensitivity testing

We have undertaken sensitivity testing to understand the robustness of the RIT-T assessment to underlying assumptions about key variables. In particular, we have undertaken two sets of sensitivity tests:

- Step 1 – testing the sensitivity of the optimal timing of the project ('trigger year') to different assumptions in relation to key variables; and
- Step 2 – once a trigger year has been determined, testing the sensitivity of the total NPV benefit associated with the investment proceeding in that year, in the event that actual circumstances turn out to be different.

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

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

6.4.1. Step 1 – Sensitivity testing of the optimal timing

This section outlines the sensitivity of the identification of the commissioning year of Option 2 to changes in the underlying assumptions. In particular, the optimal timing of Option 2 is found to be invariant to the assumptions of:

- a 25 per cent decrease in the assumed network capital costs;
- higher assumed safety, environmental and financial risks; and
- a lower discount rate of 3.21 per cent as well as a higher rate of 7.5 per cent.

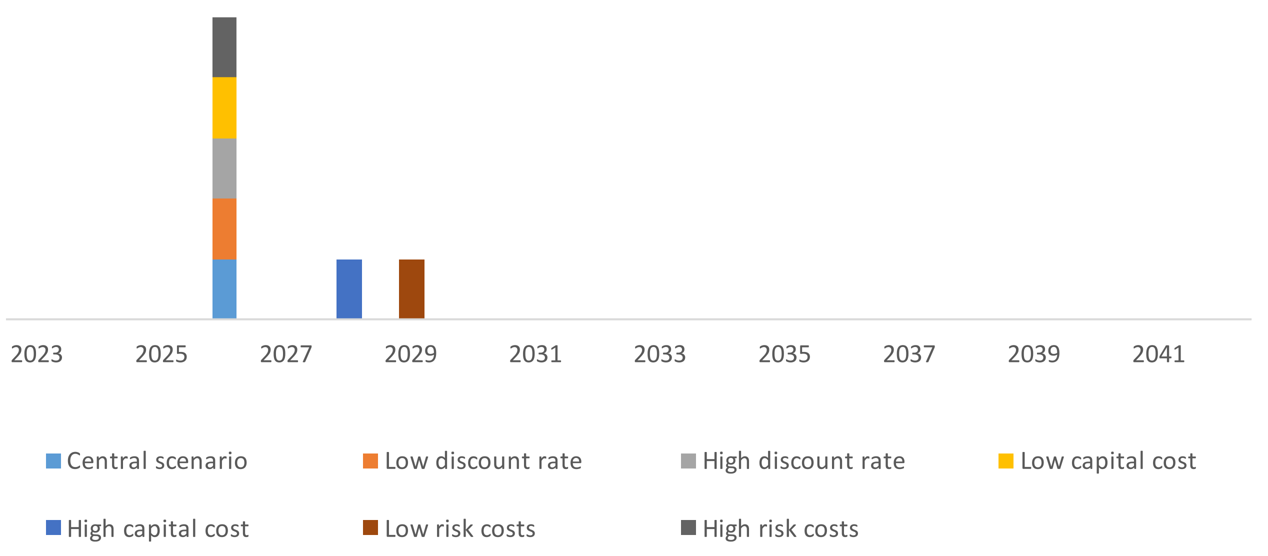
The optimal timing of Option 2 is found to be variant to the assumptions of:

- a 25 per cent increase in the assumed network capital costs; and
- lower assumed safety, environmental and financial risks.

These alternate assumptions push the optimal timing back two years and three years, respectively. Each timing sensitivity has been undertaken on the central scenario.

Figure below outlines the impact on the optimal commissioning year, under a range of alternative assumptions. It illustrates that for Option 2, the optimal commissioning date is found to be in 2025/26 for five of the seven of the sensitivities investigated. The findings are the same for Option 1.

Figure 6-2 Optimal timing of Option 2



6.4.2. Step 2 – Sensitivity of the overall net benefit

We have conducted sensitivity analysis on the present value of the net economic benefit, based on undertaking the project by 2025/26. Specifically, we have investigated the same sensitivities under this step as in the first step:

- a 25 per cent increase/decrease in the assumed network capital costs;
- lower (or higher) assumed safety, environmental and financial risks; and
- lower discount rate of 3.21 per cent as well as a higher rate of 7.5 per cent.

