Managing asset risks at Forbes substation

RIT-T – Project Assessment Conclusions Report

Region: Central

Date of issue: 30 November 2020

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Executive summary

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating the risks caused by the deteriorating condition of transformers at Forbes substation. Publication of this Project Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

Forbes 132/66 kV substation is located on TransGrid's Central NSW network. It connects two of TransGrid's 132 kV transmission lines — Line 94U to Parkes and Line 998 to Cowra. It also connects the Essential Energy distribution network and supports approximately 200 MW of existing renewable generation in the area[1].

Forbes substation will continue to play a central role in the safe and reliable operation of the power system. The substation is located within an area of interest for new renewable connections.

There are two transformers at Forbes substation (No.1 Transformer and No.2 Transformer), which are used to change the voltages levels. Different voltages are used for generation, high voltage transmission and local distribution. The transformers at Forbes substation are essential for the safe and reliable transmission of electricity to the Central NSW network. The transformers were both commissioned in 1969 and have now reached the end of serviceable life. Both transformers are showing signs of deterioration attributable to ageing. Table E-1 outlines the condition issues on Transformer 1 and 2 at Forbes substation, the impact of those condition issues if not remediated, and the consequences if no action is taken.

Table E-1 Condition issues at Forbes substation, their potential impacts and consequences

Issue	Potential impact	Consequence
Carbon particle contamination	Carbon is a conductor and there can be a tendency for the individual particles to accumulate in areas of strong high electric fields. This could lead to electrical breakdown resulting in a catastrophic failure of the transformer.	Increased risk of prolonged and frequent involuntary load shedding
Paper insulation moisture	The transformer insulation system is based on special papers impregnated with insulating oil. Moisture acts to increase the rate of degradation of the paper insulating system. At high levels, it may compromise the insulation. The papers provided insulation and also support the structure of the transformer winding. Over time and with load and the presence of moisture, the paper becomes embrittled. This may progress to the point where a mechanical shock caused by a	

[1] Summation of approximate load from Molong Solar Farm, Manildra Solar Farm, Parkes Solar Farm, and Goonumbla Solar Farm.

	through fault can result in electrical failure.	
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.	
Mechanical failure of the tap changer	The tapchanger switches the voltage ratio on the transformer while it is under load. It is a mechanical device and in the case of failure, large amounts of energy are expected to be released and transformer loss is likely.	Lack of voltage control at Forbes substation

These condition issues, if not remediated, will increase the risk of failures at Forbes substation resulting in prolonged and frequent involuntary load shedding on the Central NSW network.

Identified need: avoid prolonged and frequent involuntary load shedding in Central NSW attributed to deteriorating asset condition at Forbes substation

The transformers at Forbes substation play a central role in supplying electricity to TransGrid's Central NSW transmission network.

If the deteriorating asset condition at Forbes substation is not addressed by a technically and commercially feasible credible option in sufficient time (by 2022/23), the likelihood of prolonged and involuntary load shedding in the Central West will increase.

In addition to the market benefit of avoided prolonged and frequent involuntary load shedding, the proposed investment will also assist TransGrid to manage and mitigate safety risks that would otherwise arise from continued deterioration of asset condition. Rectifying the worsening condition of the transformers will reduce safety risks, as well as lower planned and unplanned corrective maintenance costs. However, these costs are of small magnitude compared to the cost of prolonged and frequent involuntary load shedding and do not affect the preference amongst the options[2].

No submissions received in response to Project Specification Consultation Report

TransGrid published a Project Specification Consultation Report (PSCR) on 14 August 2020 and invited written submissions on the material presented within the document. No submissions were received in response to the PSCR.

[2] TransGrid manages and mitigates safety risk to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with TransGrid's obligations under the New South Wales *Electricity Supply (Safety and Network Management) Regulation 2014* and TransGrid's Electricity Network Safety Management System (ENSMS). In particular, risks for TransGrid and its consumers are mitigated unless it is possible to demonstrate that the cost involved in further reducing the risk would be grossly disproportionate to the benefit gained.

No developments since publication of the PSCR

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

Option 1 remains the preferred option at this stage of the RIT-T process.

Replacement of both transformers with new assets remains the most prudent and economically efficient option to avoid prolonged and frequent involuntary load shedding

In the PSCR, TransGrid put forward for consideration two credible options that would meet the identified need from a technical, commercial, and project delivery perspective.[3]

- **Option 1** – Replace Transformer No.1 and No.2 with new assets; and
- **Option 2** – Replace Transformer No.1 with a new asset and replace Transformer No.2 with a redeployed asset

The implementation of Option 1, replacing No.1 and No.2 transformers with new 132/66 kV 60 MVA transformers at Forbes substation, remains the most efficient technically and commercially feasible option at this stage of the RIT-T process. Option 1 addresses the identified need, offers the most benefit to consumers, and can be implemented in sufficient time to meet the identified need (by 2022/23). The investment will also assist TransGrid to manage and mitigate safety risks that would otherwise arise from continued deterioration of asset condition. It is therefore the preferred option presented in this PACR.

TransGrid expects coronavirus (COVID-19) to impact its suppliers and disrupt their supply chains. TransGrid has preliminary advice that this is already occurring, although at this time the extent of the current or future impact is unknown. Consequently, some of the costs associated with the works outlined in this document may be affected.

All costs presented in this PACR are in 2020/21 dollars. The options are summarised in the table below.

Table E-2 Summary of credible options

Option	Transformer No.1	Transformer No.2	Capital cost ($m 2020/21)	Operating costs ($ per year)	Remarks
Option 1	**Replace with new asset**	**Replace with new asset**	**~9.1 (+/- 25%)**	**~1,000**	**Preferred option, would maintain regulatory obligations and provide highest net economic benefits**
Option 2	Replace with new asset	Replace with redeployed asset	~8.1 (+/- 25%) Additional 3.6m in 2036/37 to replace redeployed asset	~1,100	Would maintain regulatory obligations but provide less net benefits to consumers.

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

TransGrid also considered whether there are other credible options that would meet the identified need. Other options that are not considered credible include:

> As both transformers are of similar age and condition, replacing one transformer and leaving the other unit in service would result in increasing risk over time to an unacceptable level. TransGrid proposes to remediate both transformers in order to mitigate the risks associated with catastrophic failure as they approach end of life.
> Refurbishment of the Forbes transformers would provide no improvement to their underlying condition and therefore risk of failure. This is because of the inherent nature of the issues are affecting the oil, main tank and tap changer.
> Replacing one transformer and decommissioning the other is also not feasible as TransGrid must maintain reliability standards for the Forbes bulk supply point (BSP) under the IPART - Electricity transmission reliability standards[4].

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

TransGrid does not consider non-network options to be commercially feasible to assist with meeting the identified need for this RIT-T. Although technically feasible, TransGrid does not consider non-network options are able to cost-effectively defer the need for a second transformer replacement. Specifically, to be considered equal to or cheaper than Option 1, non-network solutions would need to cost below $8/kW for a minimum of 37 MW.

For non-network options to efficiently reduce the risk of unserved energy, non-network solutions would need to have higher economic net benefits than the incremental network option.

Notwithstanding the above, TransGrid set out the required technical characteristics for non-network options in the PSCR, consistent with the requirements of the RIT-T and invited interested parties to make submissions regarding non-network options that satisfy, or contribute to satisfying, the identified need.

No non-network submissions were received in response to the PSCR.

Net economic benefits have been assessed under three different scenarios

The assessment was conducted under three net economic benefits scenarios. These are plausible scenarios which reflect different assumptions about the future market development and other factors that are expected to affect the relative economic benefits of the options being considered. All scenarios (low, central and high) involve a number of assumptions that result in the lower bound, the expected, and the upper bound estimates for present value of net economic benefits respectively.

A key expected driver of the net economic benefits is the Value of Customer Reliability (VCR) and the underlying demand forecast since avoided EUE is the primary market benefit. TransGrid has applied a VCR estimate of $42.90/kWh in the central scenario and +/-30 per cent for the other two scenarios, which is consistent with the AER's VCR review released in December 2019[5].

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

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4 IPART Electricity transmission reliability standards Final Report, August 2016, Appendix B Recommended reliability standards, Section 8 Table of Values.

5 The central estimate of $42.90/kWh reflects an inflation adjustment to the load weighted VCR estimate for NSW and ACT ($42.12/kWh). The confidence interval selected is also drawn from the AER's VCR review. AER, *Value of Customer Reliability Review – Final report*, December 2019, pp 71 (Table 5.22) & 84. https://www.aer.gov.au/system/files/AER%20-%20Values%20of%20Customer%20Reliability%20Review%20-%20Final%20Report%20-%20December%202019.pdf.

