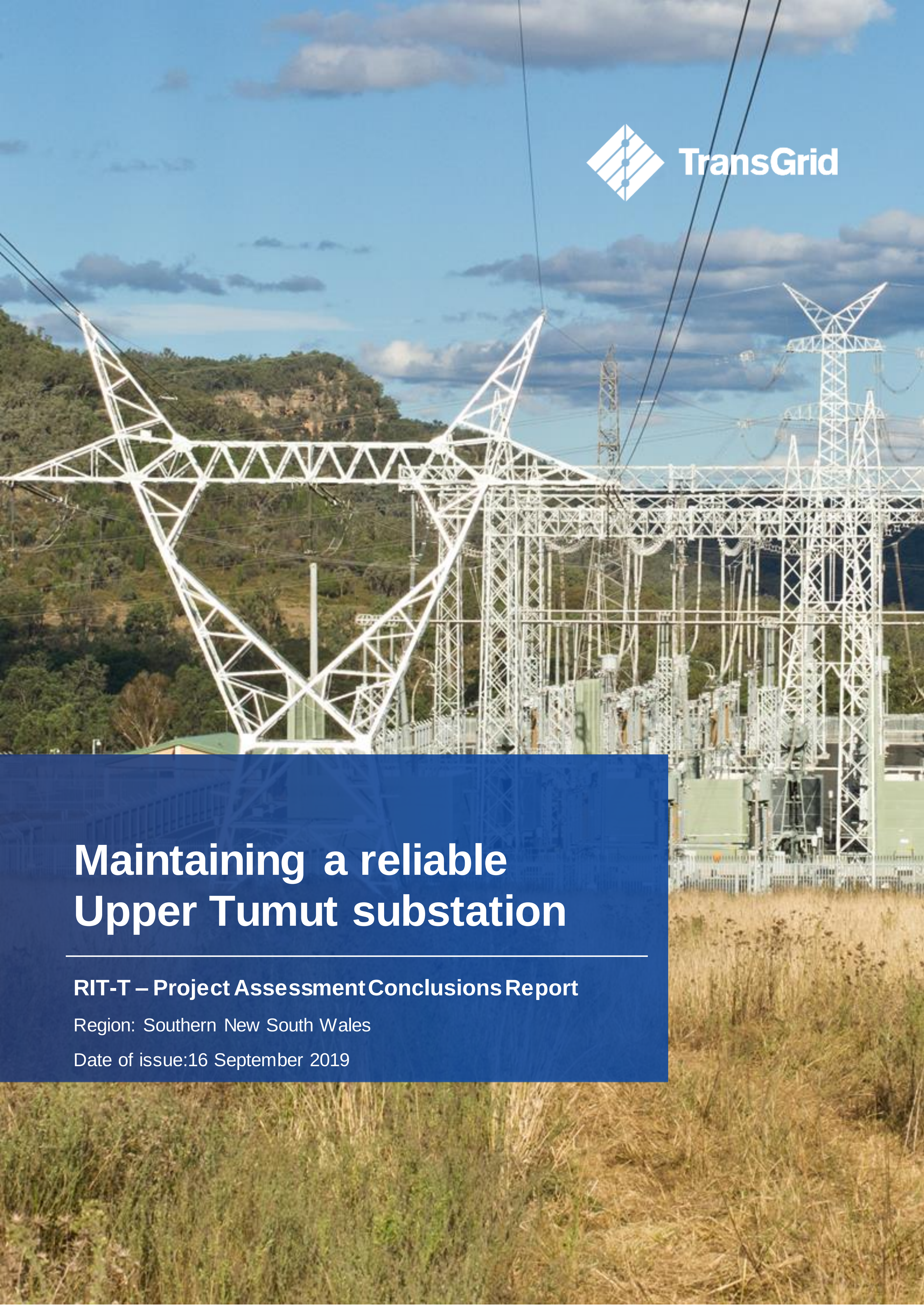

TransGrid

Maintaining a reliable Upper Tumut substation

RIT-T – Project Assessment Conclusions Report

Region: Southern New South Wales

Date of issue:16 September 2019

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Executive summary

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining a reliable Upper Tumut substation. Publication of this Project Assessment Consultations Report (PACR) represents the final step in the RIT-T process.

Upper Tumut substation:

> connects approximately 616 MW of renewable hydro-electric energy generation
> supports four transmission lines in the southern New South Wales network
> provides electricity flow paths between the Snowy Mountains, Canberra and Sydney.

At Upper Tumut substation, gantries support high voltage connections between switchbays and busbars. They are mainly used to support the power conductor in both directions between the transmission tower closest to the substation and the equipment within the substation. Gantries are connected to concrete footings by concrete plinths, holding down bolts and baseplates. They also support overhead earthwires that protect the substation equipment from direct lightning strikes and are essential for the safe and reliable operation of the substation.

Corrosion has been found on a large portion of gantries at Upper Tumut substation. The corrosion of holding down bolts and structural components, or 'members', ranges from initial development through to loss of steel thickness (cross-sectional area). Corrosion of holding down bolts is the key issue at this site and has been accelerated by the cracking of the concrete base plate plinths resulting from the repeated freezing and thawing of water inside cracks in the concrete.