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

Figure , Figure and Figure below illustrate the estimated net economic benefits for each option if separate key assumptions in the central scenario are varied individually. Option 2 delivers positive benefits under all scenarios.

The sensitivity testing focuses on the central scenario given the ranking of the options is found to be the same across all three scenarios investigated and there are significant expected net market benefits under each scenario. That is, we do not expect the key findings to change for this RIT-T if the sensitivity testing was expanded to cover the low risk and high risk scenarios.

Figure 6-3 Capital cost sensitivity

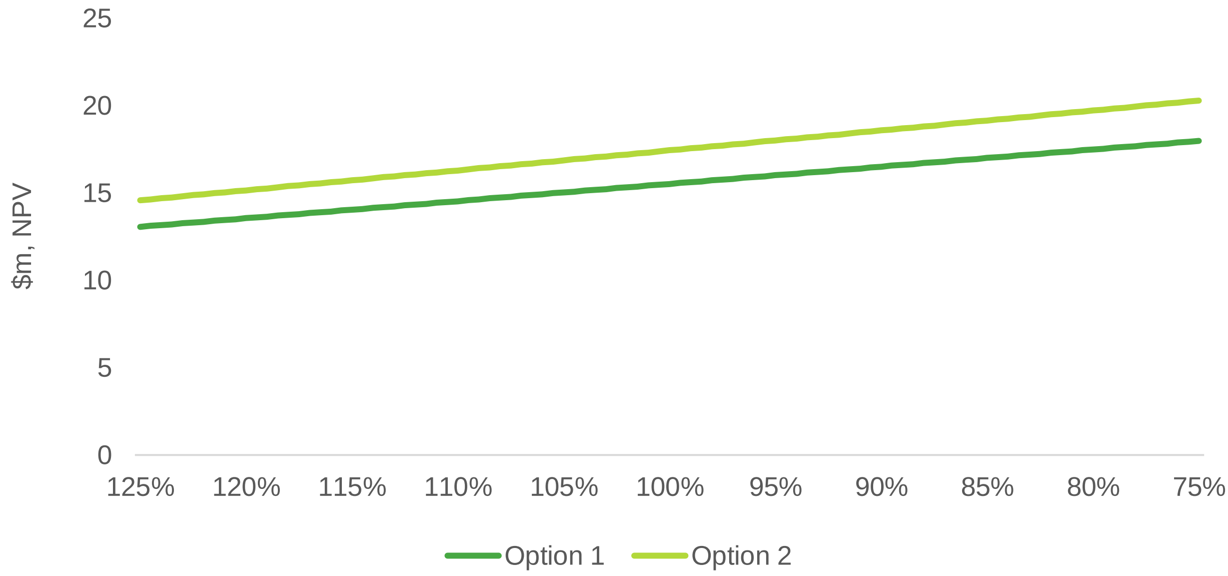


Figure 6-4 Risk costs sensitivity

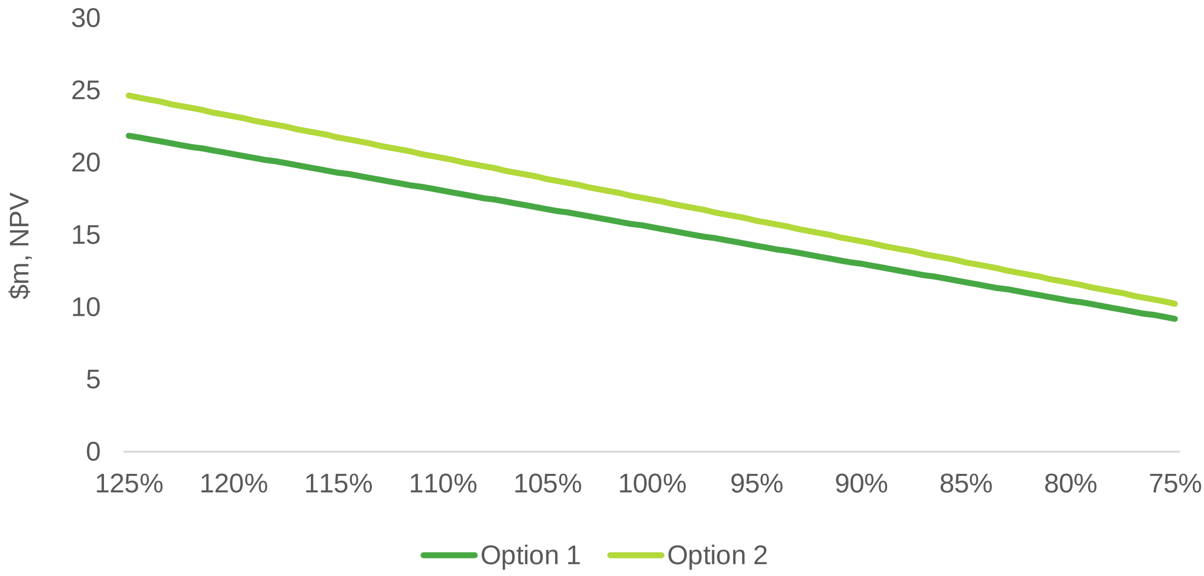
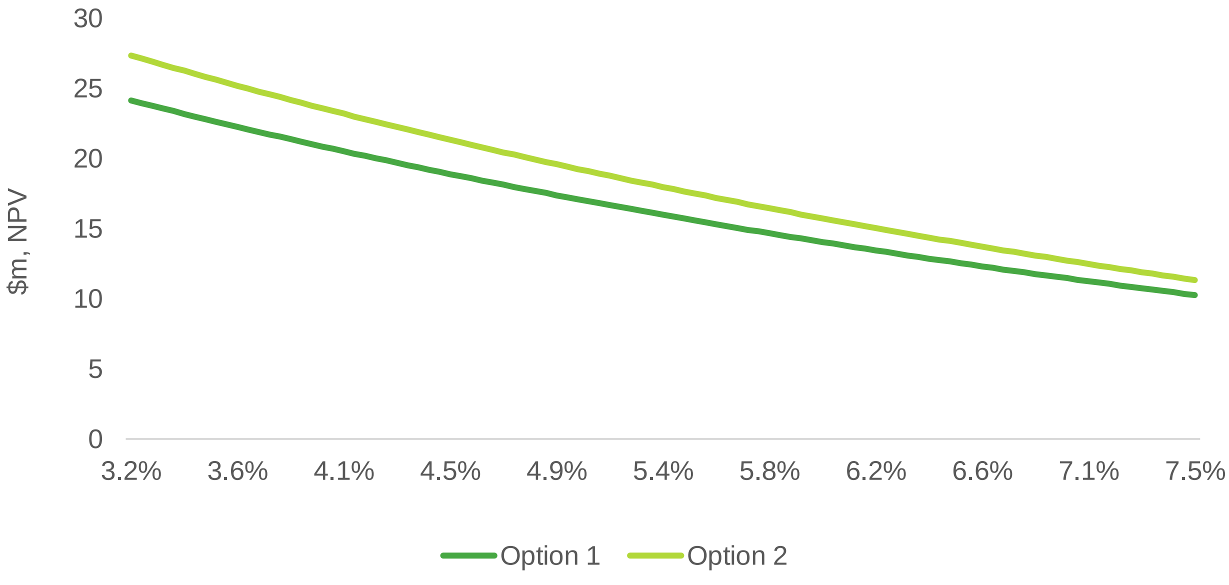


Figure 6-5 Commercial discount rate sensitivity



In terms of boundary testing, we find that the following would need to occur for Option 1 to have net market benefits equal to that of Option 2:

- assumed network capital costs (for all options) would need to increase by 122 per cent;
- the estimated risk costs (in aggregate) would need to fall by approximately 55 per cent; or
- the discount rate would need to be greater than 11 per cent.

We therefore consider the finding that Option 2 is preferred over Option 1 to be robust to the key underlying assumptions.

7. Final conclusion on the preferred option

This PACR has found that Option 2 is the preferred option for this RIT-T. Option 2 involves:

- replacement of all suspension structures on the line with concrete or steel pole structures, including the non-standard wood pole structure;
- remediating line components on tension structures that have identified condition issues based on the latest Transmission Line Refurbishment Criteria document; and
- replacing all phase conductor and earthwires.