Table E-3 Summary of scenarios

Variable / Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Discount rate	5.90%	9.57%	2.23%
Costs			
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Benefits (negative benefits)			
Reduction in operating and maintenance costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Reduction in safety and environmental risk costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Reduction in financial risks	Base estimate	Base estimate - 25%	Base estimate + 25%
Demand forecasts	Based on POE50 demand forecasts	Based on POE90 demand forecasts	Based on POE10 demand forecasts
Value of Customer Reliability (VCR)	The AER's VCR	The AER's VCR - 30%	The AER's VCR + 30%

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

Option 1 delivers the highest net economic benefits

In the central and high benefit scenarios, as well as on a weighted basis, positive net economic benefits result from implementing Option 1 as demonstrated in the table below.

Table E-4 Estimated net economic benefits from credible options relative to the base case, present value ($m 2020/21)

Option	Central	Low benefit scenario	High benefit scenario	Weighted	Ranking
Scenario weighting	*50%*	*25%*	*25%*		
Option 1 – Replace both transformers with new transformers	35.9	11.6	77.2	40.2	1
Option 2 – Replace No.1 transformer with a new transformer and replace No.2 transformer with a redeployed transformer from another site	35.0	11.5	75.1	39.1	2

Sensitivity testing finds that, while the results are most sensitive to the assumed discount rate and adjustments to expected unserved energy estimates, Option 1 is still found to deliver strongly positive net benefits over a range of alternate assumptions regarding key parameters. Option 1 delivers the most benefit under all scenarios and sensitivities.

Conclusion: replacement of both transformers with new assets is optimal

The implementation of Option 1, replacing No.1 and No.2 transformers with new 132/66 kV 60 MVA transformers at Forbes substation, is the most efficient technically and commercially feasible option at this draft stage of the RIT-T process. Option 1 addresses the identified need, offers the most benefit to consumers and can be implemented in sufficient time to meet the identified need (by 2022/23). The investment will also assist TransGrid to manage and mitigate safety risks that would otherwise arise from continued deterioration of asset condition. It is therefore the preferred option presented in this PACR.

This preferred option, Option 1, is found to have positive net benefits under all scenarios investigated and on a weighted basis will deliver $40.2 million in net economic benefits. TransGrid also conducted sensitivity analysis on the net economic benefit to investigate the robustness of the conclusion to key assumptions. TransGrid finds that under all sensitivities, positive net benefits are expected from new transformers at Forbes.

The estimated capital cost of this option is approximately $9.1 million. Routine and operating maintenance costs are approximately $1,000 per year on average.

The works will be undertaken between 2020/21 and 2022/23. Planning (including commencement of the RIT-T) commenced in 2019/20 and is due to conclude in 2020/21.The detailed design will commence in 2020/21 with procurement and delivery of the identified assets planned to occur in 2021/22. All works will be completed by 2022/23. Necessary outages of relevant assets in service will be planned appropriately in order to complete the works with minimal impact on the network.

Next steps

This PACR represents the third and final step of the consultation process in relation to the application of the Regulatory Investment Test for Transmission (RIT-T) process undertaken by TransGrid. It follows a Project Specification Consultation Report (PSCR) released in August 2020. No submissions were received in response to the PSCR.

The second step, 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[6] due to:

- the estimated capital cost of the proposed preferred option being less than $43 million;
- the PSCR stating:
  - the proposed preferred option (including reasons for the proposed preferred option)
  - the RIT-T is exempt from producing a PADR
  - the proposed preferred option and any other credible option will not have material market benefits[7] except for voluntary load curtailment and involuntary load shedding
- the RIT-T proponent considers that there were 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 4 January 2021 (30 days after publication of this PACR[8]). 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.

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

[7] As per clause 5.16.1(c)(6)

[8] Additional days have been added to cover public holidays

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

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1. Introduction

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options to avoid prolonged and frequent involuntary load shedding in Central NSW attributed to deteriorating asset condition at Forbes substation. Publication of this Project Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

There are two transformers at Forbes substation (No.1 Transformer and No.2 Transformer), which are used to change the voltage levels. Different voltages are used for generation, high voltage transmission and local distribution. The transformers at Forbes substation are essential for the safe and reliable transmission of electricity to the Central NSW network.

If the deteriorating asset condition at Forbes substation is not addressed by a technically and commercially feasible credible option in sufficient time (by 2022/23), the likelihood of prolonged and involuntary load shedding in the Central West will increase.

In addition to the market benefit of avoided prolonged and frequent involuntary load shedding, the proposed investment will also assist TransGrid to manage and mitigate safety risks that would otherwise arise from continued deterioration of asset condition. Rectifying the worsening condition of the transformers will reduce safety risks, as well as lower planned and unplanned corrective maintenance costs. However, these costs are of small magnitude compared to the cost of prolonged and frequent involuntary load shedding and do not affect the preference amongst the options[9].

1.1 Purpose of this report

The purpose of this PACR[10] is to:

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

1.2 Exemption from preparing a Project Assessment Draft Report (PADR)

Publication of a Project Assessment Draft Report (PADR) is not required for this RIT-T as TransGrid considers its investment in relation to the preferred option to be exempt from that part of the process under NER clause 5.16.4(z1). Production of a PADR is not required due to:

> the estimated capital cost of the proposed preferred option being less than $43 million[11];
> the PSCR stating:
  – the proposed preferred option (including reasons for the proposed preferred option)

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9 TransGrid manages and mitigates safety risk to ensure they are below risk tolerance levels or ‘As Low As Reasonably Practicable’ (‘ALARP’), in accordance with TransGrid’s obligations under the New South Wales *Electricity Supply (Safety and Network Management) Regulation 2014* and TransGrid’s Electricity Network Safety Management System (ENSMS). In particular, risks for TransGrid and its consumers are mitigated unless it is possible to demonstrate that the cost involved in further reducing the risk would be grossly disproportionate to the benefit gained.

10 See Appendix A for the National Electricity Rules requirements.

11 Varied from $35m to $43m based on the AER Final Determination: Cost threshold review November 2018.14. Accessed 20 May 2020 https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/cost-thresholds-review-for-the-regulatory-investment-tests-2018

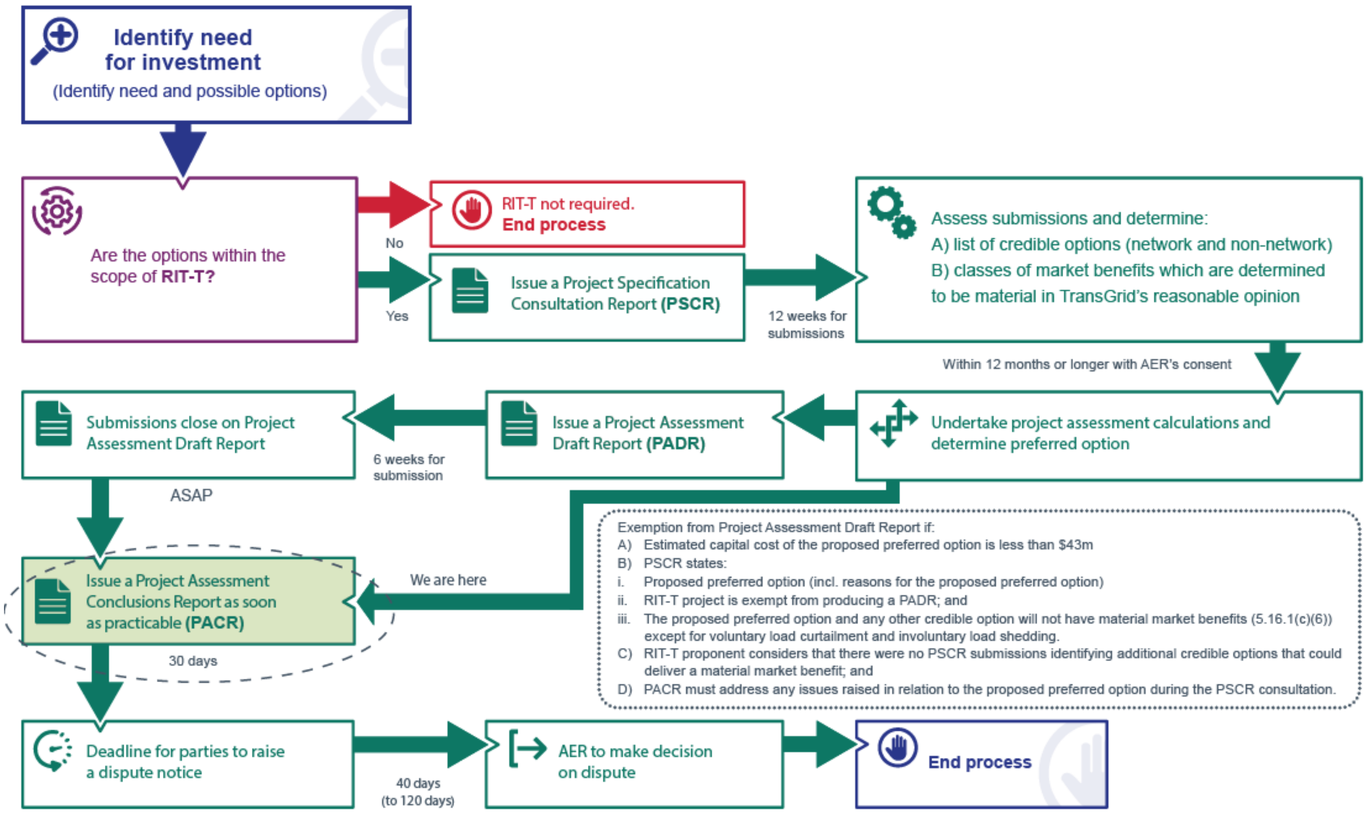
– that the RIT-T is exempt from producing a PADR
– that the proposed preferred option and any other credible option will not have material market benefits[12] except for voluntary load curtailment and involuntary load shedding