TransGrid's analysis indicates that the holding down bolts and several of the gantry members will reach the end of serviceable life by 2020/21. After this time, the loss of physical cross-sectional area from corrosion will decrease their capacity to provide structural support. This reduces structual integrity and significantly increases their probability of structural failure, especially during high wind events. Deterioration of holding down bolts has occurred across the site and action is required on the majority of structure footings.

If unaddressed, these issues may cause tower collapse; failure of steelwork, holding down bolts or baseplates; or failure of the whole substation.

Table E-1 outlines the condition issues identified at Upper Tumut substation and the potential consequences if not remediated.

Table E-1 – Condition issues at Upper Tumut substation and their consequences

Issue	Consequences if not remediated
Corrosion of gantry steel members	Steel corrosion, particularly of critical members, can lead to structural failure of tower
Corrosion of holding down bolts and base plates	Structural failure
Cracking of concrete plinths	Structural failure
Corroded fasteners	Structural failure
Corrosion of earth wire attachment fittings	Conductor drop

No submissions received in response to the Project Specification Consultation Report

TransGrid published a Project Specification Consultation report (PSCR) on 26 March 2019 and invited written submissions on the material presented within the document. No submissions were received in response to this PSCR.

The PSCR presented a range of credible network options that would meet the identified need from a technical, commercial, and project delivery perspective.[1] The options are summarised in the table below.

Table E-2 – Summary of the four credible options considered ($2019/20)

Option	Description	Capital costs ($m)	Operating costs ($ per year)	Remarks
Option 1	Refurbishment of holding down bolts and identified corroded steel members as required	8.36 ± 25%	409	Most economic and preferred option
Option 2	Staged delivery of Option 1 over multiple years	greater than 8.36 ± 25%	409	Cost-inefficiencies by spreading the work across multiple years (eg site establishment costs, etc) Requires outages over multiple years and is impacted by snow during winter annually.
Option 3	Replacement of all substation gantries	greater than 50	409	Significant project costs
Option 4	Decommissioning of substation gantries	Not progressed	Not progressed	Significant reduction in southern NSW network capacity. Disconnection of at least 616 MW of low-cost, zero-emission hydro-electric generation from the NEM.

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

The PSCR noted that non-network options are not considered to be commercially and technically feasible to assist with meeting the identified need for this RIT-T.

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

Conclusion: refurbishment of holding down bolts and corroded steel members is optimal

The optimal commercially and technically feasible option presented in the PSCR — Option 1, the refurbishment of holding down bolts and identified corroded steel members as required — remains the

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

preferred option to meet the identified need. Option 1 involves in-situ repair of holding down bolts and in-situ gantry steelwork renewal by removing corrosion, painting and replacing identified components.

Moving forward with this option is the most prudent and economically efficient solution to maintain a reliable Upper Tumut substation.

The estimated capital expenditure associated with this option is $8.36 million ± 25% (weighted present value of $7.04 million), and depends on the extent of corrosion, works required to address corrosion and the final selected remediation methods across the site.

The works will be undertaken between 2018/19 and 2020/21. Planning and procurement (including completion of the RIT-T) will occur between 2018/19 and 2019/20, while project delivery and construction will be completed by 2020/21. All works will be completed in accordance with the relevant standards by 2020/21 with minimal modification to the wider transmission assets.

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

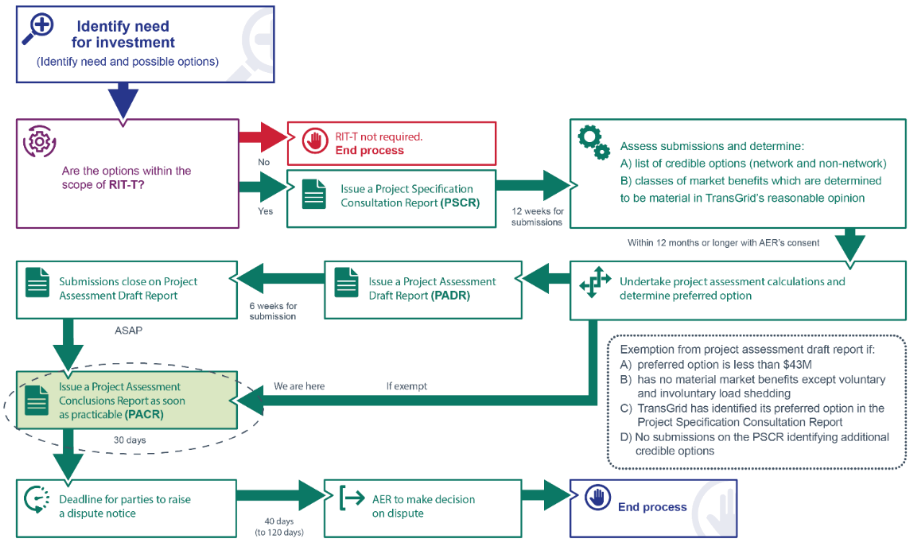
Next steps

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

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

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

Figure E-1 This PACR is the third and final stage of the RIT-T process[2]



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

Parties wishing to raise a dispute notice with the AER may do so prior to 15 October 2019 (30 days after publication of this PACR). Any dispute notices raised during this period will be addressed by the AER within 40 to 120 days, after which the formal RIT-T process will conclude.