Option 2 delivers the greatest risk reduction of the two options and, overall, the greatest estimated net market benefits. Option 2 also remains the preferred option across all sensitivities tested.

The estimated capital expenditure associated with this option is $13.4 million. Routine operating and maintenance costs are the same as the base case for this option (estimated at $10,120 per year).

The works are estimated to take 26 months to complete. Project completion is assumed in 2025/26.

Option 2 is the preferred option in accordance with NER clause 5.15A.2(b)(12) because it is the credible option that maximises the net present value of the net economic benefit to all those who produce, consume and transport electricity in the market. The analysis undertaken and the identification of Option 2 as the preferred option satisfies the RIT-T.

Appendix A Compliance checklist

This appendix sets out a checklist which demonstrates the compliance of this PACR with the requirements of the National Electricity Rules version 200.

Rules clause	Summary of requirements	Relevant section(s) in the PACR
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 & 6
	(4) a detailed description of the methodologies used in quantifying each class of material market benefit and cost;	4 & 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);	NA
	(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

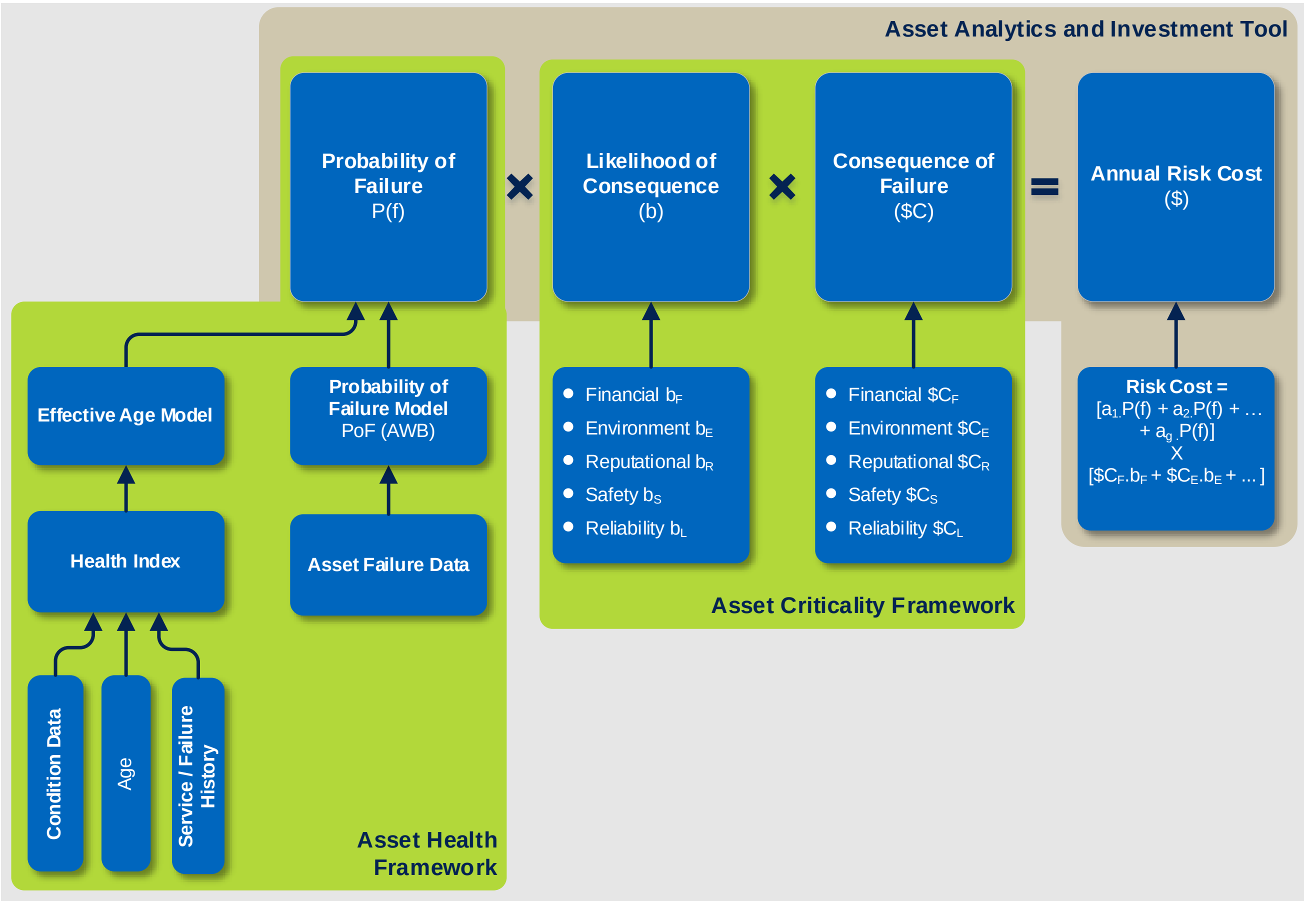
This appendix summarises our network risk assessment methodology that underpins the identified need for this RIT-T. Our risk assessment methodology is aligned with the AER's Asset Replacement Planning guideline[24] and its principles.