> the RIT-T proponent considers that there were 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.

1.3 Next steps

This PACR represents the third and final step of the consultation process in relation to the application of the Regulatory Investment Test for Transmission (RIT-T) process undertaken by TransGrid. It follows a Project Specification Consultation Report (PSCR) released in August 2020. No submissions were received in response to the PSCR.

Figure 1-1 This PACR is the third stage of the RIT-T process[13]



[12] As per clause 5.16.1(c)(6)

[13] Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.65. Accessed 14 May 2020. https://www.aemc.gov.au/sites/default/files/content/89fbf559-2275-4672-b6ef-c2574eb7ce05/Final-rule-determination.pdf

Parties wishing to raise a dispute notice with the AER may do so prior to 4 January 2021 (30 days after publication of this PACR[14]). 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 RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Forbes substation transformer PACR'.

[14] Additional days have been added to cover public holidays

2. The identified need

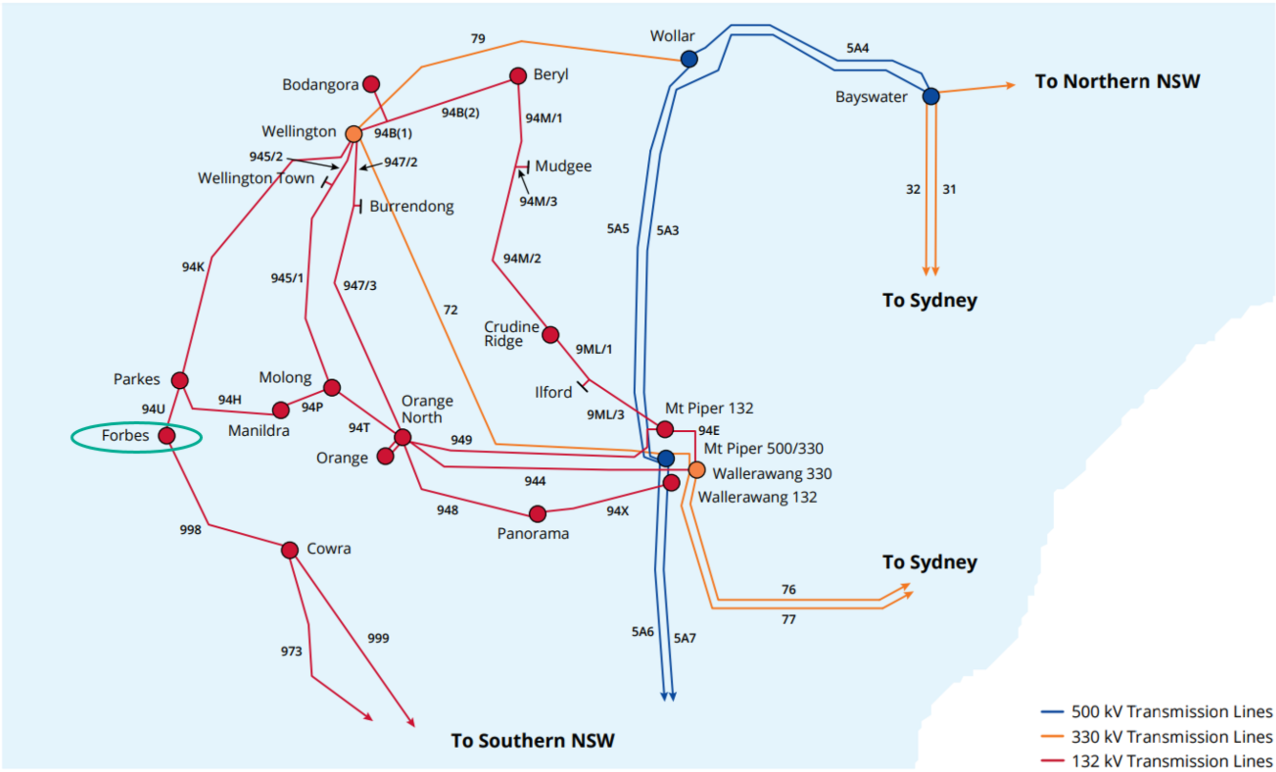
This section outlines the identified need for this RIT-T, as well as the assumptions and data underpinning it. It first sets out background information related to the Central Western NSW network and existing electricity supply arrangements.

2.1 Background to the identified need

Forbes 132/66 kV substation was commissioned in 1969 and forms part of TransGrid's network that serves the Central West region of NSW. Forbes substation connects two of TransGrid's 132 kV transmission lines — Line 94U to Parkes and Line 998 to Cowra.

The location of Forbes substation and supply arrangements for the Central NSW network is provided in Figure 2-1 below.

Figure 2-1 Central NSW transmission network



A customer connection point supplying Essential Energy in the Forbes area, Forbes substation supports the flow of electricity to local industries[15], as well as a residential population of more than 9,000[16]. TransGrid's

[15] Gross Regional Product is $594.5 million, including the Agriculture, Forestry and Fishing industry valued at $243.3 million and the manufacturing industry valued at $173 million. Forbes Shire Council, "Economic profile", accessed 22 October 2020. https://www.forbes.nsw.gov.au/business/economic-profile/economic-profile

[16] The population of Forbes Shire currently sits at 9,808. Forbes Shire Council, "Our Community", accessed 22 October 2020. https://www.forbes.nsw.gov.au/community/our-community

Central NSW network currently connects approximately 200 MW[17] of renewable generation and is an area of interest for new renewable generation projects[18].

Forbes substation will continue to play a central role in the safe and reliable operation of the power system.

TransGrid manages and mitigates safety risk to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with TransGrid's obligations under the New South Wales Electricity Supply (Safety and Network Management) Regulation 2014 and TransGrid's Electricity Network Safety Management System (ENSMS). In particular, risks for TransGrid and its consumers are mitigated unless it is possible to demonstrate that the cost involved in further reducing the risk would be grossly disproportionate to the benefit gained. The proposed investment will assist TransGrid to manage and mitigate safety risks that would otherwise arise from continued deterioration of asset condition.

2.2 Description of the identified need

The transformers at Forbes substation play a central role in supplying electricity to TransGrid's Central NSW transmission network.

If the deteriorating asset condition at Forbes substation is not addressed by a technically and commercially feasible credible option in sufficient time (by 2022/23), the likelihood of prolonged and involuntary load shedding in the Central West will increase.

In addition to the market benefit of avoided prolonged and frequent involuntary load shedding, the proposed investment will also assist TransGrid to manage and mitigate safety risks that would otherwise arise from continued deterioration of asset condition. Rectifying the worsening condition of the transformers will reduce safety risks, as well as lower planned and unplanned corrective maintenance costs. However, these costs are of small magnitude compared to the cost of prolonged and frequent involuntary load shedding and do not affect the preference amongst the options[19].

2.3 Assumptions underpinning the identified need

TransGrid adopts a risk cost methodology to quantify and evaluate the likelihood and consequences of asset failures. Appendix B provides an overview of the Risk Assessment Methodology adopted by TransGrid.

2.3.1 Deteriorating asset condition

Assessment of the condition of Transformer No.1 and No.2 at Forbes substation using TransGrid's Risk Assessment Methodology noted signs of deterioration attributed to accelerated aging. At 51 years old the transformers are exhibiting a condition reflecting that they are beyond the typical expected asset life. Additionally, specific condition issues, summarised in Table 2-1, render the transformers more challenging and more costly to service and repair. No remedial action would mean that their probability of failure will escalate in the future, and the likelihood of simultaneous transformer outage will continue to rise. Failing to correct the condition of the transformers creates a significant risk of prolonged and frequent unserved energy.