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

TransGrid intends to undertake refurbishment works between 2018/19 and 2020/21. Planning and procurement will occur between 2018/19 and 2019/20 and project delivery and construction will be completed by 2020/21. All works will be completed by 2020/21.

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1. Introduction

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining a reliable Upper Tumut substation. Publication of this Project Assessment Consultations Report (PACR) represents the final step in the RIT-T process.

The Project Specification Consultation Report (PSCR) released in March 2019 sets out the:

> reasons TransGrid proposed that action be taken
> credible options TransGrid considered to address the identified need.

No submissions were received in response to the PSCR.

1.1 Purpose of this report

The purpose of this PACR 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.

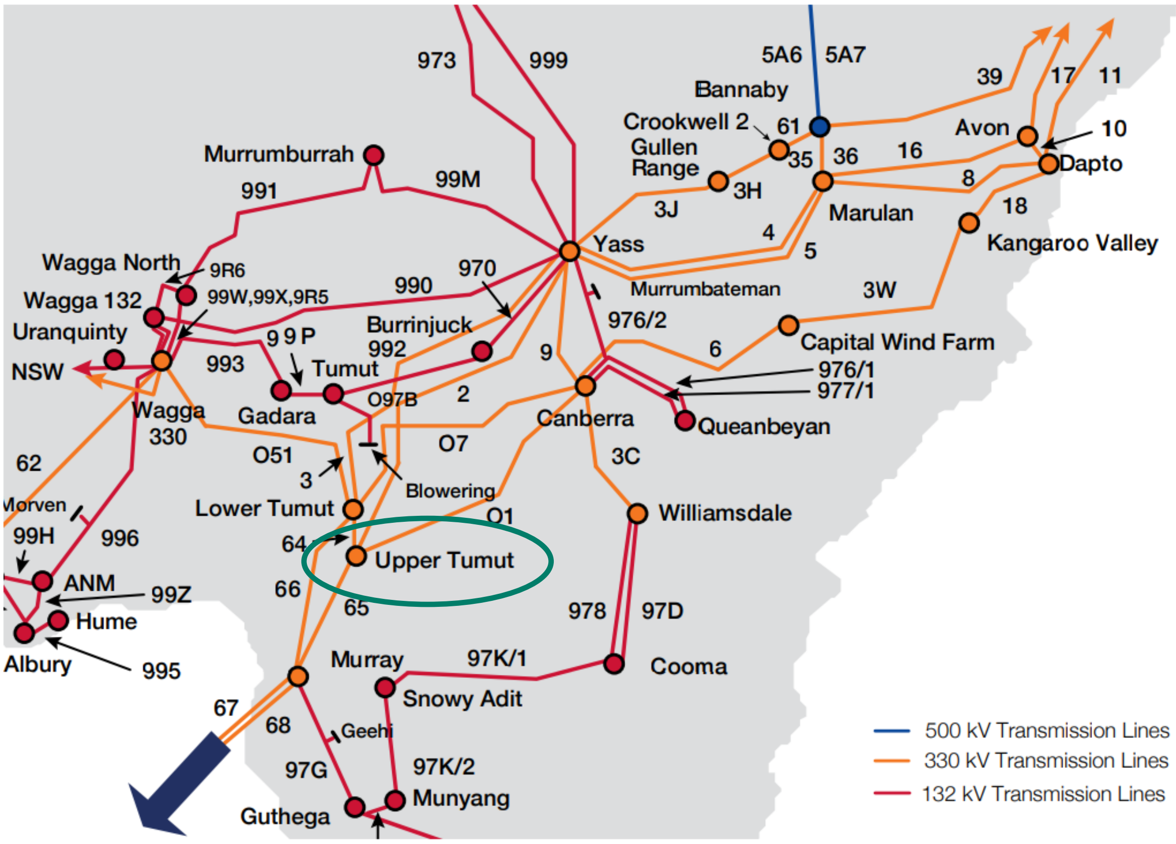
2. The identified need

2.1 Background

TransGrid's Upper Tumut substation was established in 1959 and forms part of TransGrid's southern NSW network, see Figure 2-1. The substation connects eight hydro-electric generation units to the NEM which total 616 MW. It forms part of the wider southern NSW network which supports renewable energy zone development and allows flow paths between Snowy Mountains, Canberra and Sydney.

In 2017/18, the hydro-electric generation units produced 1.47 TWh of electricity – enough to power 350,000 homes for a year.[3]

Figure 2-1 – TransGrid's southern NSW network



Like most substations, Upper Tumut substation contains numerous gantry structures that support high voltage connections between switchbays and busbars. They are mainly used to support the power conductor between the transmission tower closest to the substation and the equipment within the substation. The gantries are connected to concrete footings by concrete plinths, holding down bolts and baseplates. They also support overhead earthwires that protect the substation equipment from direct lightning strikes. They are essential for the safe and reliable operation of the substation and the southern NSW network.

Routine asset monitoring and maintenance conducted by TransGrid found evidence of corrosion on a large portion of gantries at Upper Tumut substation. The corrosion of holding down bolts and structural components, or 'members', ranges from initial development through to loss of steel thickness. Corrosion of

[3] Based on the typical household consumption in NSW according to Australian Energy Market Commission, "*2018 Residential Electricity Price Trends*," accessed 21 January 2019. https://www.aemc.gov.au/market-reviews-advice/2018-residential-electricity-price-trends

holding down bolts is the key issue at this site and has been accelerated by the cracking of concrete base plate plinths resulting from repeated freezing and thawing of water inside cracks in the concrete. During winter the substation is more exposed to moisture as it is located above the snowline.

