Transgrid

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Maintaining safe and reliable operation of Tamworth substation

RIT-T Project Assessment Conclusions Report

Region: Northern NSW

Date of issue: 6 December 2024

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Executive summary

We are applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining the safe and reliable operation of Tamworth substation. Publication of this Project Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

Tamworth 330 kV substation is located in Transgrid's Northern NSW network. It connects to Transgrid's 330 kV Armidale, Liddell and Muswellbrook substations as well as Transgrid's 132 kV Narrabri, Tamworth and Gunnedah substation, which all support Essential Energy's 66 kV network.

There are three transformers at Tamworth's 330 kV substation. The No.1 and No.2 transformers were commissioned along with the substation in 1967 and the No.3 transformer was commissioned in 1998.

The purpose of this RIT-T is to examine and consult on options to address the deterioration of the Tamworth No.1 and No. 2 transformers at Tamworth substation to reduce the likelihood of prolonged and involuntary load shedding in Northern NSW region and reduce the risk of safety and environmental hazards associated with a catastrophic failure.

Identified need: ensure the safe and reliable operation of Tamworth substation

The identified need for this project is to maintain the safe and reliable operation of Tamworth substation and the broader transmission network in NSW by addressing the risk of failure of Tamworth substation's No. 1 and No. 2 power transformers.

The No.1 and No.2 transformers are approaching the end of their serviceable lives and showing signs of deterioration due to the following key factors:

- Natural age: The transformers were manufactured in 1966 and commissioned in 1967. The natural age of the transformers will be 58 years in 2024/25. This is well above the 45-year expected useful life of a power transformer.
- Corrosive sulphur: The insulating oil has corrosive sulphur, which can form conductive compounds on the insulation paper and tap changer contacts. This can cause an internal flashover and could lead to a catastrophic failure.
- Oil leaks: There are leaks from the bushings, pumps, valves, main tank and tap changer allowing moisture ingress and oxygen into the main insulation.
- Corrosion: The paint and galvanic protection on the transformer has failed resulting in rusting and deterioration.

These condition issues have been evaluated through the transformer health index methodology to give an effective age of 58 years (2024/25, No.1 and 2), which is only slightly below its chronological age. These condition issues, if not remediated, increase the probability of transformer failure.

The No.3 transformer at Tamworth substation is in satisfactory condition and not part of this need.

The identified need for this project is to maintain the safe and reliable operation of Tamworth substation and the broader transmission network in NSW by addressing the risk of failure of Tamworth substation's No. 1 power transformer.

Replacement of the Tamworth transformers will significantly reduce the likelihood of prolonged and involuntary load shedding in the northern region and help Transgrid manage its safety obligations.

The key economic benefits associated with addressing this need are summarised as:

- Reduction of risk as valued as direct impact to Transgrid and consumers including:
  - Changes in involuntary load shedding
  - Safety and environmental hazards associated with a catastrophic failure.
- Avoided operating expenditure related to an escalation of corrective maintenance.

No submissions received in response to the Project Specification Consultation Report

We published a Project Specification Consultation Report (PSCR) on 15 August 2024 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 that there are two credible network options that meets the identified need from a technical, commercial, and project delivery perspective.[1] These options are summarised in the table below.

Table E-1 Summary of the credible options

Option	Description	Capital costs ($M, 2024/25)	Operating costs ($/yr, 2024/25)
Option 1	Replacement of the No.1 and No.2 Tamworth transformers	20.32	1,141
Option 2	Refurbishment of the No.1 and No.2 Tamworth transformers	2.51	1,128

No submissions received in relation to non-network options

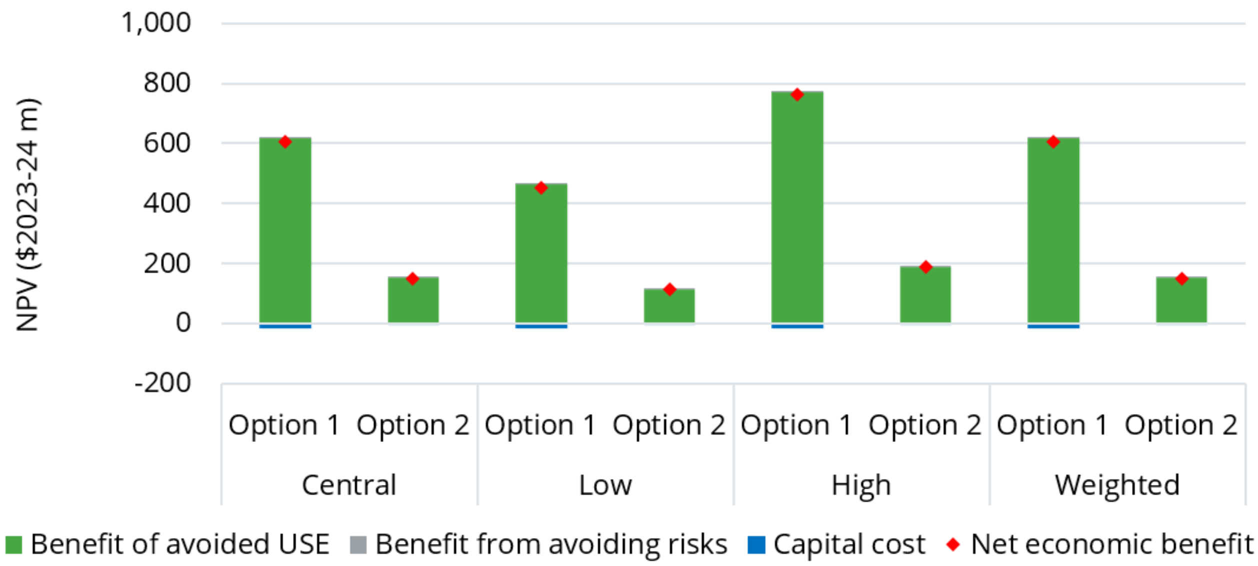
In the PSCR, we noted that we do not consider non-network options to be commercially and technically feasible to assist with meeting the identified need for this RIT-T. Non-network options will not mitigate the expected lost load, safety risks and environmental risks from failure of the No. 1 and No. 2 transformers. No submissions were received in response to the PSCR in relation to non-network options.

Option 1 delivers the highest net economic benefit and will meet NER requirements

We have assessed that Option 1 is the best performing option under all three reasonable scenarios considered in this PACR. On a weighted basis, where each scenario is weighted equally, Option 1 is expected to deliver net benefits of approximately $618.5 million.

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

Figure E-1 NPV of net economic benefits ($2024/25 m)



Conclusion

This PACR finds that Option 1 is the preferred option to address the identified need. Option 1 involves replacement of the No.1 and No. 2 transformer at Tamworth substation due to the transformer having reached the end of its technical life.

The capital cost of this option is approximately $20.32 million (in $2024/25). The expected project timeframe is 48 months with an expected asset life of 45 years. Routine operating and maintenance costs are estimated at approximately $1,141 per annum (in $2024/25).

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. It follows a PSCR released on 15 August 2024. No submissions were received in response to the PSCR.

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 $54 million;[2]
- 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;

[2] Varied from $43m to $54m based on the AER Final Determination: Cost threshold review, November 2024.

- no PSCR submissions identifying additional credible options that could deliver a material market benefit; and
- the PACR addressing any issues raised in relation to the proposed preferred option during the PSCR consultation.

Parties wishing to raise a dispute notice with the AER may do so prior to 17 January 2025 (30 days after publication of this PACR). Any dispute notices raised during this period will be addressed by the AER within 40 to 100 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 'Tamworth substation renewal PACR'.

Contents

1. Introduction

We are applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining the safe and reliable operation of Tamworth substation. Publication of this Project Assessment Conclusions Report (PACR) is the final step in the RIT-T process.

Tamworth 330 kV substation is located in Transgrid's Northern NSW network. It connects to Transgrid's 330 kV Armidale, Liddell and Muswellbrook substations as well as Transgrid's 132 kV Narrabri, Tamworth and Gunnedah substation, which all support Essential Energy's 66 kV network.

There are three transformers at Tamworth's 330 kV substation. The No.1 and No.2 transformers were commissioned along with the substation in 1967 and the No.3 transformer was commissioned in 1998.

The Tamworth 330/132 kV transformers play an essential role in the suppling Transgrid's 132 kV network in the northern region, which supply Essential Energy's customer connection points in the Tamworth, Gunnedah, Moree and Inverell area.

Transgrid's Northern NSW network will host the future New England Renewable Energy Zone, which aims to ultimately connect up to 8,000 MW of renewable generation. It is also an area of interest for new renewable generation projects around the Tamworth to Narrabri area. Tamworth 330 kV substation will continue to play a central role in the safe and reliable operation of the power system.

The No.1 and No.2 transformers (330/132 kV, 150 MVA) commissioned in 1967 during initial construction of Tamworth 330 kV substation have now reached the end of their serviceable lives leading to an increasing risk of failure which could result in reliability, safety, environment and financial consequences. The No.3 transformer commissioned in 1998 is in satisfactory condition and not part of this need. The three transformers at the substation play a central role in supplying electricity to the distribution network in the northern region.

The purpose of this RIT-T is to examine and consult on options to address the deterioration of the Tamworth No.1 transformer at Tamworth substation to reduce the likelihood of prolonged and involuntary load shedding in the Central NSW region and reduce the risk of safety and environmental hazards associated with a catastrophic failure.