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[17] Total generation for Molong Solar Farm, Manildra Solar Farm, Parkes Solar Farm, and Goonumbla Solar Farm.

[18] The Central-West Orana REZ will be located on the Central Western network north of Forbes. TransGrid. "Transmission Annual Planning Report 2020." Sydney: TransGrid, 2020.28.Accessed 22 October 2020. https://www.transgrid.com.au/what-we-do/Business-Planning/transmission-annual-planning/Documents/2020%20Transmission%20Annual%20Planning%20Report.pdf

[19] TransGrid manages and mitigates safety risk to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with TransGrid's obligations under the New South Wales *Electricity Supply (Safety and Network Management) Regulation 2014* and TransGrid's Electricity Network Safety Management System (ENSMS). In particular, risks for TransGrid and its consumers are mitigated unless it is possible to demonstrate that the cost involved in further reducing the risk would be grossly disproportionate to the benefit gained.

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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.	
Mechanical failure of the tap changer	The tapchanger switches the voltage ratio on the transformer while it is under load. It is a mechanical device and in the case of failure, large amounts of energy are expected to be released and transformer loss is likely.	Lack of voltage control at Forbes substation

2.3.1 The likelihood of unserved energy will increase in the absence of remedial action

Due to the increase in failure rates as a result of the worsening asset condition, the forecasts for involuntary load shedding for different levels of transformer outages will increase in the absence of any remedial action. These unserved energy forecasts under different unplanned transformer outage configuration are weighted by the probabilities of those outages to estimate an expected unserved energy (EUE) figure.

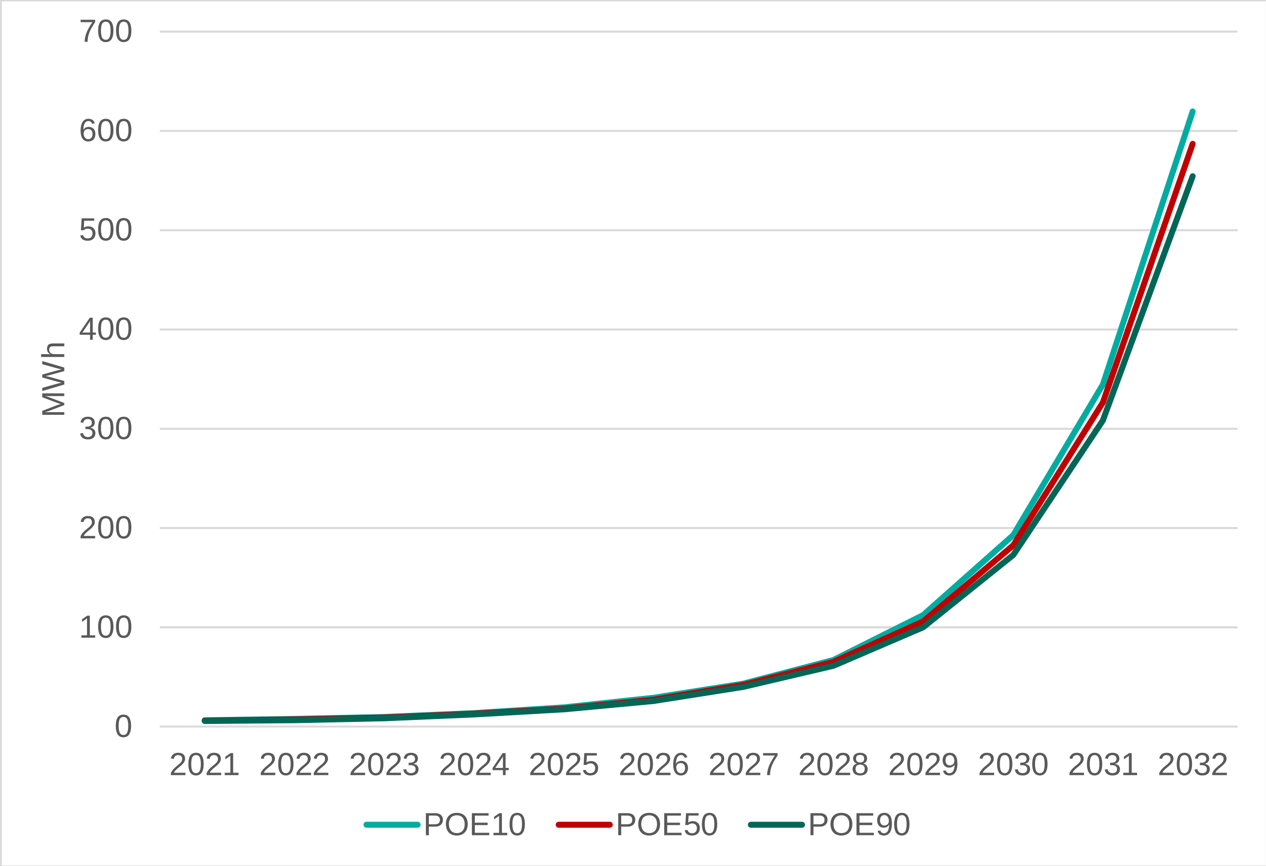
Figure 2-3 shows the expected unserved energy projections using three different Forbes BSP load forecasts:

> a central forecast of 50 per cent probability of exceedance (POE50)

> a low forecast using POE90

> a high forecast using the POE10 forecasts.

Figure 2-2 Expected unserved energy



TransGrid values the EUE forecasts under each option at the Value of Consumer Reliability (VCR). Measured in dollars per MWh, the VCR is a proxy to economic impact of involuntary customer load shedding under the RIT-T. TransGrid has applied a VCR estimate of $42.90/kWh in the central scenario and +/- 30 per cent for the other two scenarios, which is consistent with the AER's VCR review released in December 2019.[20]

[20] The central estimate of $42.90/kWh reflects an inflation adjustment to the load weighted VCR estimate for NSW and ACT ($42.12/kWh). The confidence interval selected is also drawn from the AER's VCR review. AER, Value of Customer Reliability Review – Final report, December 2019, pp 71 (Table 5.22) & 84. https://www.aer.gov.au/system/files/AER%20-%20Values%20of%20Customer%20Reliability%20Review%20-%20Final%20Report%20-%20December%202019.pdf

3. Potential credible options

This section describes the options explored by TransGrid to address the need, including the scope of each option and the associated costs. Refer to section 6.1 for benefits of each option.

TransGrid considers there are two technically and commercially feasible options that would meet the need from a technical, commercial and project delivery perspective[21]:

> **Option 1** – replace both transformers with new transformers and replacement of transformer protection and control systems; and

> **Option 2** – replace No.1 transformer with a new transformer and replace No.2 transformer with a redeployed transformer from another site. As well as the replacement of transformer protection and control systems.

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

TransGrid expects coronavirus (COVID-19) to impact its suppliers and disrupt their supply chains. TransGrid has preliminary advice that this is already occurring, although at this time the extent of the current or future impact is unknown. Consequently, some of the costs associated with the works outlined in this document may be affected.

All costs presented in this PACR are in 2020/21 dollars.

3.1 Base case

The costs and benefits of each option in this PACR are compared against those of a base case[22]. Under this base case, no proactive capital investment is made to remediate the condition issues at Forbes substation and the transformers will continue to operate under the current regime.

Under the base case, the risk of prolonged and frequent involuntary load shedding and risks on safety will continue to increase. The regular maintenance regime will not be able to address the identified need to undertake action, and as a consequence, will not address the increasing probability of transformer failure. It is expected that this will expose end-customers to prolonged and frequent unserved energy.

Annual operating and maintenance costs under the base case are approximately $1,800 per year increasing to approximately $4,000 until one of the transformers are replaced.

The table below provides a breakdown of the operating expenditure under the base case.

Table 3-1 Operating expenditure breakdown under the base case ($2020/21)

Item	Operating expenditure ($)
Annualised routine and corrective maintenance	2,300 (25 year average)
Total operating cost	**2,300 (+/- 25%)**

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

22 As per the RIT-T Application Guidelines, the base case provides a clear reference point for comparing the performance of different credible options. Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018.22. Accessed 14 May 2020. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

However, the maintenance regime will not be able to mitigate the risk of the transformer failure, which will continue to expose consumers to involuntary load shedding worth approximately $260,000 per year in 2020/21 increasing to $25 million per year in 2031/32. This increases over time as the failure rate of the transformers increases.