2.2 Description of the identified need

TransGrid's analysis indicates that gantry structure holding down bolts and a portion of gantry members will reach the end of serviceable life by 2020/21. After this time, the corrosion will decrease the capacity of the affected members to provide structural support, reducing their structural integrity, and significantly increasing their probability of structural failure, especially during high wind events. While some holding down bolts have yet to fully corrode, this process is already underway.

Figure 2-2 and Figure 2-3 show advanced stages of corrosion of holding down bolts, base plates, and member connection bolts at Upper Tumut substation.

Figure 2-2 – View of gantry steel members showing corrosion

Figure 2-3 – View of corrosion to holding down bolts and baseplates

Upper Tumut substation is a key node connecting the southern NSW network to support the National Electricity Market (NEM). A gantry steelwork failure at Upper Tumut substation will:

> decrease the total NSW generation capacity by at least 616 MW, or an equivalent of a probability-weighted figure of 48 GWh per year (estimated to cost the wholesale electricity market $1.2 million per year of fuel costs from 2021/22 onward)
> dispatch generation with higher variable and operating maintenance (VOM) costs (estimated to cost the wholesale electricity market $156,143 per year)
> remove a key connecting node in the southern NSW network
> incur reactive replacement costs in excess of $1 million per year.[4]

TransGrid intends to make investments to mitigate these potential consequences. TransGrid determines that these cost savings will benefit consumers of electricity.

The corrosion issue needs to be addressed as a matter of urgency as several gantry components are near the end of serviceable life.

[4] This is based on a cost of replacement of all gantries for Canberra substation which is estimated to be in excess of $50 million, weighted by the probability of failure of the gantries. However, this underestimates the exact cost as replacement works for Upper Tumut would be more complex.

3. Options that meet the identified need

In identifying the refurbishment of the existing substation as a credible option, TransGrid took the following factors into account: energy source; technology; ownership; the extent to which the option enables intra-regional or inter-regional trading of electricity; whether it is a network option or a non-network option; whether the credible option is intended to be regulated; whether the credible option has proponent; and any other factor which TransGrid reasonably considered should be taken into account[5].

Of the credible options considered[6] and summarised in Table 3-1, the optimal timing for the most efficient option (Option 1: the refurbishment of holding down bolts and identified corroded steel members as required) that meets the identified need to maintain a reliable Upper Tumut substation is before 2020/21.

TransGrid did not receive any responses to the PSCR.

Table 3-1 – Summary of the credible options ($2019/20)

Option	Description	Capital costs ($m)	Operating costs ($ per year)	Remarks
Option 1	Refurbishment of holding down bolts and identified corroded steel members as required	8.36 ± 25%	409	Most economic and preferred option
Option 2	Staged delivery of Option 1 over multiple years	greater than 8.36 ± 25%	409	Cost-inefficiencies by spreading the work across multiple years (eg site establishment costs, etc) Requires outages over multiple years and is impacted by snow during winter annually.
Option 3	Replacement of all substation gantries	greater than 50	409	Significant project costs
Option 4	Decommissioning of substation gantries	Not progressed	Not progressed	Significant reduction in southern NSW network capacity. Disconnection of at least 616 MW of low-cost, zero-emission hydro-electric generation from the NEM.

5 In accordance with the requirements of NER clause 5.15.2(b).

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

3.1 Base case

The costs and benefits of each option in this PACR were compared against those of a base case[7]. Under the base case, no proactive capital investment is made. Upper Tumut substation will continue to operate and be maintained under the current regime and reactive replacement costs will be required.

The substation failure risks will increase over time and these have been included in the base case in this RIT-T.

3.2 Option 1 – In-situ gantry steelwork renewal and remediation

Option 1 involves the in-situ steelwork renewal by removing corrosion, painting and replacing identified components. This option will appropriately manage the risk of prolonged substation outage. Table 3-2 summarises the remediation works under Option 1 to address key issues.

Table 3-2 – Remediation works for Upper Tumut substation under Option 1

Issue	Remediation
Corrosion of gantry holding down bolts and base plates	> removal of concrete plinths > removal of corrosion, painting and repair of holding down bolts and base plates > reinstatement of concrete plinths.
Corrosion of gantry steel members	> targeted removal of rust via a range of methods including blasting of gantry columns, beams, and earth wire peaks > painting blasted gantries with zinc-based paint > replacing connection bolts and steel members (if required).

A breakdown of the estimated capital cost of Option 1 is shown in Table 3-3.

Table 3-3 – Capital Expenditure Breakdown for Upper Tumut substation under Option 1 ($million 2019/20)

Item	Expenditure
Lead paint removal and repaint & foundation demo and rebuild	5.31
Steel works remediation	3.05
Total	**8.36 (+/- 25%)**

The estimated capital expenditure associated with this option is $8.36 million ± 25% (weighted present value of $7.04 million), depending on the extent of corrosion, works required to address corrosion and the final selected remediation methods across the site.