1.1 Purpose of this report

The purpose of this PACR[3] is to:

- describe the identified need;
- summarise the submissions received to the Project Specification Consultation Report (PSCR);
- 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.

3 See Appendix A for the National Electricity Rules requirements

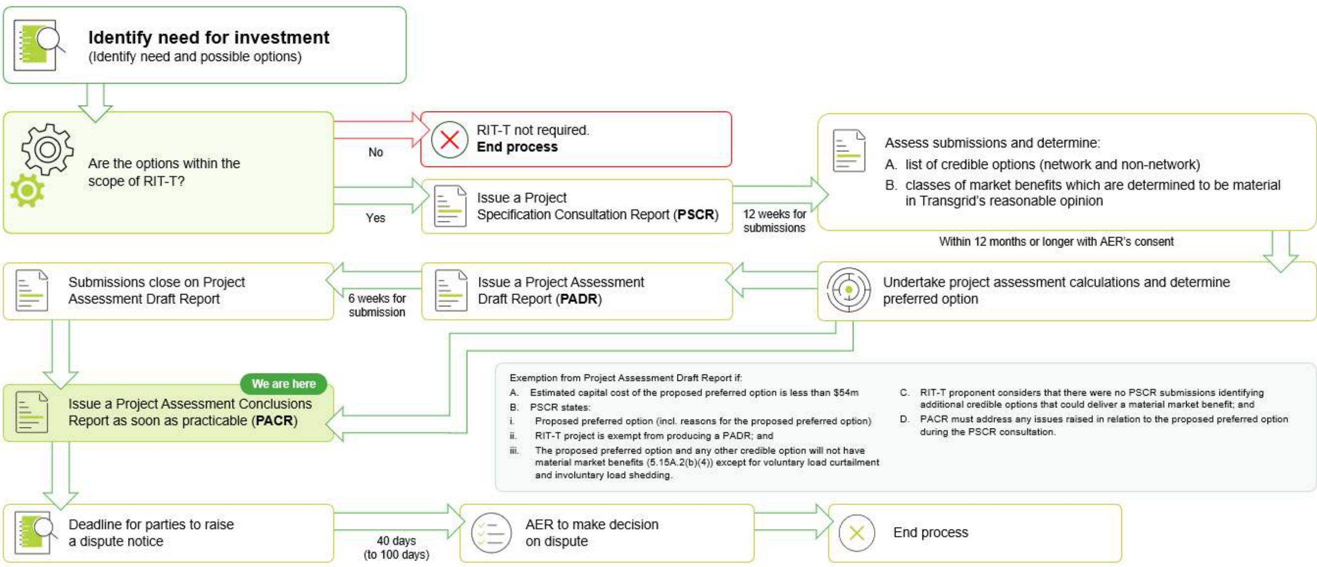
1.2 No submissions received in response to the PSCR and no material developments

We published a PSCR on 15 August 2024 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 Submissions and 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.

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



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 $54 million;[4]
- 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

[4] Varied from $43m to $54m based on the AER Final Determination: Cost threshold review, November 2024.

- the PACR addressing any issues raised in relation to the proposed preferred option during the PSCR consultation.

Parties wishing to raise a dispute notice with the AER may do so prior to 17 January 2025 (30 days after publication of this PACR). Any dispute notices raised during this period will be addressed by the AER within 40 to 100 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 'Tamworth substation renewal PACR'.

2. The identified need

2.1 Background to the identified need

Tamworth 330 kV substation has three transformers – No. 1 and No. 2 were commissioned in 1967 and No. 3 was commissioned in 1998. These form a part of Transgrid's network that serves the northern region of NSW. Tamworth 330 kV substation connects to Transgrid's 330 kV Armidale, Liddell and Muswellbrook substations as well as Transgrid's 132 kV Narrabri, Tamworth and Gunnedah substation.

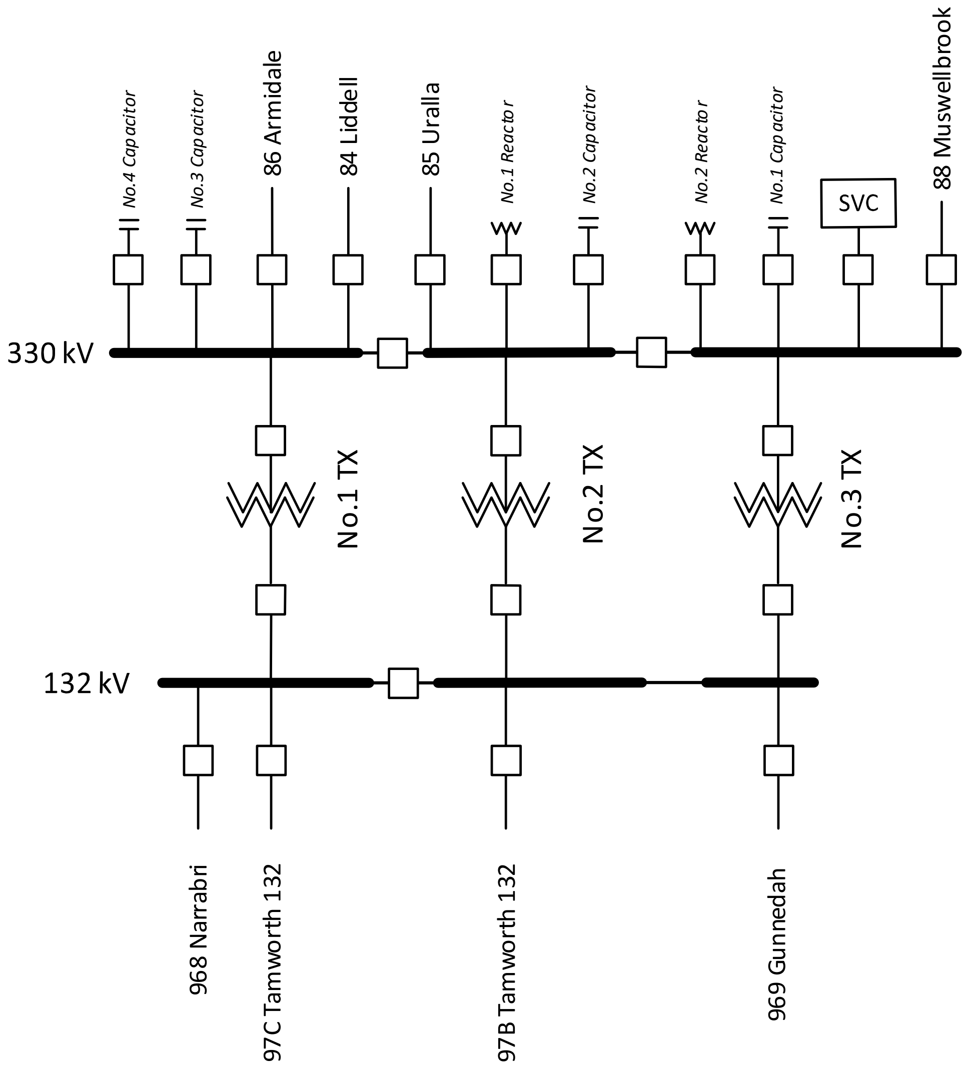
The location of Tamworth 330 kV substation and supply arrangements for the Northern NSW network is provided in Figure 2-1 below.

Figure 2-1 Location of Tamworth substation

Transgrid's Northern NSW network will host the future New England Renewable Energy Zone, which aims to ultimately connect up to 8,000 MW of renewable generation. Transgrid's Northern NSW network is also an area of interest for new renewable generation projects around the Tamworth to Narrabri area. Tamworth 330 kV substation will continue to play a central role in the safe and reliable operation of the power system.

The existing electrical layout of Tamworth 330 kV substation is shown in Figure 2-2.

Figure 2-2 Tamworth 330 kV substation electrical layout



2.2 Description of the identified need

The identified need for this project is to maintain the safe and reliable operation of Tamworth substation and the broader transmission network in Northern NSW by addressing the risk of failure of the Tamworth No.1 and No. 2 330 kV transformer at Tamworth substation.

The No.1 and No.2 transformer (330/132 kV, 150 MVA) were commissioned in 1967 during the initial construction of Tamworth 330 kV substation and have now reached the end of their serviceable lives. The No.3 transformer which was commissioned in 1998 is in satisfactory condition and not part of this need. The three transformers at the substation play a central role in supplying electricity to the distribution network in the northern region.

Condition assessment of the No.1 and No.2 transformer at Tamworth 330 kV substation using Transgrid's Network Asset Risk Assessment Methodology (RAM) has noted signs of deterioration, primarily due to condition issues associated to corrosion.

Power transformers are essential to the task of transmitting electricity as they change the voltage level between different sections of an electricity network. This enables electricity transportation infrastructure to be significantly more cost-effective, by reducing the power losses experienced between generators and consumers, while providing power at the appropriate voltage for end-users.

If the deteriorating asset condition is not addressed by a technically and commercially feasible option, the likelihood of prolonged and involuntary load shedding in the northern region will increase.

In addition, the increased risk of failure presents a safety risk which Transgrid is obligated to manage.[5] Rectifying the worsening condition of the transformer will reduce safety risks, as well as lower planned and unplanned corrective maintenance costs.