TransGrid calculates the annual safety, environmental and financial risk costs associated with the Forbes transformers under the base case to be approximately $180,000 per year increasing to approximately $2.5m by 2031/32.[23]

The failure rate and the risks associated with the transformers in the base case will become unacceptable by 2031/32. This means that TransGrid must either decommission one or both of the transformers or mitigate the risk under alternate options. The high level of risk has not been applied to the base case beyond 2031/32 for NPV purposes, even though no proactive capital investment is made[24]. This is because TransGrid considers this to overstate the level of risk and therefore would not be reflective of the situation. TransGrid considers this to be a conservative approach.

3.2 Option 1 – Replace both transformers with new transformers

Option 1 consists of replacing No.1 and No.2 transformers with new 132/66 kV 60 MVA transformers. This option involves:

> installation of two new power and auxiliary transformers;
> installation of associated switchgear, protection and control systems (secondary systems);
> upgrading the oil containment system; and
> civil works where required.

The first transformer that is replaced will be installed in a new compound with associated bays in order to maintain N-1 reliability during construction.

The estimated capital costs for the option total approximately $9.1 million. The table below provides a breakdown.

Table 3-2 Capital expenditure breakdown under Option 1 ($m 2020/21)

Item	Capital expenditure ($m)
Electrical costs	6.1
Civil and structural costs	3.0
Total capital cost	**9.1 (+/- 25%)**

The asset life of the new transformers is assumed to be 45 years. There will be a reduction in operating and maintenance costs resulting from the transformer replacement with new units.

Routine operating and maintenance costs are approximately $1,000 per year. The table below provides a breakdown.

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

24 Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018.22. Accessed 14 May 2020. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

Table 3-3 Operating expenditure breakdown under Option 1 ($ 2020/21)

Item	Operating expenditure ($)
Annualised routine and corrective maintenance	1,000
Total operating cost	**1,000 (+/- 25%)**

Following the implementation of Option 1, the risk costs associated with the assets at Forbes substation per year are minimal. This saving is driven by extending the routine maintenance intervals and decreasing the corrective maintenance by new transformers.

The works will be undertaken between 2020/21 and 2022/23. Planning (including commencement of the RIT-T) commenced in 2019/20 and is due to conclude in 2020/21.The detailed design will commence in 2020/21 with procurement and delivery of the identified assets planned to occur in 2021/22. All works will be completed by 2022/23. All works under all options will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission network.

3.3 Option 2 – Replace No.1 transformer with a new transformer and replace No.2 transformer with a redeployed transformer from another site

Option 2 consists of replacing No.1 transformer with a new 132/66 kV 60 MVA transformer and replacing No. 2 transformer with a redeployed 132/66 kV 60 MVA transformer from Wagga 132 kV substation. This option involves:

> installation of one new transformer;
> installation of associated switchgear, protection and control systems (secondary systems) ;
> civil works where required;
> upgrading the oil containment system; and
> transport and refurbishment on the redeployed transformer.

The new transformer will be installed in a new compound and with associated bays in order to maintain N-1 reliability during construction.

The estimated capital costs for the option total approximately $11.7 million. The table below provides a breakdown.

Table 3-4 Capital expenditure breakdown under Option 2 ($m 2020/21)

Item	Capital expenditure ($m)
Electrical costs	4.8
Civil and structural costs	3.3
New transformer in FY34	3.6
Total capital cost	**11.7m (+/- 25%)**

The asset life is assumed to be 45 years and 14 years for the new and redeployed transformer, respectively. There will be a reduction in operating and maintenance costs associated with defect work and maintenance resulting from the transformer replacement with new unit.

Routine operating and maintenance costs are approximately $1,100 per year. The table below provides a breakdown.

Table 3-5 Operating expenditure breakdown under Option 2 ($ 2020/21)

Item	Operating expenditure ($)
Annualised operating and corrective maintenance	1,100
Total operating cost	**1,100 (+/- 25%)**

Following the implementation of Option 2, the risk costs associated with the assets at Forbes substation per year are minimal. This saving is driven by extending the routine maintenance intervals and decreasing the corrective maintenance by new transformers.

The works will be undertaken between 2020/21 and 2022/23. Planning (including commencement of the RIT-T) commenced in 2019/20 and is due to conclude in 2020/21.The detailed design will commence in 2020/21 with procurement and delivery of the identified assets planned to occur in 2021/22. All works will be completed by 2022/23. All works under all options will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission network.

3.4 Options considered but not progressed

TransGrid also considered whether there are other credible options that would meet the identified need. The reasons are outlined in the table below.

Table 3-6 Options considered but not progressed

Option	Description	Reason(s) for not progressing
Option 3	Replace one transformer and leave the other unit in service	As both transformers are of similar age and condition, replacing one transformer and leaving the other unit in service would increase the risk over time to an unacceptable level and likely catastrophic failure.
Option 4	Refurbish both transformers	Refurbishment of the Forbes transformers would provide no improvement to its underlying condition and therefore risk. This is because of the nature of the inherent issues affecting the oil, main tank and tap changer.
Option 5	Replace one transformer and decommission the other unit	Replacing one transformer and decommissioning the other is also not feasible as TransGrid must maintain reliability standards for the Forbes bulk supply point (BSP) under the IPART - Electricity transmission reliability standards[25].

25 IPART Electricity transmission reliability standards Final Report, August 2016, Appendix B Recommended reliability standards, Section 8 Table of Values.

3.5 Non-network options

TransGrid does not consider non-network options to be commercially feasible to assist with meeting the identified need for this RIT-T. Although technically feasible, TransGrid does not consider non-network options are able to cost-effectively defer the need for a second transformer replacement. Specifically, to be considered equal to or cheaper than Option 1, non-network solutions would need to cost below $8/kW for a minimum of 37 MW.

For non-network options to efficiently reduce the risk of unserved energy, non-network solutions would need to have higher economic net benefits than the incremental network option.

Notwithstanding the above, TransGrid set out the required technical characteristics for non-network options in the PSCR, consistent with the requirements of the RIT-T and invited interested parties to make submissions regarding non-network options that satisfy, or contribute to satisfying, the identified need.

No non-network submissions were received in response to the PSCR.

3.6 No material inter-network impact is expected

TransGrid has considered whether the credible options listed above are expected to have material inter-regional impact.[26] A 'material inter-network impact' is defined in the NER as:

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

AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following:[27]

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

By reference to AEMO's screening criteria, there is no material inter-network impacts associated with any of the credible options considered.

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

27 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.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.[28]

4.1 All credible options are expected to reduce prolonged and frequent involuntary load shedding

Involuntary load shedding is where a customer's load is interrupted from the network without their agreement or prior warning. TransGrid has employed Essential Energy's load forecasts over the assessment period to quantify the expected unserved energy by comparing forecast load to network capabilities based upon aggregate transformer failure and mean time to repair. A reduction in prolonged and frequent involuntary load shedding is expected under each option, relative to the base case, as outlined in section 2.3.

4.2 Wholesale electricity market benefits are not material

The AER has recognised that if the credible options considered will not have an impact on the wholesale market, then a number of classes of market benefits will not be material in the RIT-T assessment, and so do not need to be estimated[29].

TransGrid determines that the credible options considered in this RIT-T will not address network constraints between competing generating centres and are therefore not expected to result in any change in dispatch outcomes and wholesale market prices. TransGrid therefore considers that the following classes of market benefits are not material for this RIT-T assessment:

- changes in fuel consumption arising through different patterns of generation dispatch
- changes in voluntary load curtailment (since there is no impact on pool price)
- changes in costs for parties other than the RIT-T proponent
- changes in ancillary services costs
- competition benefits
- Renewable Energy Target (RET) penalties.

4.3 No other classes of market benefits are material

In addition to the classes of market benefits listed above, NER clause 5.16.1(c)(4) requires TransGrid to consider the following classes of market benefits, listed in Table 5-1, arising from each credible option. TransGrid considers that none of the classes of market benefits listed are material for this RIT-T assessment for the reasons in Table 5-1.

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[28] The NER requires that all classes of market benefit identified in relation to the RIT-T are included in the RIT-T assessment, unless the TNSP can demonstrate that a specific class (or classes) is unlikely to be material in relation to the RIT-T assessment for a specific option – NER clause 5.16.1(c)(6). See Appendix A for requirements applicable to this document.

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

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

Market benefits	Reason
Differences in the timing of expenditure	Options considered will provide an alternative to meeting reliability requirements and are unlikely to affect decisions to undertake unrelated expenditure in the network. Consequently, material market benefits will neither be gained nor lost due to changes in the timing of expenditure from any of the options considered.
Option value	TransGrid notes the AER's view that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available in the future is likely to change and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[30] TransGrid does not consider there to be any option value with the options considered in this RIT-T.
Changes in network losses	As there is no change to the transmission lines or the destination of the line under any of the options considered, there will not be any material market benefits associated with changed to network losses.