The capital cost included $5.31 million for the replacement of the holding down bolts, which was estimated using standard unit rates. The estimate also includes $3.05 million for repair of corroded steel members in the

[7] As per the RIT-T Application Guidelines, the base case provides a clear reference point for comparing the performance of different credible options. Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018. Accessed 1 August 2019. 22. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

gantries, which was based on standardised costs and an assumed corrosion rate of steel in the gantries. The amount of above ground repairs will be confirmed once the works commence. Planned outages are required to undertake an inspection of the assets to determine the true extent of the corrosion. The costs also include standard site establishment costs and electrical works.

Once remediation of corroded bolts and affected members has been completed under Option 1, planned operating costs[8] will not materially differ from the base case – approximately $409 per year. This is the annualised cost of routine inspections. There will be significantly lower unplanned remediation costs as Option 1 is designed to mitigate gantry failures due to corrosion.

3.3 Options considered but not progressed

The primary driver for the identified need is to maintain a reliable Upper Tumut substation. Three other options to address the need were considered but were not progressed as they were not viable when assessed against the preferred option.

Table 3-4 summarises the reasons the following credible options were not progressed further.

Table 3-4 – Options considered but not progressed

Option	Description	Reason(s) for not progressing
Option 2	Staged delivery of Option 1 over multiple years	There are cost efficiencies gained with replacing all identified components in one stage as opposed to spreading the replacement across multiple years. For example, site establishment costs and the costs of outages would be incurred over multiple years. In addition, delaying the replacement of any components comes with greater expected risks. The combination of greater costs and less expected benefits (from avoided prolonged substation and generation unit outages) makes this option less commercially feasible relative to Option 1.
Option 3	Replacement of all substation gantries	The capital costs of replacing all substation gantries at Upper Tumut are estimated to be significantly more than Option 1, approximately in excess of $50 million, but will not provide additional benefits. In addition, replacing all gantries or rebuilding the substation would require prolonged planned substation outages and is not economically feasible.
Option 4	Decommissioning of substation gantries	A prolonged outage of the substation would already create significant downside impact to the market, decommissioning the substation would be further detrimental.

8 The planned operating costs included in the NPV analysis presented in this PACR are comprised of routine maintenance costs. These costs typically include routine inspections but do not include costs associated with remediating defects detected during inspection. The severity of such defects is expected to continue to increase if a technically and commercially feasible option is not implemented in sufficient time to meet the identified need.

3.4 Non-network options

In the PSCR, TransGrid noted that non-network options are not considered to be commercially and technically feasible to assist with meeting the identified need for this RIT-T. To be considered, non-network options would have to:

- economically replace a significant amount of low-cost, zero-emission generation from the NEM
- connect substations and transmission lines in the southern NSW network which also serves several power stations
- provide flow paths between the Snowy Mountains, Canberra and Sydney.

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

4. Assessment of credible options

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

The assessment compares the costs and benefits of the option to a base case where:

> the existing condition issues at Upper Tumut substation will not be remediated
> the existing maintenance regime is continued
> the substation will continue to operate with an increasing level of risk.

The analysis presented in the corresponding PSCR for this RIT-T was conducted using an earlier discount rate. The original calculations have been re-done using the base discount rate of 5.9% (real, pre-tax), which is consistent with the commercial discount rate calculated in the Energy Network Australia's (ENA) RIT-T Economic Assessment Handbook[9].

4.1 Assessment under three different scenarios 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.

Table 4-1 – Summary of scenarios

Variable/Scenario	Central	Low net economic benefits	High net economic benefits
Scenario Weighting	*50%*	*25%*	*25%*
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Avoided reactive replacement costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Avoided system fuel costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Avoided system variable operating and maintenance (VOM) costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Discount rate	5.9%	4.60%	7.2%

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%, with the other two scenarios being weighted equally with 25% each.

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

4.2 Estimated gross economic benefits

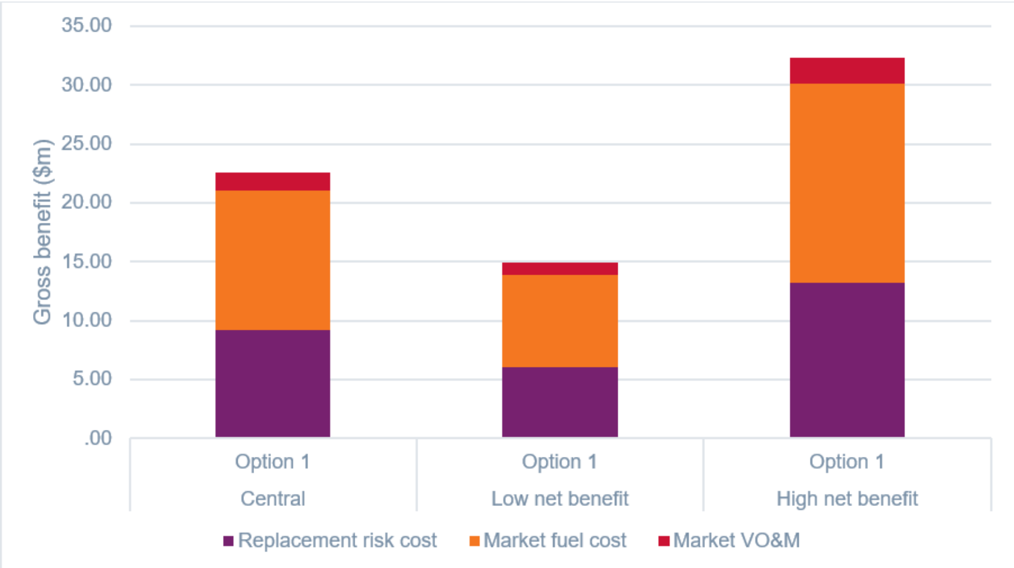
Table 4-2 summarises the present value of estimated gross economic benefits for Option 1 relative to the base case under the three reasonable scenarios. It shows that in all scenarios, positive net economic benefits result from implementing Option 1.