The key economic benefits associated with addressing this need are summarised as:

- Reduction of risk as valued as a direct impact to Transgrid and consumers including:
  - Changes in involuntary load shedding;
  - Safety and environmental hazards associated with a catastrophic failure.
- Avoided operating expenditure related to corrective maintenance.

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.

We note that the risk cost estimating methodology aligns with that used in our Revised Revenue Proposal for the 2023-28 period. It reflects feedback from the Australian Energy Regulator (AER) on the methodology initially proposed in our initial Revenue Proposal.

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

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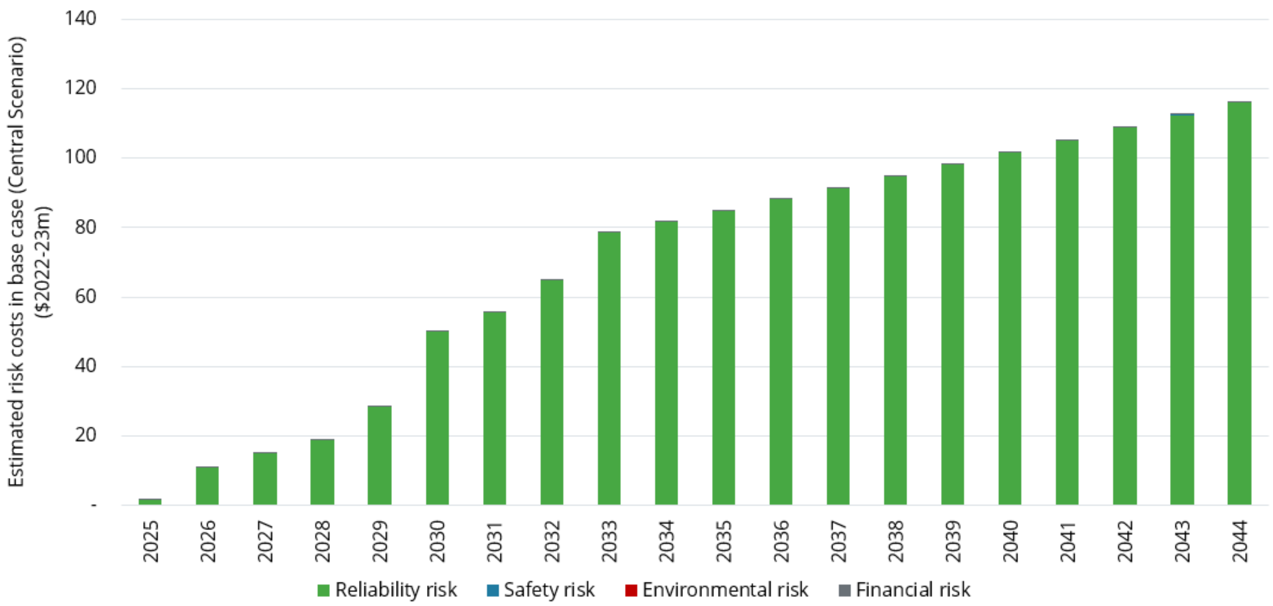
[5] We manage and mitigate safety and bushfire risk to ensure they are below risk tolerance levels or ‘As Low As Reasonably Practicable’ (‘ALARP’), in accordance with our obligations under the *New South Wales Electricity Supply (Safety and Network Management) Regulation 2014* and our Electricity Network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

Figure 2-3 Estimated risk costs under the base case (central scenario)



This section describes the assumptions underpinning our assessment of the risk costs, i.e., the value of the risk avoided by undertaking each of the credible options. The aggregate risk cost under the base case is currently estimated at around $1.73 million/year in 2025 and it is expected to increase going forward if action is not taken and the transformer is left to deteriorate further (reaching approximately $76.80 million/year by 2033 and over $116.39 million/year by the end of the 20-year assessment period).

2.3.1 Asset health and the probability of failure

Power transformers are essential to the task of transmitting electricity as they change the voltage level between different sections of an electricity network. This enables electricity transportation infrastructure to be significantly more cost-effective, by reducing the power losses experienced between generators and consumers, while providing power at the appropriate voltage for end-users. The Tamworth substation connects to 330 kV and 132 kV networks.

We have identified the following power transformers at Tamworth substation with condition deterioration that requires replacement or refurbishment. These condition issues have been evaluated through the transformer health index methodology[6] to give an effective age of 58 years (2024/25, No.1 and 2), which is

[6] Further details are available in Appendix B, and via our Network Asset Risk Assessment Methodology.

only slightly below its chronological age. These condition issues, if not remediated, increase the probability of transformer failure.

The No.3 transformer at Tamworth substation is in satisfactory condition and not part of this need.

Table 2-2 Current transformers considered under this RIT-T

Asset	Effective age (as at 2024/25)	Key issues
No. 1 transformer	58	Condition deterioration
No. 2 transformer	58	Condition deterioration

These Power transformers at Tamworth substation have reached the end of their serviceable lives. As power transformers age, the following conditions materialise which increase the risk of asset failure:

- Corrosive sulphur: The insulating oil has corrosive sulphur, which can form conductive compounds on the insulation paper and tap changer contacts. This can cause an internal flashover and could lead to a catastrophic failure.
- Oil leaks: There are leaks from the bushings, pumps, valves, main tank and tap changer allowing moisture ingress and oxygen into the main insulation.
- Corrosion: The paint and galvanic protection on the transformer has failed resulting in rusting and deterioration.

Table 2-3 outlines the signs of deterioration of the No. 1 and No. 2 transformers at Tamworth substation.

Table 2-3 Condition issues with Tamworth No.1 and No. 2 transformers

Issue	Potential impact
Corrosive sulphur	Corrosive sulphur can form conductive compounds on insulating paper. Disrupting the integrity of the paper leading to thermal insulation failure or electrical breakdown between adjacent conductors. Sulphur compounds can also attack the silver coating on selector switching contacts, creating loose sections of conductive silver sulphide. This can result in a catastrophic failure of the tap changer and/or transformer.
Corrosion resulting in loss of oil due to leaks	Corrosion resulting in leaks or leaking gaskets can cause loss of oil within the transformer resulting in a catastrophic failure. Moisture and oxygen can also enter the transformer resulting in accelerated aging of the insulation resulting in failure.

If left unreplaced or not refurbished, continued degradation in the condition of the asset will significantly increase the risk of asset failure and the risk of unplanned network outages. There will be an increased cost to replace the assets upon failure in a reactive fashion. A failure can also pose serious safety and environmental hazards. A failure of the power transformers can result in the risk of injuring people, cause collateral damage and outages of nearby services, and other environmental issues such as fires. Replacing the power transformers at Tamworth substation will reduce the risk of involuntary load shedding for customers in Northern NSW and reduce the risk of safety and environmental hazards associated with any catastrophic failures occurring.

2.3.2 Reliability risk

We have considered the risk of unserved energy for customers following a failure of one or more of the high voltage and secondary systems assets identified in this PSCR. The likelihood of a consequence takes into account the likelihood of contingent planned/unplanned outages, the anticipated load restoration time (based on the expected time to undertake any repair work), and the load at risk (based on forecast demand). The monetary value is based on an assessment of the value of customer reliability, which measures the economic impact to affected customers of a disruption to their electricity supply.

Reliability risk makes up over 99 per cent of the total estimated risk cost in present value terms. The relative size of this risk is due to the high voltage transformer at the Tamworth substation having an effective age beyond its technical life. As the asset continue to age the probability of the transformer failing increases. This increased probability of failure combined with a long load restoration time means that there is likely to be significant amounts of unserved energy over the assessment period without replacement or refurbishment of the asset.

2.3.3 Safety risk

This refers to the safety consequence to staff, contractors and/or members of the public of an asset failure. The likelihood of a consequence takes into account the frequency of workers on-site, the duration of maintenance and capital work on-site, and the probability and area of effect of an explosive asset failure. The monetary value takes into account the cost associated with fatality or injury compensation, loss of productivity, litigation fees, fines and any other related costs.

We manage and mitigate 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). 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 makes up less than 1 per cent of the total estimated risk cost in present value terms.

2.3.4 Environmental risk

This refers to the environmental consequence (including bushfire risk) to the surrounding community, ecology, flora and fauna of an asset failure. The likelihood of a consequence takes into account the location of the site and sensitivity of surrounding areas, the volume and type of contaminant, the effectiveness of control mechanisms, and the likelihood and impact of bushfires. The monetary value takes into account the cost associated with damage to the environment including compensation, clean-up costs, litigation fees, fines and any other related costs.

Environmental risk makes up less than 1 per cent of the total estimated risk cost in present value terms.

2.3.5 Financial risk

This refers to the financial consequence of an asset failure. The likelihood of a consequence takes into account any compliance and regulatory factors which are not covered by the other categories. The monetary value takes into account the cost associated with disruption to business operations, any third party liability, and the cost of replacement or repair of the asset, including any temporary measures.

Financial risk makes up less than 1 per cent of the total estimated risk cost in present value terms.

3. Options that meet the identified need

This section describes the option(s) that we have explored to address the identified need, including the scope of each option and the associated costs.

We consider that there are two technically and commercially feasible options to address the identified need.[7] This involves replacement or refurbishment of the No. 1 and No. 2 power transformers at Tamworth substation, as it has reached the end of their serviceable lives based on an assessment of their age, condition, and technological obsolescence. The options are summarised in the table below. We do not consider non-network options to be technically or commercially feasible to assist with meeting the identified need for this RIT-T.