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

5. Overview of the assessment approach

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

5.1 Description of the base case

The costs and benefits of each option in this document are compared against the base case.

Under this base case, no proactive capital investment is made to remediate the condition issues at Forbes substation and the transformers will continue to operate under the current regime.

Under the base case, the risk of prolonged and frequent involuntary load shedding and risks associated with the transformers will continue to increase and become unacceptable by 2031/32. The regular maintenance regime will not be able to address the identified need to undertake action, and as a consequence, will not address the increasing probability of transformer failure. This means that TransGrid must either decommission the transformers or mitigate the risk under alternate options.

The high level of risk (prolonged and frequent unserved energy) has not been applied to the base case beyond 2031/32 for NPV purposes, even though no proactive capital investment is made[31]. This is because TransGrid considers this to overstate the level of risk and therefore would not be reflective of the situation. TransGrid considers this to be a conservative approach.

5.2 Assessment period and discount rate

A 25 year assessment period from 2020/21 to 2044/45, was considered in this analysis. This period takes into account the size, complexity and expected asset life of the options. Since the new transformers have an asset life greater than 25 years, TransGrid took a terminal value approach to ensure that the capital costs of those assets were appropriately captured in the 25 year assessment period.

TransGrid adopted a central real, pre-tax 'commercial' discount rate[32] of 5.90 per cent as the central assumption for the NPV analysis presented in this report. TransGrid considers that this is a reasonable contemporary approximation of a commercial discount rate and it is consistent with the commercial discount rate calculated in the RIT-T Economic Assessment Handbook published by Energy Networks Australia (ENA) in March 2019[33].

TransGrid also tested the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 2.23 per cent equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this document[34], and an upper bound discount rate of 9.57 per cent (a symmetrical adjustment upwards) were used.

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31 No proactive capital investment has been adopted since it is consistent with AER guidance on the base case for RIT-T applications. Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018.22. Accessed 14 May 2020. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

32 The use of a 'commercial' discount rate is consistent with the RIT-T and is distinct from the regulated cost of capital (or 'WACC') that applies to network businesses like TransGrid.

33 Available at https://www.energynetworks.com.au/rit-t-economic-assessment-handbook Note the lower bound discount rate of 2.23 per cent is based on the most recent final decision for a TNSP revenue determination which was Directlink in June 2020.

34 See 2020-25 Directlink's Post-tax Revenue Model (PTRM) cashflow derived pre-tax real WACC available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/directlink-determination-2020-25/final-decision

5.3 Approach to estimating option costs

TransGrid has estimated the capital costs of the options based on the scope of works necessary together with costing experience from previous projects of a similar nature. TransGrid estimates that the actual cost is within +/- 25 per cent of the central capital cost.

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

5.4 Three different scenarios have been modelled to address uncertainty

The assessment was conducted under three net economic benefits scenarios. These are plausible scenarios which reflect different assumptions about the future market development and other factors that are expected to affect the relative market benefits of the options being considered. All scenarios (low, central and high) involve a number of assumptions that result in the lower bound, the expected, and the upper bound estimates for present value of net economic benefits respectively.

A key expected driver of the net economic benefits is the Value of Customer Reliability (VCR) and the underlying demand forecast since avoided EUE is the primary market benefit. TransGrid has applied a VCR estimate of $42.90/kWh in the central scenario and +/-30 per cent for the other two scenarios, which is consistent with the AER's VCR review released in December 2019.[35]

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

Table 5-1 Summary of scenarios

Variable / Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Discount rate	5.90%	9.57%	2.23%
Costs			
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Benefits (negative benefits)			
Reduction in operating and maintenance costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Reduction in safety and environmental risk costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Reduction in financial risks	Base estimate	Base estimate - 25%	Base estimate + 25%
Demand forecasts	Based on POE50 demand forecasts	Based on POE90 demand forecasts	Based on POE10 demand forecasts
Value of Customer Reliability (VCR)	The AER's VCR	The AER's VCR - 30%	The AER's VCR + 30%

TransGrid considered that the central scenario was most likely since it was based primarily on a set of expected assumptions. TransGrid therefore assigned this scenario a weighting of 50 per cent, with the other two scenarios being weighted equally with 25 per cent each.

35 The central estimate of $42.90/kWh reflects an inflation adjustment to the load weighted VCR estimate for NSW and ACT ($42.12/kWh). The confidence interval selected is also drawn from the AER's VCR review. AER, *Value of Customer Reliability Review – Final report*, December 2019, pp 71 (Table 5.22) & 84. https://www.aer.gov.au/system/files/AER%20-%20Values%20of%20Customer%20Reliability%20Review%20-%20Final%20Report%20-%20December%202019.pdf.

6. Assessment of credible options

This section outlines the assessment TransGrid has 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 reduction in costs or risks compared to the base case.

All costs presented in this PACR are in 2020/21 dollars.

6.1 Estimated gross benefits

The table below summarises the present value of the gross benefit estimates for each credible option relative to the base case under the three scenarios.

The benefits included in this assessment are:

> reduction in operating and maintenance costs
> reduction in safety and environmental risks
> reduction in financial risks
> unserved energy

Table 6-1 Estimated gross benefits from credible options relative to the base case, present value ($m 2020/21)

Option/scenario	Central	Low benefit scenario	High benefit scenario	Weighted
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	43.3	21.3	81.9	47.4
Option 2	42.6	21.0	80.4	46.6

6.2 Estimated costs

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

Table 6-2 Estimated costs of credible options relative to the base case, present value ($m 2020/21)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	7.4	9.7	4.7	7.3
Option 2	7.6	9.4	5.3	7.5

6.3 Estimated net economic benefits

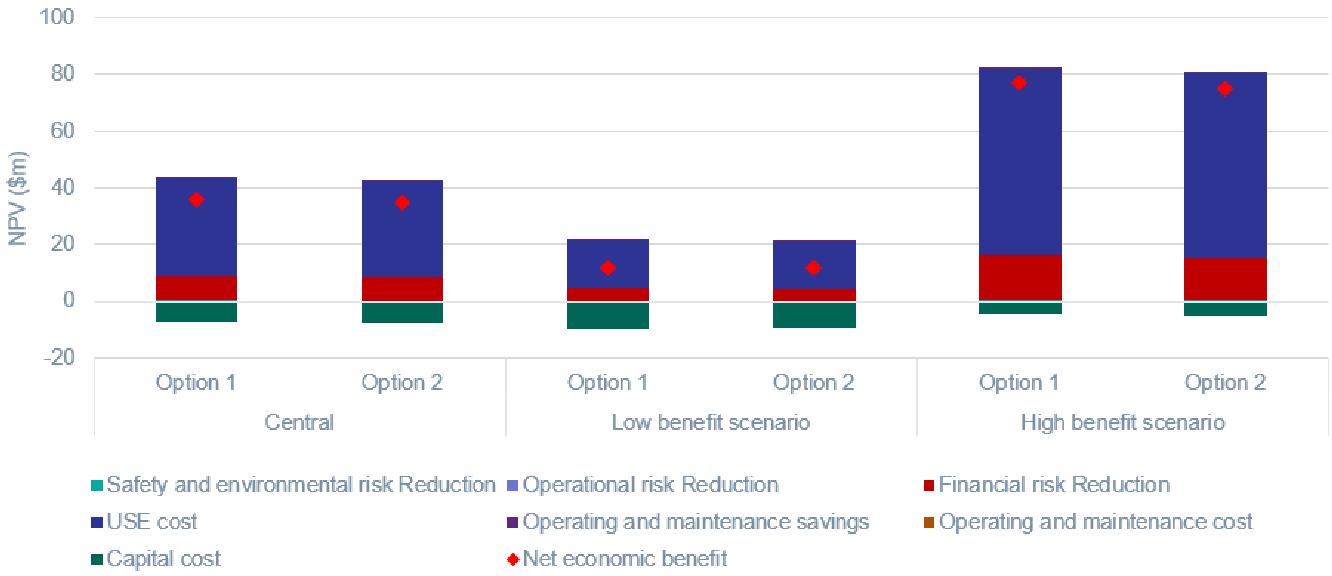
The net economic benefits are the differences between the estimated gross benefits less the estimated costs. The table below summarises the present value of the net economic benefits for each credible option across the three scenarios and the weighted net economic benefits.

Option 1 is found to have positive net benefits for all scenarios investigated. On a weighted basis, Option 1 will deliver approximately $40.2 million in net economic benefits above the base case.