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

The monetary value of risk (per year) for an individual asset failure resulting in an undesired outcome, is the likelihood (probability) of failure (in that year with respect to its age), as determined through modelling the failure behaviour of an asset (Asset Health), multiplied by the consequence (cost of the impact) of the undesired outcome occurring, as determined through the consequence analysis (Asset Criticality).

Figure B- below summarises the framework for calculating the 'risk costs', which has been applied on our asset portfolio considered to need replacement or refurbishment.

Figure B-7-1 Risk cost calculation



Economic justification of repex to address an identified need is supported by risk monetised benefit streams, to allow the costs of the project or program to be assessed against the value of the avoided risks

24 Industry practice application note - Asset replacement planning, AER January 2019

and costs. The major quantified risks we apply for repex justifications include asset failures that materialise as:

- bushfire risk;
- safety risk;
- environmental risk;
- reliability risk; and
- financial risk.

The risk categories relevant to this RIT-T are explained in Section 2.3.

Further details are available in our Network Asset Risk Assessment Methodology.

Appendix C Asset Health and Probability of Failure

The first step in calculating the PoF of an asset is determining the asset health and associated effective age,[25] which considers that:

- an asset consists of different components, each with a particular function, criticality, underlying reliability, life expectancy and remaining life - the overall health of an asset is a compound function of all of these attributes;
- key asset condition measures and failure data provides vital information on the current health of an asset, where the 'current effective age' is derived from asset information and condition data;
- the future health of an asset (health forecasting) is a function of its current health and any factors causing accelerated (or decelerated) degradation or 'age shifting' of one or more of its components – such moderating factors can represent the cumulative effects arising from continual or discrete exposure to unusual internal, external stresses, overloads and faults; and
- 'future effective age' is derived by moderating 'current effective age' based on factors such as, external environment/influence, expected stress events and operating/loading condition.

The PoF is the likelihood that an asset will fail during a given period resulting in a particular adverse event, e.g., equipment failure, pole failure, broken overhead conductor.

The outputs of the PoF calculation are one or more probability of failure time series which provide a mapping between the effective age and the yearly probability of failure value for a given asset class. This analysis is performed by generating statistical failure curves, normally using Weibull analysis, to determine a PoF time series set for each asset that gives a probability of failure for each further year of asset life. This establishes how likely it is that the asset will fail over time.

The Weibull parameters which represent the probability of failure curve for key transmission line components are summarised in Table below.

Further details are available in our Network Asset Health Methodology.

[25] Apparent age of an asset based on its condition.

Table C-1 Weibull parameters for asset components

Asset component	Weibull parameters	
	η	β
Structure - Towers C1	3901	1.32
Structure - Towers C2	879.4	3.1
Structure - Towers C3	270.9	2.17
Structure - Towers C4	141.2	2.71
Insulators - Non Ceramic Insulators	26.55	3.232
Insulators - Porcelain Disc - Low corrosion	261.7	4.581
Insulators - Porcelain Disc - High corrosion	173.7	4.763
Conductor Fittings - C1/C2	127.4	4.376
Conductor Fittings - C3/C4	64.24	10.13
Earthwire Fittings - C1/C2	116.5	5.198
Earthwire Fittings - C3/C4	66.61	10.98

Note: C1 (Very Low), C2 (Low), C3 (Medium) and C4 (High) relate to atmospheric corrosion zones based on Australian Standard AS 4312-2008.