Table 3-1 Summary of credible options

Option	Description	Estimated capex ($M, 2024/25)	Expected commission date (Financial year)
1	Replacement of the Tamworth No.1 and No. 2 transformers	20.32	2025/26
2	Refurbishment of the Tamworth No.1 and No. 2 transformers	2.51	2025/26

3.1 Base case

Consistent with the RIT-T requirements, the assessment undertaken in this PACR compares the costs and benefits of each credible option to a 'do nothing' base case. The base case is the (hypothetical) projected case if no action is taken, i.e.:[8]

> "*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'. 'BAU activities' are ongoing, economically prudent activities that occur in absence of a credible option being implemented*"

Under the base case, no proactive capital investment is made to remediate the deterioration of the power transformer at Tamworth substation. The asset will continue to be operated and maintained under the current regime.

Under the base case, increases to the regular maintenance regime will not be able to mitigate the risk of asset failure due to continued deterioration in asset condition. This will lead to an increase in the probability of failure at Tamworth substation. Rectification of an asset failure will take longer due as Transgrid does not hold a like for like spare transformer. A suitable spare will need be transported and assembled to restore supply. This will lead to an increase in the outage duration in the event of a transformer failure at Tamworth substation.

These factors will increase the risk of prolonged and frequent involuntary load shedding for end-customers. We have estimated that the cost of involuntary load shedding due to asset failure at Tamworth substation will increase from approximately $1.64 million in 2024/25 to approximately $116.20 million in 2043/44 (in $2024/25). The above factors will also expose us and our end-customers to greater environmental, safety

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

8 AER, *Regulatory Investment Test for Transmission Application Guidelines,* November 2024, p. 21.

and financial risks associated with catastrophic asset failure, such as increased risk of explosive failure resulting in injury to nearby people and collateral damage to nearby assets. We have estimated that environmental, safety and financial risks costs under the base case will be approximately $1.73 million in 2024/25 and increase to over $116.39 million in 2043/44 (in $2024/25).

3.2 Option 1 – Replacement of the Tamworth No.1 and No. 2 transformer

Option 1 involves the replacement of the Tamworth No.1 and No. 2 transformer with two new 330/132 kV 150 MVA transformers. The option will address the identified need by installing new transformers with a very low probability of failure, associated risks and lower operating costs.

This option involves:

- Installation of two 150 MVA power transformers;
- Modification of associated switchgear, protection and control systems (secondary systems);
- Civil works.

The transformer will be installed in-situ, during shoulder periods to maintain reliability during construction.

The expected project timeframe is 48 months with an expected asset life of 45 years. The estimated capital expenditure with this option is $20.32 million. This capital cost is comprised of:

- $3.023m in labour costs;
- $9.416m in materials costs; and
- $7.885m in expenses

The net annual benefit for routine maintenance over the base case is estimated at approximately $1,141 per annum (in $2024/25).

Table 3-2 Capital cost of Option 1 by financial year ($M, 2024/25)

Option	Description	Estimated capex ($M, 2024/25)	Expected commission date (Financial year)
1	Replacement of the Tamworth No. 1 and No 2 transformers	20.32	2025/26

All works will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission network. Necessary outages of relevant assets in service will be planned appropriately in order to complete the works with minimal impact on the network.

3.3 Option 2 – Refurbishment of the Tamworth No.1 and No. 2 transformer

Option 2 involves the refurbishment of the Tamworth No.1 and No.2 330/132 kV transformers, including:

- Oil treatment and/or replacement
- Corrosion repair, leak repair and repainting
- Major overhaul of the tap changer and selector
- Conservator modifications and/or repairs.

The refurbishment under this need is only expected to result in a reduction in the effective age of five years, limited by the natural age of the transformer.

Limitations of Refurbishment

Refurbishment is expected to improve condition issues associated with the insulating oil quality, gasket leaks and tap changer components. It cannot address or improve the quality of the paper insulation, eliminate gas generation, ageing in the core, improve winding clamping pressure or eliminate all sulphur compounds bonded to the tap changer contacts.

The benefits are further limited by the natural age of the transformer, which will be 62 years at the end of the 2023-28 regulatory period, 17 years above the useful life of a power transformer. The No.1 and No.2 transformers have undergone major refurbishments, in 2006 and 2003 respectively. Further refurbishments will only provide an incremental reduction in effective age due to the reduced condition issues the option can remediate.

The economic evaluation also highlights that the refurbishment (Option 2) of the No.1 and No.2 transformers does not provide the highest economic value when compared to replacement of the transformers (Option 1). Most of the reliability, safety and environmental risk will also remain even after the refurbishment and will only be addressed by replacement. The refurbishment option will essentially delay the transformer replacements into 2028 - 2033 regulatory period and result in a higher lifecycle capital expenditure investment.

The expected project timeframe is 21 months with an expected improvement of asset life of 5 years for both transformers. The estimated capital expenditure with this option is $2.51 million. This capital cost is comprised of:

- $2.055m in labour costs;
- $0.264m in materials costs; and
- $0.190m in expenses

The net annual benefit for routine maintenance over the base case is estimated at approximately $1,128 per annum (in $2024/25).

Table 3-3 Capital cost of Option 2 by financial year ($M, 2024/25)

Option	Description	Estimated capex ($M, 2024/25)	Expected commission date (Financial year)
2	Refurbishment of the Tamworth No. 1 and No. 2 transformers	2.51	2025/26

All works will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission network. Necessary outages of relevant assets in service will be planned appropriately in order to complete the works with minimal impact on the network.

3.4 Options considered but not progressed

We have also considered whether other options could meet the identified need. Reasons these options were not progressed are summarised in Table 3-4.

Table 3-4 Options considered but not progressed

Option	Reason(s) for not progressing
Increased maintenance or inspections	The condition issues have already been identified and cannot be rectified through increased maintenance or inspections, and therefore is not technically feasible to address the need.
Elimination of all associated risk	This can only be achieved by retiring the assets, which is not technically feasible due to the requirement to maintain the existing network reliability.
Non-network solutions	Transgrid does not consider non-network options to be commercially and technically feasible to assist with meeting the identified need. Non-network options will not mitigate the expected lost load, safety risks and environmental risks from failure of the No. 1 and No. 2 transformers.

3.5 No material inter-network impact is expected

We have considered whether the credible options listed above are expected to have material inter-regional impact.[9] A 'material inter-network impact' is defined in the NER as:[10]

> "*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.*"

By reference to AEMO's screening test for an inter-network impact,[11] a material inter-regional impact may arise if a credible option:

- is expected to change power transfer capability between transmission networks or in another TNSP's network by more than the minimum of 3 per cent of the maximum transfer capability and 50 MW
- is expected to result in an increase in fault level by more than 10 MVA at any substation in another TNSP's network; or
- involves either a series capacitor or modification in the vicinity of an existing series capacitor.

As none of these criteria are satisfied for this RIT-T, we consider that there are no material inter-network impacts associated with any of the credible options considered.

[9] As per clause 5.16.4(b)(6)(ii) of the NER.
[10] Definition of 'material inter-network impact,' in the Glossary to the NER.
[11] 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 21 October 2024. https://aemo.com.au/-/media/files/electricity/nem/network_connections/transmission-and-distribution/170-0035-pdf.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.[12]

4.1 Avoided unserved energy is material

We consider that changes in involuntary load shedding are expected to be material for the credible options outlined in this PACR. In the base case, involuntary load shedding would be expected to occur following a failure of the power transformer at Tamworth substation which would require taking affected primary assets, such as lines and transformers, out of service.

The probability of asset failure is expected or increase over time as the condition of the relevant assets continue to deteriorate. This is expected to increase the frequency of outages. Rectification of asset failures will take longer due to the limited availability of spares and discontinued manufacturer support. This is expected to increase the duration of outages.

We have estimated expected unserved energy under the base case and the credible options. These forecasts are based on probabilistic planning studies of failure rates and repair times. Option 1 significantly reduces the amount of expected unserved energy that would occur, while Option 2 will reduce expected unserved energy by a lesser amount. The avoided unserved energy for a credible option is calculated as the difference between the expected unserved energy under the base case and the expected unserved energy under each option.

4.2 Wholesale electricity market benefits are not material

The AER has recognised that if the credible options 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.

We determine that the credible options in this PACR will not affect 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; and
- competition benefits

[12] 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(b)(5). See Appendix A for requirements applicable to this document.

4.3 No other categories of market benefits are material

In addition to the classes of market benefits identified above, the NER also requires us to consider the following classes of market benefits, listed in Table 4-1, arising from each credible option.[13] 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 categories are considered not material

Market benefits	Reason
Differences in the timing of unrelated network expenditure	The credible options considered are unlikely to affect decisions to undertake unrelated expenditure in the network. Consequently, material market benefits will neither be gained nor lost due to changes in the timing of expenditure from any of the options considered.
Option value	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.[14] 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.[15] We do not consider there to be any option value with the options considered in this PACR. Additionally, a significant modelling assessment would be required to estimate the option value benefits which would be disproportionate to the potential additional benefits for this RIT-T. Therefore, we have not estimated additional option value benefit.
Changes in network losses	We do not expect any material difference in transmission losses between options.
Changes in Australian greenhouse gas emissions	Neither option is expected to introduce a material change in Australian greenhouse gas emissions.