Table 6-3 Estimated net economic benefits relative to the base case, present value ($m 2020/21)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value	Ranking
Scenario weighting	*50%*	*25%*	*25%*		
Option 1	35.9	11.6	77.2	40.2	1
Option 2	35.0	11.5	75.1	39.1	2

Figure 6-1 Net economic benefits, present value ($m 2020/21)



6.4 Sensitivity testing

TransGrid undertakes sensitivity testing to understand the robustness of the RIT-T assessment to underlying assumptions about key variables. In particular, TransGrid undertakes two sets of sensitivity tests – namely:

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

Having assumed to have committed to the project by this date, TransGrid has also looked at the consequences of 'getting it wrong' under step 2 of the sensitivity testing. That is, if expected 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

TransGrid has estimated the optimal timing for the preferred option based on the year in which the NPV is maximised. This process was undertaken for both the central set of assumptions and also a range of alternative assumptions for key variables. This section outlines the sensitivity of the identification of the commissioning year to changes in the underlying assumptions. In particular, the optimal timing of the option is found to be invariant to the assumptions of:

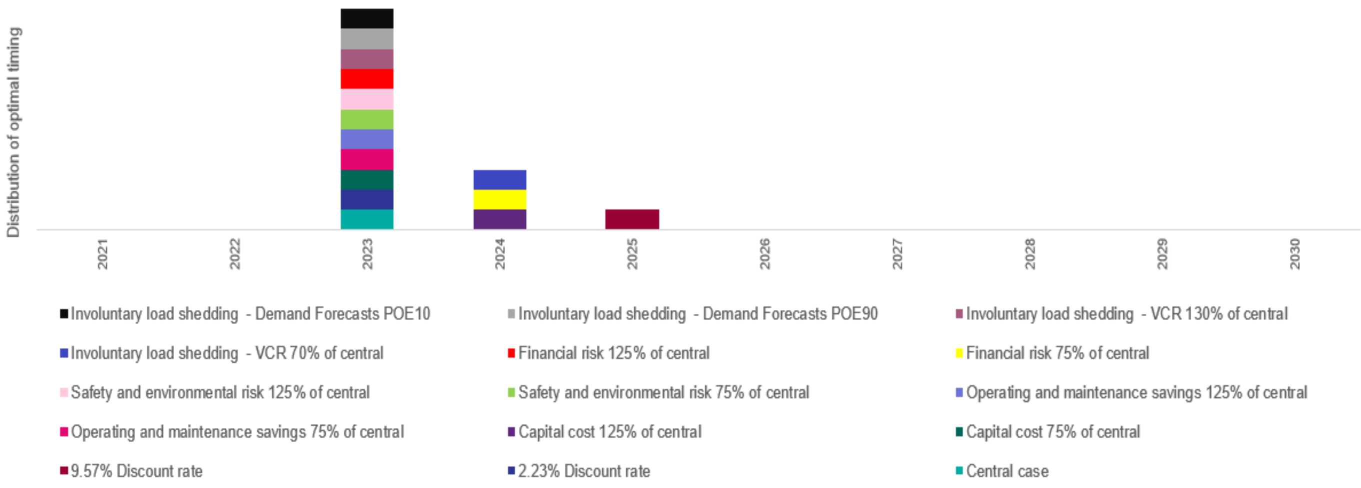
- a 25 per cent increase/decrease in the assumed network capital costs
- lower discount rate of 2.23 per cent as well as a higher rate of 9.57 per cent
- lower (or higher) assumed operation and maintenance costs
- lower (or higher) assumed safety and environmental risks
- lower (or higher) assumed financial risk
- lower (or higher) VCR estimates
- lower (or higher) demand (POE) forecasts

The figure below outlines the impact on the optimal commissioning year, under a range of alternative assumptions, and illustrates that the optimal timing for most scenarios is 2022/23.

In the scenario where the load shedding is assumed to be low (70 per cent of the central estimate), the scenario where financial risks are assumed to be low (75 per cent of the central estimate), and the scenario where capital cost is assumed to be high (125 per cent of the central estimate), the optimal timing is delayed by one year to 2023/24. In the scenario where the commercial discount rate is assumed to be high (8.95 per cent) the optimal timing is delayed by two years to 2024/25.

Please note that the figure below shows the optimal financial year to commission the project, whilst recognising that it will take one year to complete the installation works (ie the earliest the transformer can be installed and operational is 2022/2023, with capital expenditure occurring in 2021/2022).

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



6.4.2 Step 2 – Sensitivity of the overall net benefit

TransGrid has conducted sensitivity analysis on the present value of the net economic benefit, based on having to undertake the project by 2022/23. Specifically, TransGrid has investigated the following sensitivities:

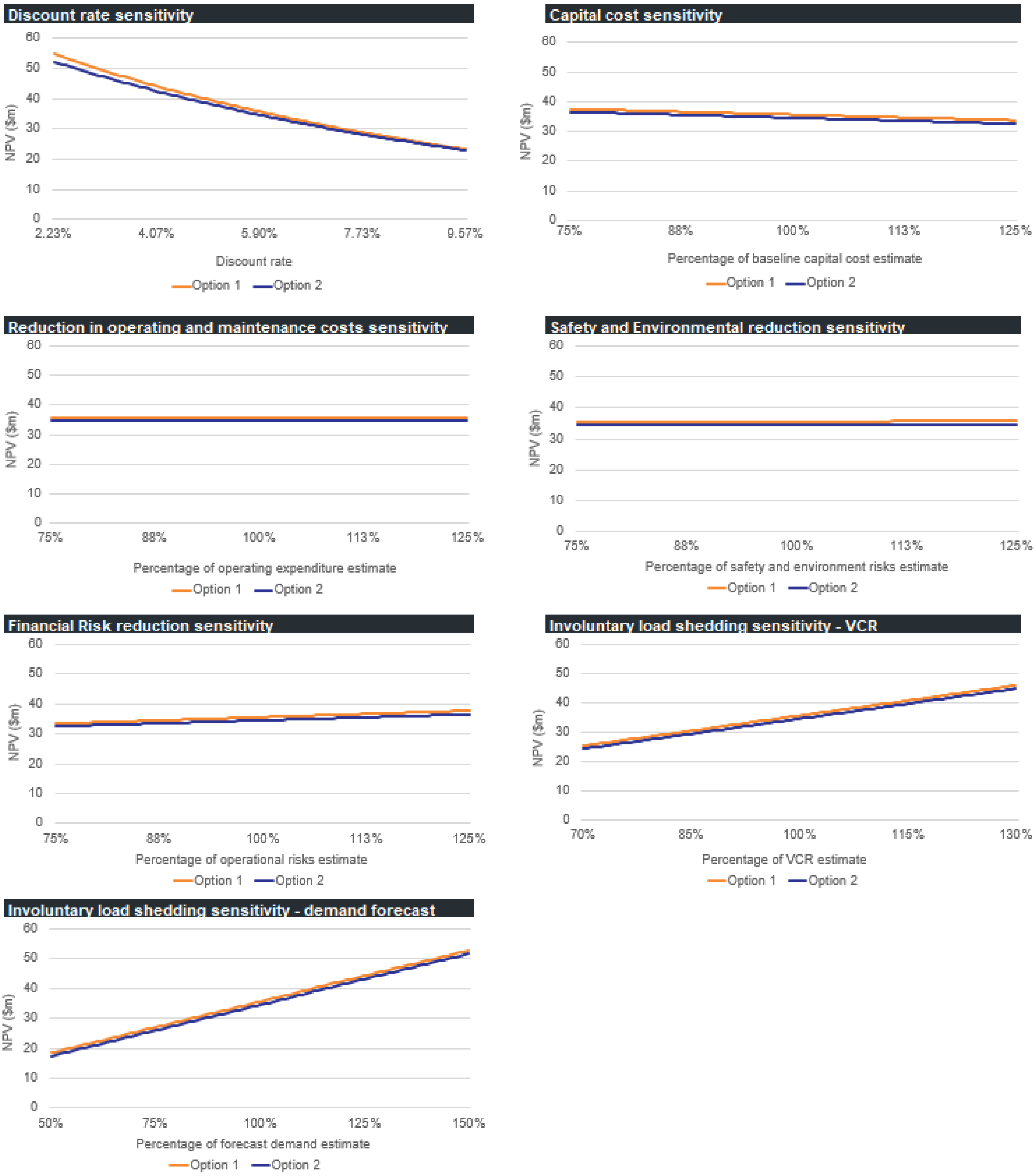
- a 25 per cent increase/decrease in the assumed network capital costs
- lower discount rate of 2.23 per cent as well as a higher rate of 9.57 per cent
- lower (or higher) assumed operation and maintenance costs
- lower (or higher) assumed safety and environmental risks
- lower (or higher) assumed financial risk
- lower (or higher) VCR estimates
- a 50 per cent increase/decrease in the demand forecasts

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

Importantly, for all sensitivity tests shown below, the estimated net economic benefit of the option considered are found to be strongly positive.