Table 4-2 – Gross economic benefits from credible options relative to the base case, present value ($m 2019/20)

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	22.62	14.91	32.37	23.13

The components of these benefits are shown in Figure 4-1. They are mostly comprised of reduction in system fuel consumption (costs) and variable operating and maintenance costs.

Figure 4-1 – Breakdown of gross economic benefits from implementing Option 1 relative to the base case, present value ($m 2019/20)



4.3 Estimated costs

Table 4-2 summarises the present values of the costs of Option 1 relative to the base case under the three reasonable scenarios.

Table 4-1 – Costs of implementing Option 1 relative to the base case, present value ($m 2019/20)

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	7.04	8.48	5.48	7.01

4.4 Estimated net economic benefits

Table 4-2 summarises the present value of the net economic benefits for Option 1 across the three scenarios and the weighted net economic benefits. These net economic benefits are the differences between the estimated gross economic benefits less the estimated costs.

The estimated net economic benefits from Option 1 are all positive under the three scenarios, as well as on a weighted basis. On a weighted basis, Option 1 is expected to deliver approximately $18.96 million in net market benefits.

Table 4-2 – Net economic benefits from implementing Option 1 relative to the base case, present value ($m 2019/20)

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Option 1	15.59	6.43	26.89	16.12

4.5 Sensitivity testing

TransGrid undertook a thorough sensitivity testing exercise to understand the robustness of the conclusion to underlying assumptions about key variables. These are implemented in stages.

> Step 1 – tested the sensitivity of the optimal timing of the project ('trigger year') to different assumptions on key variables
> Step 2 – once a trigger year was determined, tested the sensitivity of the NPV of net benefit to different assumptions on key variables such as lower or higher bushfire risks.

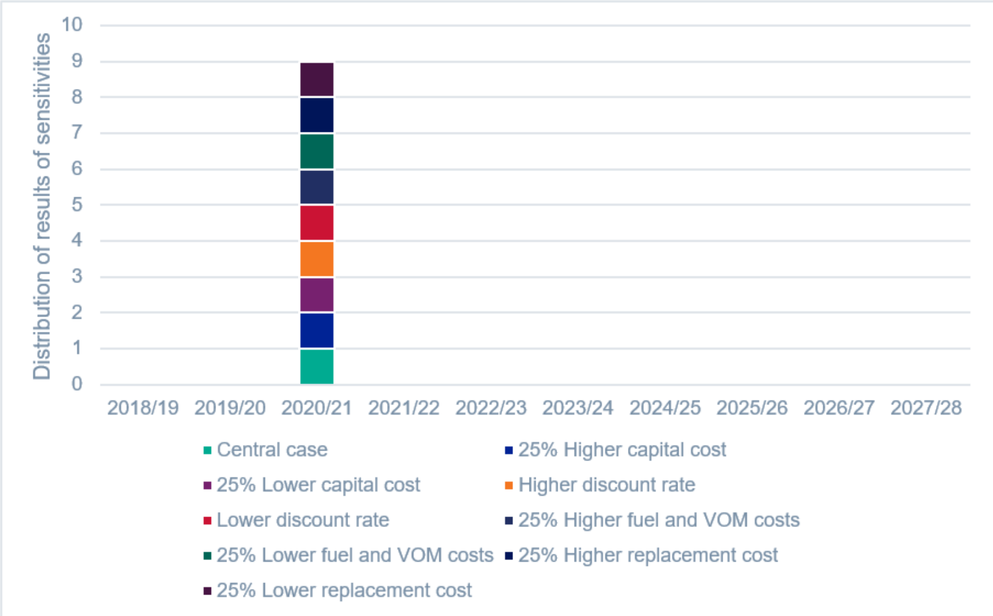
4.5.1 Step 1 – Sensitivity test of optimal timing

The optimal timing for each option is the year in which the present value of the net economic benefits are maximised. Shown on Figure 4-2, the optimal timing is 2020/21 and is invariant between the central set of assumptions and a range of alternative assumptions for the following key variables:

> a 25% increase/decrease in the assumed network capital costs
> a lower discount rate of 4.60% and a higher discount rate of 7.2%
> lower and higher benefits associated with avoided system fuel and VOM costs
> lower and higher benefits associated with avoided replacement costs.

The figure below illustrates that taking into account all sensitivities, the optimal delivery date of Option 1 is 2020/21.