[13] NER, clause 5.15A.2(b)(4)-(6).
[14] AER, *Regulatory Investment Test for Transmission Application Guidelines,* November 2024, p.56-57.
[15] AER, *Regulatory Investment Test for Transmission Application Guidelines,* November 2024, p.56-57.

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 Assessment against the base case

The costs and benefits of each option in this document are compared against a ‘do nothing’ base case. Under this base case, no proactive capital investment is made to remediate the deterioration of the high voltage and secondary systems assets at Tamworth substation. We incur regular and reactive maintenance costs, and environmental, safety and financial related risks costs, that are caused by the failure of assets at Tamworth substation. In addition, there would be a small avoided cost of routine operating and maintenance costs in Option 1 compared to the base case.

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.[16]

5.2 Assessment period and discount rate

The RIT-T analysis considers a 20-year assessment period from 2024/25 to 2043/44. A 20-year period takes into account the size, complexity and expected asset life of the secondary systems and provides a reasonable indication of the costs and benefits over a long outlook period.

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 have been calculated based on the undepreciated value of capital costs at the end of the analysis period and expected operating and maintenance cost for the remaining asset life. As a conservative assumption, we have effectively assumed that there are no additional cost and benefits after the analysis and period.

A real, pre-tax discount rate of 7 per cent has been adopted in all scenarios presented in this PACR, consistent with AEMO’s 2023 Inputs, Assumptions and Scenarios Consultation Report (IASR).[17] 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 Central scenario results to a lower bound discount rate of 3.63 per cent.[18] We have also adopted an upper bound discount rate of 10.5 per cent (i.e., AEMO’s 2023 Inputs, Assumptions and Scenarios Report).[19]

[16] Transgrid notes that the AER RIT-T Guidelines state that the base case is where the RIT–T proponent does not implement a credible option to meet the identified need, but rather continues its 'BAU activities'. The AER define 'BAU activities' as ongoing, economically prudent activities that occur in the absence of a credible option being implemented. (See: AER, *Regulatory Investment Test for Transmission Application Guidelines,* November 2024, p.21).

[17] AEMO '2023 Inputs, Assumptions and Scenarios Report', July 2023, p 123.

[18] This is equal to WACC (pre-tax, real) in the latest final decision for a transmission business in the NEM (Transgrid) as of the date of this analysis, see: AER, TasNetworks – 2024-29 – Final decision – PTRM, April 2024, WACC sheet.

[19] AEMO '2023 Inputs, Assumptions and Scenarios Report', July 2023, p 123.

5.3 Approach to estimating option costs

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

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).[20]

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

All cost estimates are prepared in real, 2024/25 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. Given that there is a minor incremental routine operating and maintenance costs saving in Option 1 compared to the base case, this is a net benefit in the assessment.

5.4 Value of customer reliability

Consistent with the AER's RIT-T Guideline, we have developed VCR estimates that are based on the estimates developed and consulted on by the AER, weighted to reflect the mix of customers that are likely to be affected by the options.

We have applied a NSW-wide VCR value based on the estimates developed and consulted on by the AER.[21] We have used this VCR as we consider this reasonably reflects the mix of customers supplied from the Tamworth substation, which includes residential, agricultural and industrial customers.

5.5 Three different scenarios have been modelled

The RIT-T must include any of the ISP scenarios from the most recent IASR that are relevant unless:[22]

- the RIT–T proponent demonstrates why it is necessary to vary, omit or add a reasonable scenario to what was in the most recent IASR, and
- the new or varied reasonable scenarios are consistent with the requirements for reasonable scenarios set out in the RIT–T instrument.

The AER's RIT-T Guidelines clarifies that the number and choice of reasonable scenarios must be appropriate to the credible options under consideration, and that the choice of reasonable scenarios must

[20] 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.
[21] This VCR is equal to the $49,216 within AEMO's July 2023 2023 Inputs, Assumptions and Scenarios Report inflated to September 2024.
[22] AER, *Regulatory investment test for transmission*, November 2024.

reflect any variables or parameters that are likely to affect the ranking or sign of the net benefit of any credible option.[23]

For the purposes of this RIT-T, we consider that the ISP scenarios are not relevant. The key input parameter that is likely to affect the ranking or sign of the net market benefits of the credible options is the probability of failure and consequence of failure of the assets at Tamworth substation. The probability and consequence is assessed by reference to the condition of the asset under consideration and the reliability, safety, environmental and financial consequences. These are independent from the assumptions underpinning the ISP scenarios. It follows that adopting the ISP scenarios would not be consistent with adopting scenarios that reflect parameters that could reasonably change the ranking or sign of the net market benefits of the credible options.

In line with the RIT-T Guideline, we have constructed reasonable alternative scenarios. To do this, we developed a **Central Scenario** which reflects our best estimate of each of the modelling parameters, including the asset risk (probability of failure and consequence of failure), expected unserved energy, and capital and operating costs. We developed the Central Scenario around a static model of demand scenarios, described further in our Section A.3 of our Network Asset Criticality Framework. We consider that this approach is appropriate since it materially reduces the computational effort required, and since differences in demand forecasts will not materially affect the sign or ranking of the credible options.

As indicated above, we consider that the key input parameter that is likely to affect the ranking or sign of the net market benefits of the credible options is the asset failure risk of the identified high voltage and secondary systems assets. We do not consider that variations in other parameters of the Central Scenario are likely to affect the outcome of the RIT-T assessment. In view of this, we have developed additional reasonable scenarios that reflect variations in the asset risk while holding other parameters the same as the Central Scenario.

Specifically, we have developed the following additional scenarios:

- A **High Risk Costs Scenario**, where the asset failure risk is 25% higher than in the Central Scenario. This higher risk would be expected to increase the frequency and duration of outages, and safety, environmental and financial risk costs, in the base case (as compared with the Central Scenario). We have modelled this scenario by increasing our estimate of gross benefits associated with avoided unserved energy and risk costs in this scenario by 25%.
- A **Low Risk Costs Scenario**, where the asset failure risk is 25% lower than in the Central Scenario. This lower failure risk would be expected to reduce the frequency and duration of outages, and safety, environmental and financial risk costs, in the base case (as compared with the Central Scenario). We have modelled this scenario by reducing our estimate of gross benefits associated with avoided unserved energy and risk costs in this scenario by 25%.

The NPV results in this PACR are reported for each scenario, as well as on a weighted basis. As we have no evidence or rationale for assigning a higher probability for one reasonable scenario over another, we have weighted each reasonable scenario equally.[24]

A summary of the key variables in each scenario is provided in the table below.

[23] AER, *Regulatory investment test for transmission: Application guidelines*, November 2024, p.42-44.
[24] As per: AER, *Regulatory investment test for transmission: Application guidelines*, November 2024, p.51.

Table 5-1 Summary of scenarios

Variable / Scenario	Central scenario	Low risk costs scenario	High risk costs scenario
Scenario weighting	1/3	1/3	1/3
Discount rate	7.0%	7.0%	7.0%
VCR ($2024/25 m)	51,196/MWh	51,196/MWh	51,196/MWh
Network capital costs	Base estimate	Base estimate	Base estimate
Avoided unserved energy	Base estimate	Base estimate - 25%	Base estimate + 25%
Safety, environmental and financial risk benefit	Base estimate	Base estimate - 25%	Base estimate + 25%
Avoided routine operating and maintenance costs	Base estimate	Base estimate	Base estimate

5.6 Sensitivity analysis

In addition to the scenario analysis, we have also considered the robustness of the outcome of the cost benefit analysis through undertaking various sensitivity testing.

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

- Optimal timing of the project
- Alternate scenario weights
- Higher or lower VCRs
- Higher or lower network capital costs of the credible options
- 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.

6. Assessment of credible options

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

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. The results have been presented separately for each credible scenario, and on a weighted basis.

The benefits included in this assessment are:

- Reduction of risk as valued as direct impact to Transgrid and consumers including:
  - Changes in involuntary load shedding
  - Safety and environmental hazards associated with a catastrophic failure.
- Avoided operating expenditure related to an escalation of corrective maintenance.

Table 6-1 NPV of gross economic benefits relative to the base case ($2024/25 m)

Option	Central scenario	Low risk costs scenario	High risk costs scenario	Weighted scenario
Scenario weighting	*1/3*	*1/3*	*1/3*	
Option 1	639.85	479.89	799.82	639.85
Option 2	157.15	117.87	196.44	157.41

Option 1 produces larger gross benefits under all scenarios.

6.2 Estimated costs

The table below summarises the present value of capital costs of each credible option relative to the base case. The results have been presented separately for each credible scenario, and on a weighted basis.

Table 6-2 NPV of capital costs relative to the base case ($2024/25 m)

Option	Central scenario	Low risk costs scenario	High risk costs scenario	Weighted scenario
Scenario weighting	*1/3*	*1/3*	*1/3*	
Option 1	17.01	17.01	17.01	17.01
Option 2	2.34	2.34	2.34	2.34

Option 2 is lower cost under all scenarios.