The figures below illustrate the estimated net economic benefits for each option if separate key assumptions in the central scenario are varied individually. Option 1 delivers the most benefit under all scenarios. The results are found to be most sensitive to the discount rate and the benefits derived from a reduction in involuntary load shedding. TransGrid extended the sensitivity exercise to better understand how net economic benefits vary with changes in either VCR or forecasted demand, and have found that even with no reduction in involuntary load shedding would provide positive net economic benefits.

Figure 6-3 Sensitivities ($m 2020/21)



7. Final conclusion on the preferred option

The implementation of Option 1, replacing No.1 and No.2 transformers with new 132/66 kV 60 MVA transformers at Forbes substation, is the most efficient technically and commercially feasible option at this draft stage of the RIT-T process. Option 1 addresses the identified need, offers the most benefit to consumers and can be implemented in sufficient time to meet the identified need (by 2022/23). The investment will also assist TransGrid to manage and mitigate safety risks that would otherwise arise from continued deterioration of asset condition. It is therefore the preferred option presented in this PACR. The analysis undertaken and the identification of Option 1 as the preferred option satisfies the RIT-T.

This preferred option, Option 1, is found to have positive net benefits under all scenarios investigated and on a weighted basis will deliver $40.2 million in net economic benefits. TransGrid also conducted sensitivity analysis on the net economic benefit to investigate the robustness of the conclusion to key assumptions. TransGrid finds that under all sensitivities, positive net benefits are expected from new transformers at Forbes.

The estimated capital cost of this option is approximately $9.1 million. Routine and operating maintenance costs are approximately $1,000 per year on average.

The works will be undertaken between 2020/21 and 2022/23. Planning (including commencement of the RIT-T) commenced in 2019/20 and is due to conclude in 2020/21. The detailed design will commence in 2020/21 with procurement and delivery of the identified assets planned to occur in 2021/22. All works will be completed by 2022/23.

Necessary outages of relevant assets in service will be planned appropriately in order to complete the works with minimal impact on the network.

Appendix A – Compliance checklist

This section sets out a checklist which demonstrates the compliance of this PACR with the requirements of the National Electricity Rules version 154.

Rules clause	Summary of requirements	Relevant section
5.16.4(v)	The project assessment conclusions report must set out:	–
	(1) the matters detailed in the project assessment draft report as required under paragraph (k); and	See below.
	(2) a summary of, and the RIT-T proponent's response to, submissions received, if any, from *interested parties* sought under paragraph (q).	NA
5.16.4(k)	The project assessment draft report must include:	–
	(1) a description of each credible option assessed;	3
	(2) a summary of, and commentary on, the submissions to the project specification consultation report;	NA
	(3) a quantification of the costs, including a breakdown of operating and capital expenditure, and classes of material market benefit for each credible option;	3, 4
	(4) a detailed description of the methodologies used in quantifying each class of material market benefit and cost;	5
	(5) reasons why the RIT-T proponent has determined that a class or classes of market benefit are not material;	4
	(6) the identification of any class of market benefit estimated to arise outside the *region* of the *Transmission Network Service Provider* affected by the RIT-T project, and quantification of the value of such market benefits (in aggregate across all regions);	3, 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;	7
	(9) for the proposed preferred option identified under subparagraph (8), the RIT-T proponent must provide: (i) details of the technical characteristics; (ii) the estimated construction timetable and commissioning date; (iii) if the proposed preferred option is likely to have a *material inter-network impact* and if the *Transmission Network Service Provider* affected by the RIT-T project has received an augmentation technical report, that report; and (iv) a statement and the accompanying detailed analysis that the preferred option satisfies the *regulatory investment test for transmission*.	3, 7

Appendix B – Risk Assessment Methodology

This appendix summarises the key assumptions and data from the risk assessment methodology that underpin the identified need for this RIT-T and the assessment undertaken for the Revenue Proposal[36].

As part of preparing its Revenue Proposal for the current regulatory control period, TransGrid developed the Network Asset Risk Assessment Methodology to quantify risk for replacement and refurbishment projects. The risk assessment methodology:

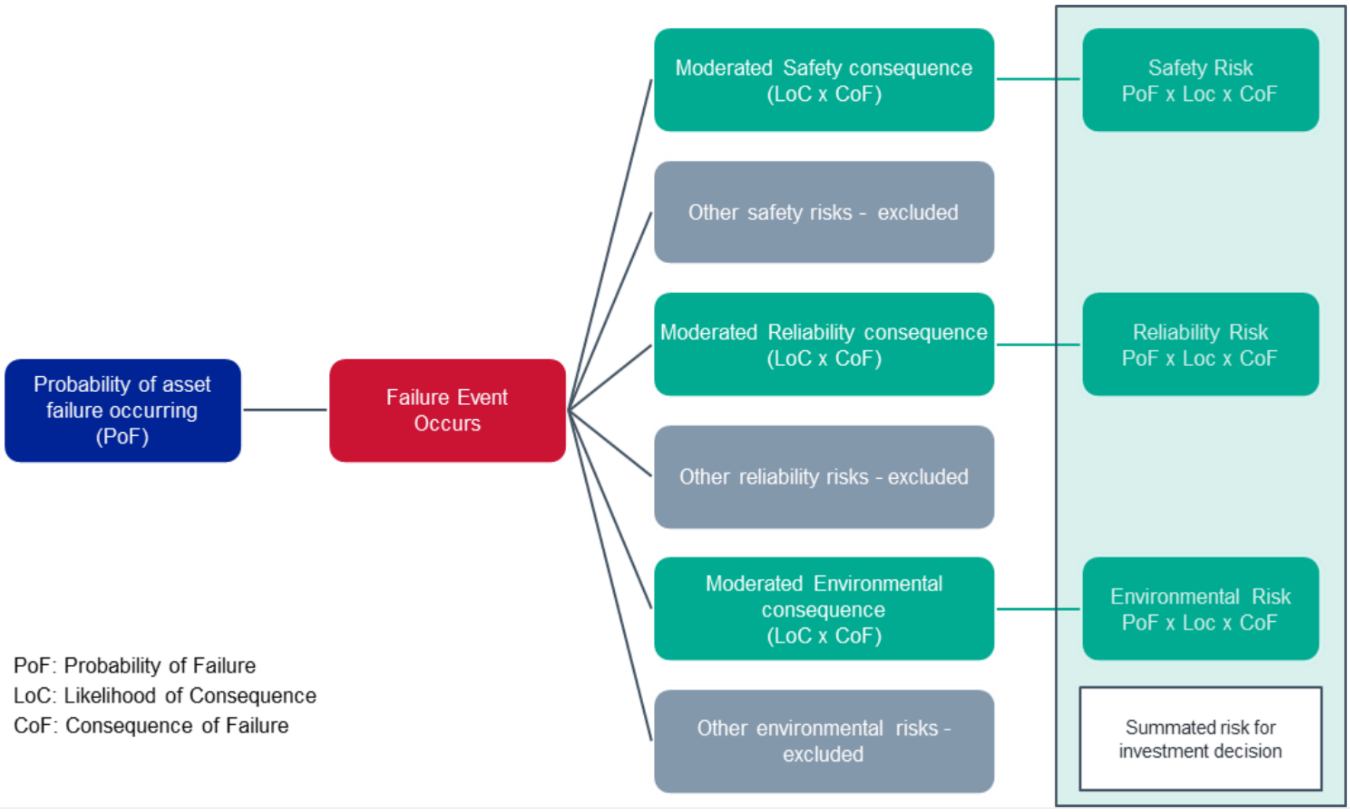
> uses externally verifiable parameters to calculate asset health and failure consequences
> assesses and analyses asset condition to determine remaining life and probability of failure
> applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence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

B.1 Overview of the risk assessment methodology

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

The figure below summarises the framework for calculating the risk costs, which has been applied on TransGrid's asset portfolio considered to need replacement or refurbishment.

Figure B-1 Overview of TransGrid's 'risk cost' framework



36 TransGrid. "Revised Regulatory Proposal 2018/19-2022/23." Melbourne: Australian Energy Regulator, 2017. 63-69. Accessed 15 March 2019. https://www.aer.gov.au/system/files/TransGrid%20-%20Revised%20Revenue%20Proposal%20-%201%20December%202017.pdf

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

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

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