Figure 4-2 – Distribution of optimal delivery year for Option 1



4.5.2 Step 2 – sensitivity of the net economic benefits

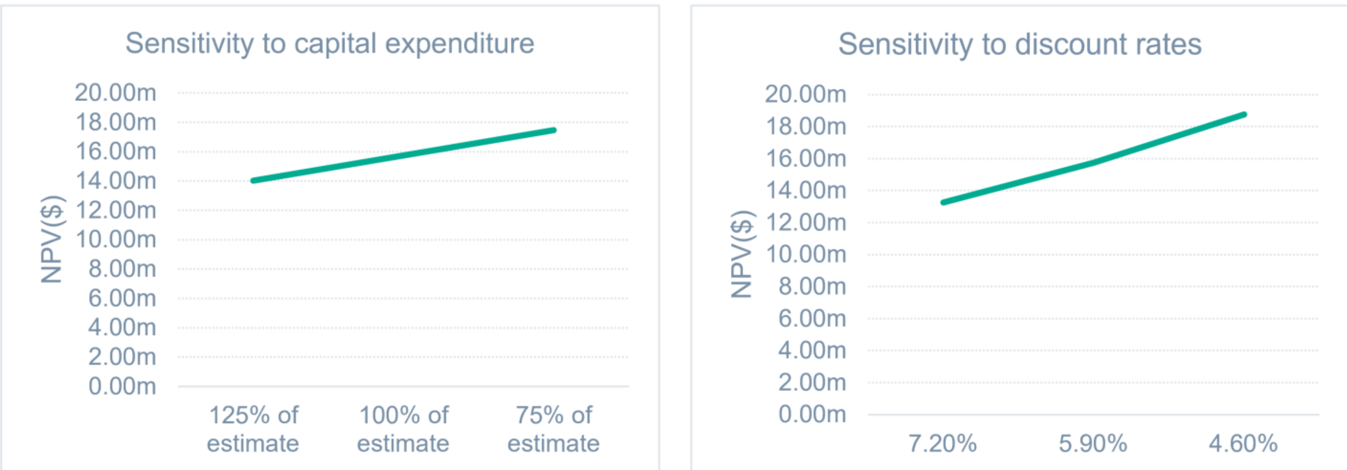
TransGrid also conducted sensitivity analysis on the overall net present value of the net economic benefits assuming the optimal timing established in Step 1.

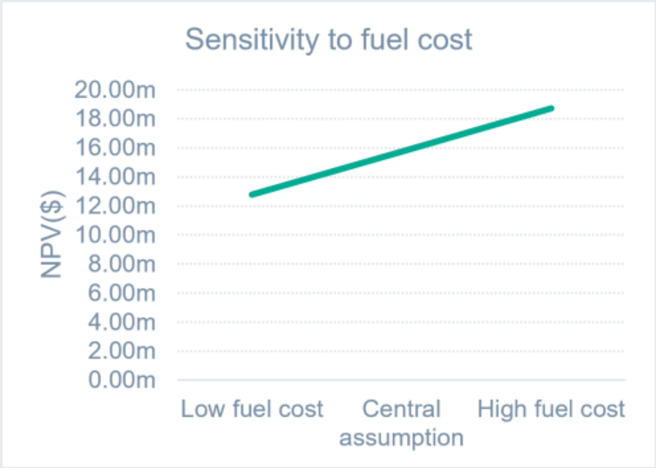
Specifically, TransGrid investigated the same sensitivities under this step:

> a 25% increase/decrease in the assumed network capital costs
> a lower discount rate of 4.60% and a higher discount rate of 7.2%
> lower and higher benefits associated with avoided system fuel and VOM costs
> lower and higher benefits associated with avoided replacement costs.

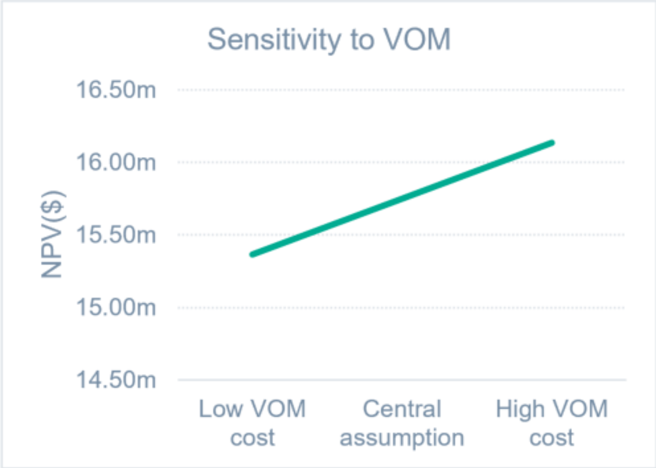
The figures below illustrate that for all sensitivity tests, the estimated net economic benefits from Option 1 are positive.