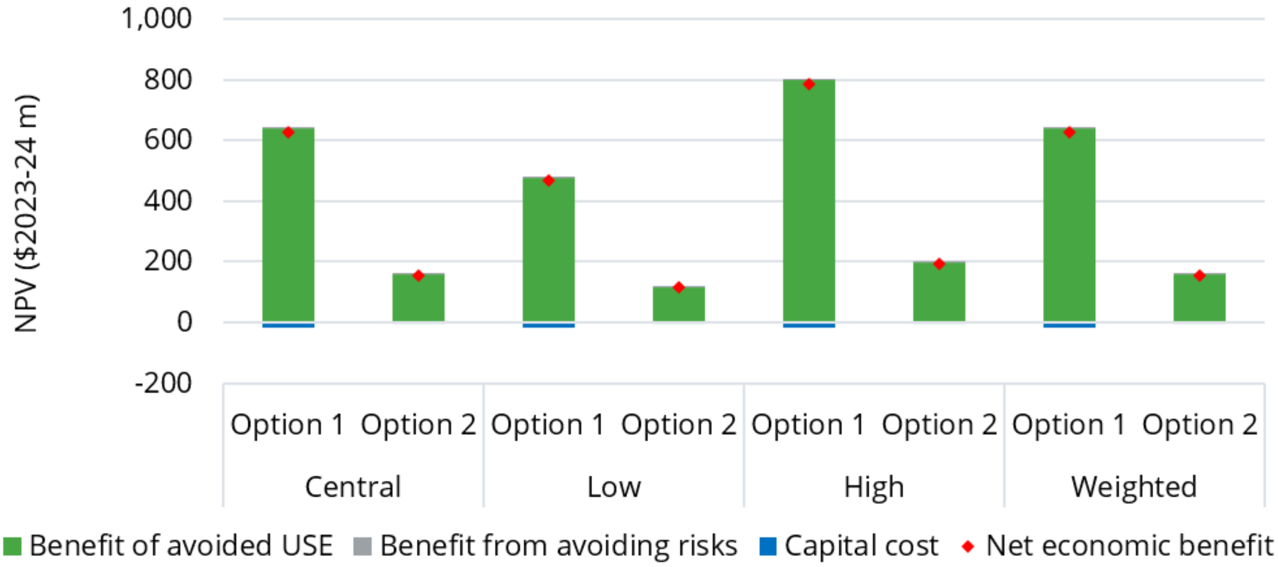
6.3 Estimated net economic benefits

The net economic benefits are calculated as the estimated gross benefits less the estimated costs plus the terminal value. The table below summarises the present value of the net economic benefits for each credible option. The results have been presented separately for each reasonable scenario, and on a weighted basis.

Table 6-3 NPV of net economic benefits relative to the base case ($2024/25 m)

Option	Central scenario	Low risk costs scenario	High risk costs scenario	Weighted scenario
Scenario weighting	*1/3*	*1/3*	*1/3*	
Option 1	627.64	467.68	787.61	627.42
Option 2	155.07	115.71	194.42	155.07

Figure 6-1 NPV of net economic benefits ($2024/25 m)



Option 1 has the greatest net market benefits under each scenario and the weighted scenario and is therefore our preferred option.

6.4 Sensitivity testing

We have undertaken sensitivity testing to examine how the net economic benefit of the credible options changes with respect to changes in key modelling assumptions. The factors tested as part of the sensitivity analysis for this PACR are:

- Optimal timing of the project
- Alternate scenario weights
- Higher or lower VCRs
- Higher or lower network capital costs of the credible options
- Alternate commercial discount rate assumptions.

The sensitivity testing was undertaken as against the central scenario. Specifically, we individually varied each factor identified above and estimated the net economic benefit in that scenario relative to the base case while holding all other assumptions under the central scenario constant. The results of the sensitivity tests are set out in the sections below.

6.4.1 Optimal timing of the project

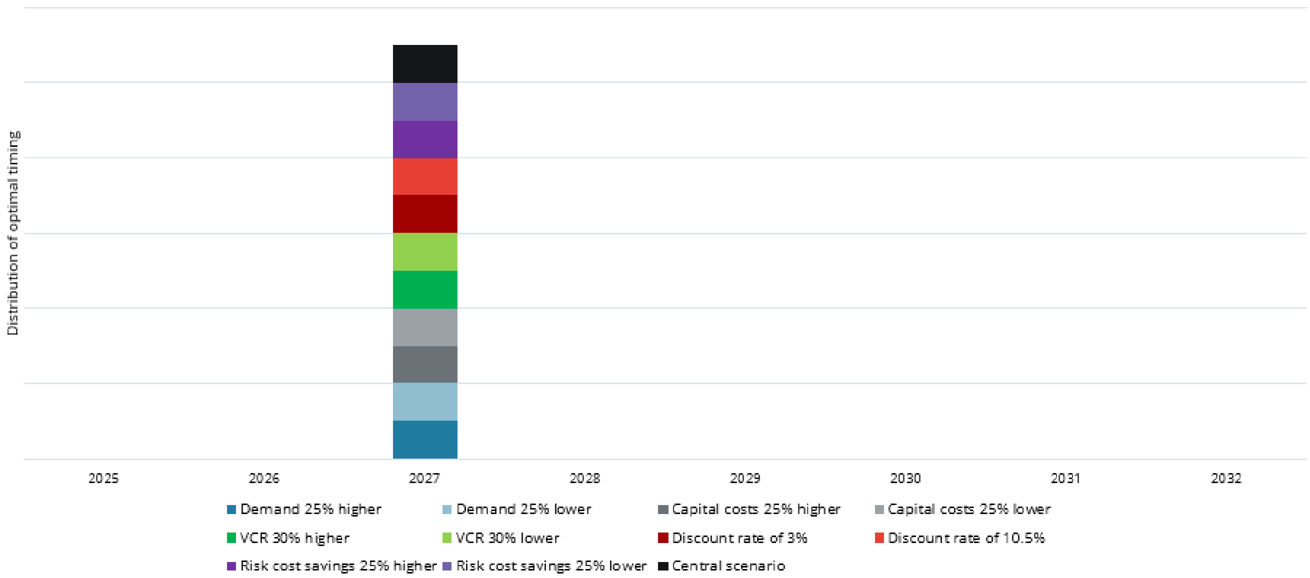
We have estimated the optimal timing for the preferred option. The optimal timing of an investment is the year when the annual benefits (avoided risk costs) from implementing the option become greater than the annualised investment costs. The analysis was undertaken under the central set of assumptions and a range of alternative assumptions for key variables. The purpose of the analysis is to examine the sensitivity of the commissioning year to changes in the underlying assumptions.

The sensitivities we considered are:

- a 25% increase / decrease in capital costs
- a 25% increase / decrease in demand
- a lower discount rate of 3.63% and a higher discount rate of 10.5%
- a 30% increase / decrease in the VCR
- a 25% increase / decrease in reliability, safety, environmental and financial risk costs

The results of this analysis are presented in the figure below. In all cases, the optimal timing for the preferred option is 2026/27.

Figure 6-2 Distribution of optimal timing under a range of different key assumptions



6.4.2 Scenario weights

There are no alternative scenario weights that will change the RIT-T outcome (i.e., lead to the identification of a different preferred option, or no preferred option).

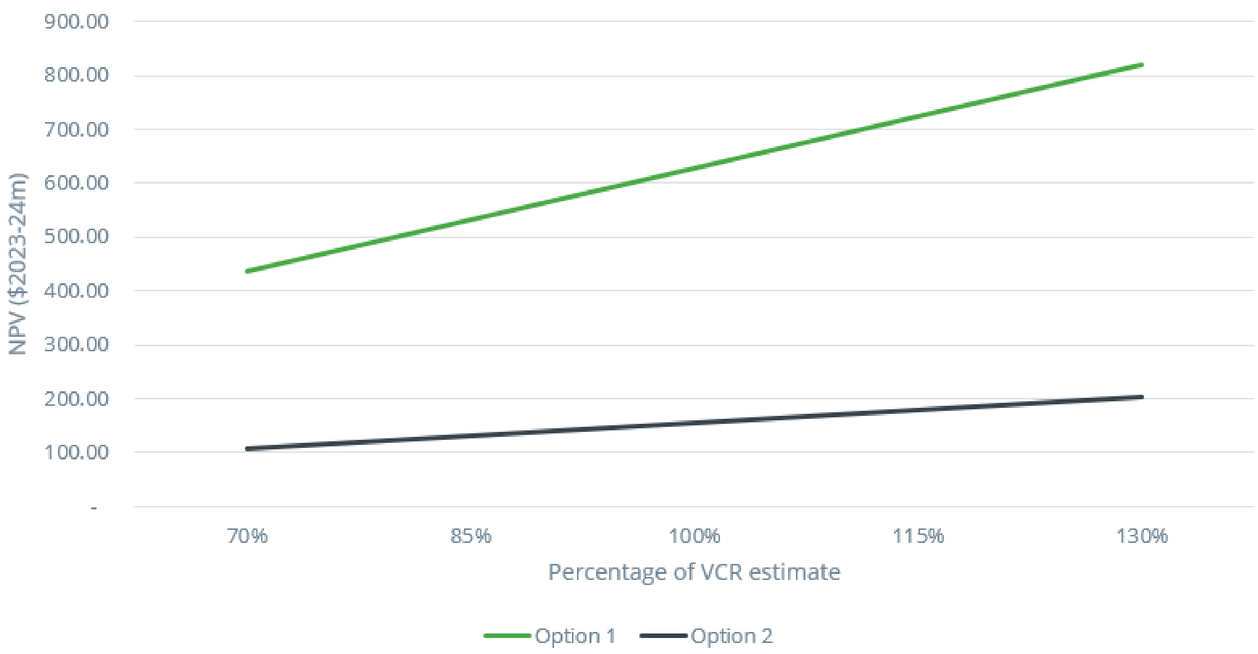
6.4.3 Value of customer reliability

We estimated the net economic benefit of each option by adopting a VCR that is 30% higher (the 'High VCR' scenario) and 30% lower (the 'Low VCR' scenario) than the estimate of VCR adopted in our central scenario. The results of this analysis are presented in the table and figure below.

Table 6-4 Sensitivity of net economic benefits under a lower and higher VCR ($2024/25 m)

Option/scenario	Low VCR	High VCR	Ranking
Sensitivity	*Central estimate - 30%*	*Central estimate + 30%*	
Option 1	436.11	819.18	1
Option 2	107.92	202.21	2

Figure 6-3 Sensitivity of net economic benefits under a lower and higher VCR ($2024/25 m)



Option 1 remains the preferred option under both a low and high VCR scenario.

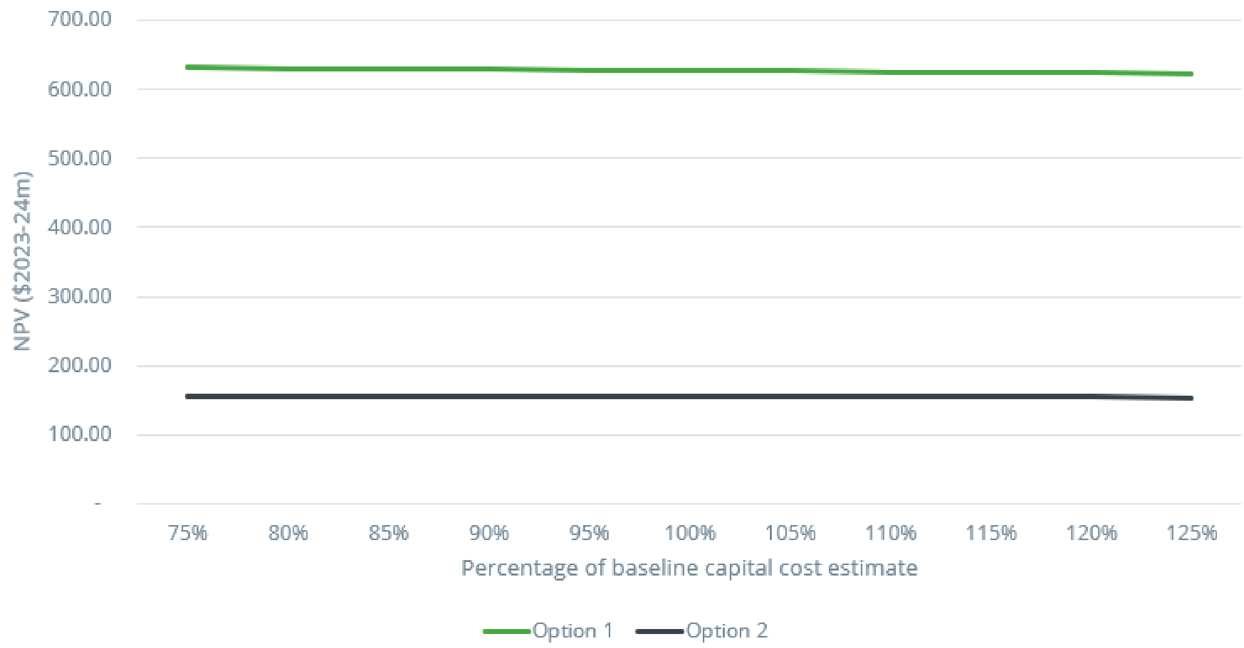
6.4.4 Network capital costs

We estimated the net economic benefit of each option by adopting capital costs for each option that are 25% higher (the 'High capex' scenario) and 25% lower (the 'Low capex' scenario) than the capital cost estimates in our central scenario. The results of this analysis are presented in the table and figure below.

Table 6-5 Sensitivity of net economic benefits under lower and higher capital costs ($2024/25 m)

Option/scenario	Low capex	High capex	Ranking
Sensitivity	*Central estimate - 25%*	*Central estimate + 25%*	
Option 1	631.90	623.29	1
Option 2	155.65	154.48	2

Figure 6-4 Sensitivity of net economic benefits under lower and higher capital costs ($2024/25 m)



Option 1 remains the preferred option under both a low and high capital cost scenario.

We have also undertaken a threshold analysis to identify whether a change in capital cost estimates would change the RIT-T outcome. Specifically, we considered the level of increase in the capital costs of Option 1 to change the RIT-T outcome (i.e. the base case or Option 2 to be the preferred option). Our results suggests that there is no reasonable change in capital costs that would change the expected net benefit to negative, we therefore consider the expected positive net benefits provided by Option 1 to be robust to reasonable capital cost sensitivities.

6.4.5 Discount rate

We estimated the net economic benefit of each option by adopting a low discount rate of 3.63% which is consistent with the AER's latest final determination for a TNSP (the 'Low discount rate' scenario),[25] and a high discount rate of 10.5% which aligns with the high discount rate scenario in the 2023 IASR (the 'High discount rate' scenario).[26] The results of this analysis are presented in the table and figure below.

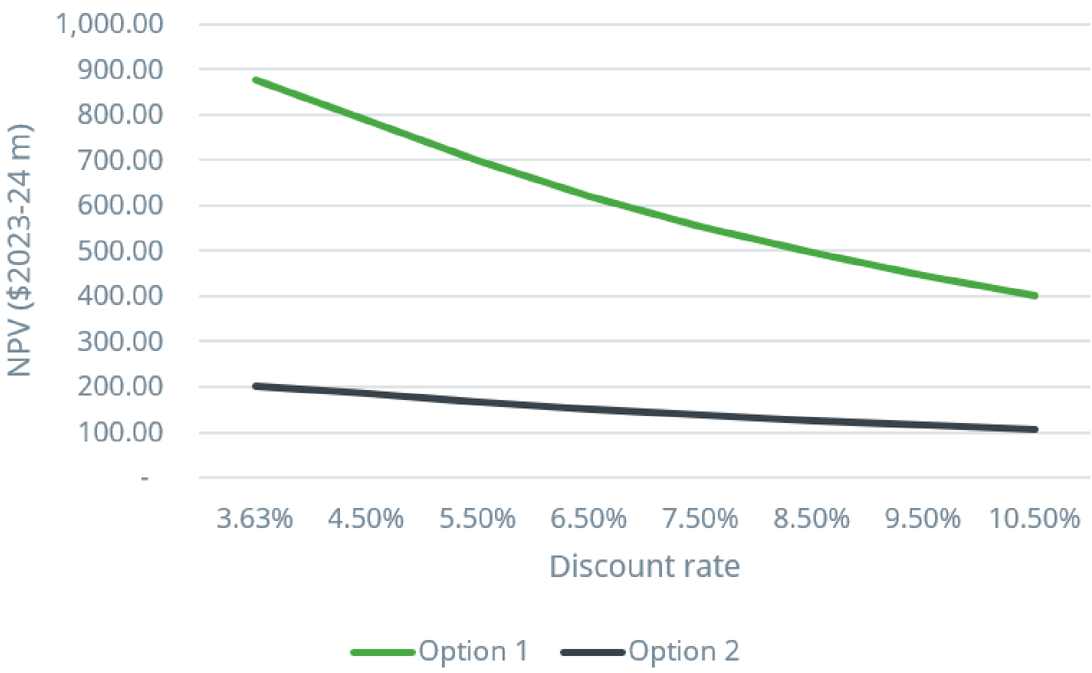
Table 6-6 Sensitivity of net economic benefits under a lower and higher discount rates ($2024/25 m)

Option/scenario	Low discount rate	High discount rate	Ranking
Sensitivity	*3.63%*	*10.5%*	
Option 1	876.95	400.06	1
Option 2	202.55	106.21	2

25 This is equal to WACC (pre-tax, real) in the latest final decision for a transmission business in the NEM (Transgrid) as of the date of this analysis, see: Final decision | Australian Energy Regulator (AER)https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/transgrid-determination-2023–28/final-decision

26 AEMO '2023 Inputs, Assumptions and Scenarios Report', July 2023, p 123.

Figure 6-5 Sensitivity of net economic benefits under a lower and higher discount rates ($2024/25



We have also undertaken a threshold analysis to identify whether a change in the discount rate would change the RIT-T outcome. Our approach involved solving for the discount rate that would result Option 1 not being the preferred option (i.e. the base case or Option 2 becoming the preferred option). Our results suggests that there is no reasonable discount rate that would change the expected net benefit to negative, we therefore consider the expected positive net benefits provided by Option 1 to be robust to reasonable discount rate sensitivities.

7. Final conclusion on the preferred option

This PACR finds that Option 1 is the preferred option to address the identified need.

Option 1 involves replacement of the Tamworth No. 1 and No 2 transformers. Implementation of Option 1 is expected to reduce the probability of failure of the power transformer at Tamworth substation. This will reduce the frequency and duration of involuntary load shedding associated with the failure of this asset. Option 1 will also reduce the risk of asset failure, which will in turn reduce associated environmental, safety and financial risk costs.

The capital cost of this option is approximately $20.32 million (in $2024/25). The expected project timeframe is 48 months with an expected asset life of 45 years. Routine operating and maintenance costs are estimated at approximately $1,141 per annum (in $2024/25).

Option 1 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 or transport electricity in the market. The analysis undertaken and the identification of Option 1 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 220.

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) See below.	See below
	(2) a summary of, and the RIT-T proponent's response to, submissions received, if any, from interested parties sought	N/A
5.16.4(k)	A RIT-T proponent must prepare a report (the assessment draft report), which 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;	N/A
	(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 & Appendix B & C
	(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);	4
	(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;	6
	(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
	(10) if each of the following apply to the RIT-T project: (i) if estimated capital cost of the proposed preferred option is greater than $103 million (as varied in accordance with a cost threshold determination); and (ii) AEMO is not the sole RIT-T proponent, the reopening triggers applying to the RIT-T project.	N/A
5.16.4(z1)	A RIT-T proponent is exempt from preparing a PADR (paragraphs (j) to (s)) if: 1. the estimated capital cost of the proposed preferred option is less than $35 million[27] (as varied in accordance with a cost threshold determination);	1

[27] Varied to $54m based on the AER Final Determination: Cost threshold review, November 2024.

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

In addition, the table below outlines a separate compliance checklist demonstrating compliance with the binding guidance in the latest AER RIT-T guidelines.

Guidelines section	Summary of the requirements	Section in the PSCR
3.5A.1	Where the estimated capital costs of the preferred option exceeds $103 million (as varied in accordance with a cost threshold determination), a RIT-T proponent must, in a RIT-T application: i. outline the process it has applied, or intends to apply, to ensure that the estimated costs are accurate to the extent practicable having regard to the purpose of that stage of the RIT-T ii. for all credible options (including the preferred option), either • apply the cost estimate classification system published by the AACE, or • if it does not apply the AACE cost estimate classification system, identify the alternative cost estimation system or cost estimation arrangements it intends to apply, and provide reasons to explain why applying that alternative system or arrangements is more appropriate or suitable than applying the AACE cost estimate classification system in producing an accurate cost estimate	NA
3.5A.2	For each credible option, a RIT-T proponent must specify, to the extent practicable and in a manner which is fit for purpose for that stage of the RIT-T: i. all key inputs and assumptions adopted in deriving the cost estimate ii. a breakdown of the main components of the cost estimate iii. the methodologies and processes applied in deriving the cost estimate (e.g. market testing, unit costs from recent projects, and engineering-based cost estimates) iv. the reasons in support of the key inputs and assumptions adopted and methodologies and processes applied v. the level of any contingency allowance that have been included in the cost estimate, and the reasons for that level of contingency allowance	6.2
3.5.3	The RIT-T proponent is required to provide the basis for any social licence costs in their RIT-T reports, and may choose to refer to best practice from a reputable, independent and verifiable source.	NA[28]
3.8.2	Where the estimated capital cost of the preferred option exceeds $103 million (as varied in accordance with an applicable cost threshold determination), a RIT-T proponent must undertake sensitivity analysis on all credible options, by varying one or more inputs and/or assumptions.	NA
3.9.4	If a contingency allowance is included in a cost estimate for a credible option, the RIT-T proponent must explain: • the reasons and basis for the contingency allowance, including the particular costs that the contingency allowance may relate to, and • how the level or quantum of the contingency allowance was determined.	NA
4.1	RIT-T proponents are required to describe in each RIT-T report • how they have engaged with local landowners, local council, local community members, local environmental groups or traditional owners and sought to address any relevant concerns identified through this engagement • how they plan to engage with these stakeholder groups, or • why this project does not require community engagement	NA[28]

28 These are new requirements stipulated in revised RIT-T Application Guidelines released by the AER, which came into effect on 21 November 2024. For compliance purposes, the AER only have regard to the guidance that was in effect when Transgrid initiated the RIT-T in question. In this context, initiated means from the publication of a project specification consultation report (PSCR). As the PSCR was published prior to 21 November 2024, these new requirements are not applicable to this RIT-T.

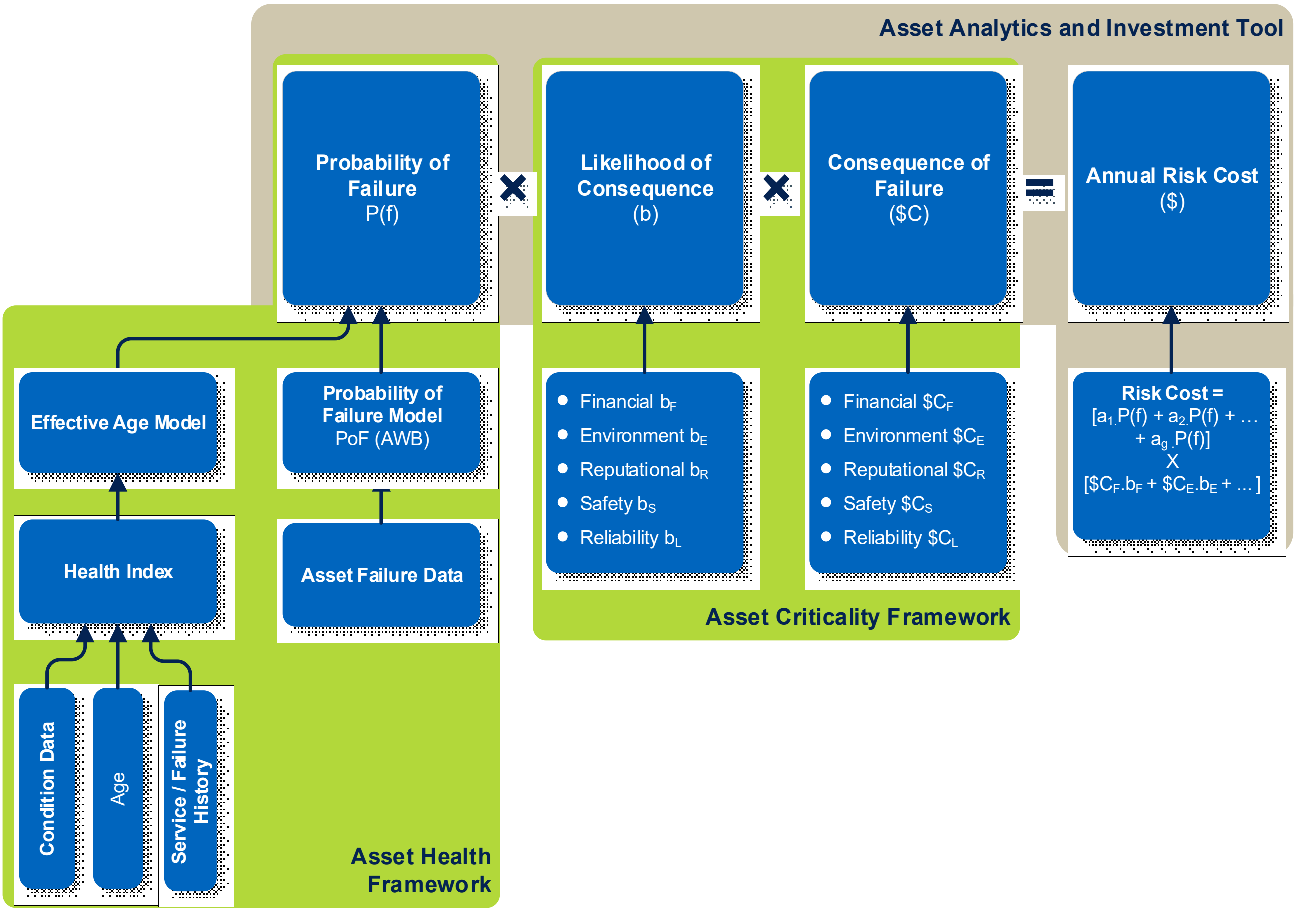
Appendix B Risk assessment framework

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[29] 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-1 illustrates the base risk equation that we apply.

Figure B-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 and costs. The major quantified risks we apply for Repex justifications include asset failures that materialise as:

29 Industry practice application note - Asset replacement planning, AER July 2024

- 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 probability of failure of an asset is determining the Asset Health and associated effective age,[30] which considers:

- 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. 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.
- '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 Probability of Failure (PoF) is the likelihood that an asset will fail during a given period resulting in a particular adverse event.

The outputs of the Probability of Failure (PoF) calculation are one or more probability of failure time series which provide a mapping between the effective age, discussed above, 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 assets are summarised in the table below.

Asset	Weibull parameters	
	η	β
Transformer	54.21	3.61
Oil Reactor	38.84	2.95
Circuit Breaker	47.76	4.3
Oil filled Current Transformer	50	3.08
Magnetic Voltage Transformer	50	3.8
Capacitive Voltage Transformer	50	3.8
Disconnector	67	4.8
Surge Arrester	55	3.2
Auxillary Transformer	70	4.5
Capacitor bank	50	4.5
Multifunction Intelligent Electronic Device:	14.3	1.78

30 Apparent age of an asset based on its condition.

- Protection - Controller - Telecommunication		
Protection Relay - Solid State	32.7	1.24
Protection Relay - Electromechanical	92.9	1.57
Protection Relay - Intertrip	26.2	1.54
Remote Terminal Unit	22.5	1.77
PC	12.7	2.09
Meter - Microprocessor	15.5	1.74
DC Battery	16.5	1.49
DC Charger	19.8	1.24