Figure 4-3 – Sensitivity of the net economic benefits from Option 1 (2019/20 $m)

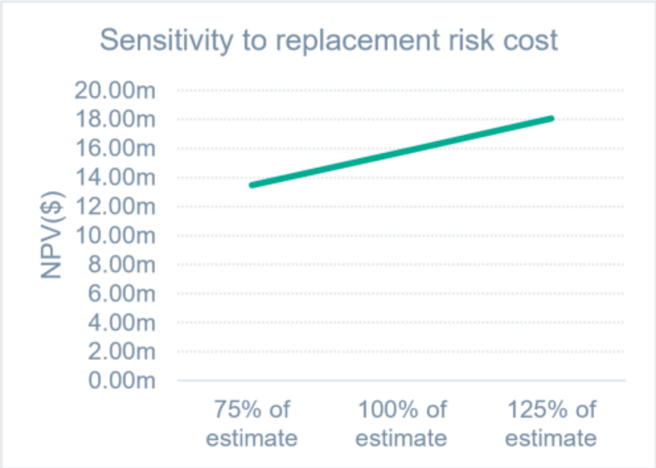




Sensitivity to fuel cost
NPV($)
20.00m
18.00m
16.00m
14.00m
12.00m
10.00m
8.00m
6.00m
4.00m
2.00m
0.00m
Low fuel cost
Central assumption
High fuel cost



Sensitivity to VOM
NPV($)
16.50m
16.00m
15.50m
15.00m
14.50m
Low VOM cost
Central assumption
High VOM cost



Sensitivity to replacement risk cost
NPV($)
20.00m
18.00m
16.00m
14.00m
12.00m
10.00m
8.00m
6.00m
4.00m
2.00m
0.00m
75% of estimate
100% of estimate
125% of estimate

5. Final conclusion on the preferred option

The optimal commercially and technically feasible option presented in the PSCR — Option 1, the refurbishment of holding down bolts and identified corroded steel members as required — remains the preferred option to meet the identified need. Option 1 involves in-situ repair of holding down bolts and in-situ gantry steelwork renewal by removing corrosion, painting and replacing identified components.

Moving forward with this option is the most prudent and economically efficient solution to maintain a reliable Upper Tumut substation.

The estimated capital expenditure associated with this option $8.36 million ± 25% (weighted present value of $7.04 million), depending on the extent of corrosion, works required to address corrosion and the final selected remediation methods across the site.

The works will be undertaken between 2018/19 and 2020/21. Planning and procurement (including completion of the RIT-T) will occur between 2018/19 and 2019/20, while project delivery and construction will be completed by 2020/21. All works will be completed in accordance with the relevant standards by 2020/21 with minimal modification to the wider transmission assets.

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 compliance checklist which demonstrates the compliance of this PACR with the requirements of clause 5.16.4(b) of the Rules version 123.

Rules clause	Summary of requirements	Relevant section(s) in PACR
5.16.4 (b)	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, Appendix C-D
	(4) a detailed description of the methodologies used in quantifying each class of material market benefit and cost;	3, 4, Appendix C-D
	(5) reasons why the RIT-T proponent has determined that a class or classes of market benefit are not material;	Appendix C
	(6) the identification of any class of market benefit estimated to arise outside the *region* of the *Transmission Network Service Provider* affected by the RIT-T project, and quantification of the value of such market benefits (in aggregate across all regions);	NA
	(7) the results of a net present value analysis of each credible option and accompanying explanatory statements regarding the results;	4
	(8) the identification of the proposed preferred option;	5
	(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 & 5, Appendix C

Appendix B – Assumptions underpinning the identified need

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.[10] Appendix D provides further details on the general modelling approaches applied including the commercial discounts rate used.

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

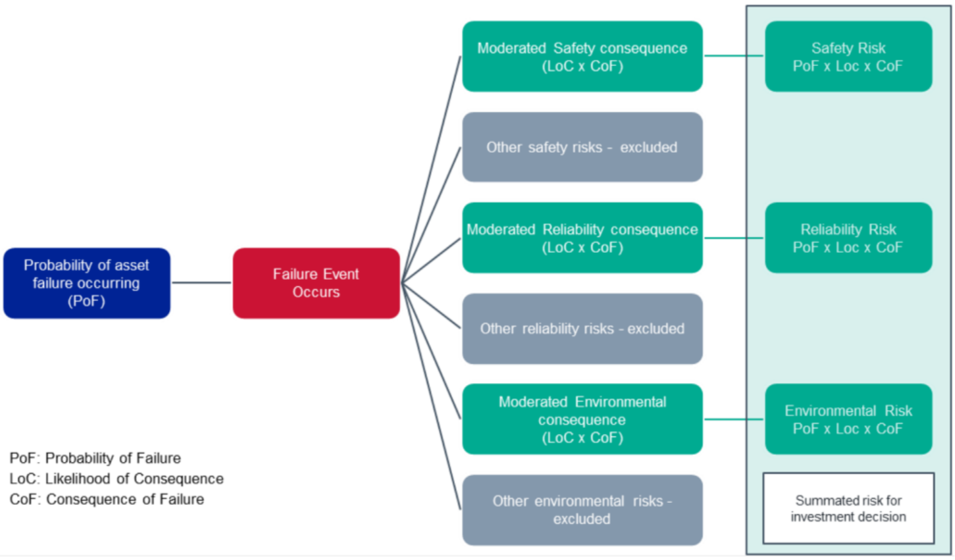
> uses externally verifiable parameters to calculate asset health and failure consequences
> assesses and analyses asset condition to determine remaining life and probability of failure
> applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence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

B.1 Overview risks assessment methodology

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

Figure B-1 below summarises the framework for calculating the 'risk cost', which has been applied on TransGrid's asset portfolio considered to need replacement or refurbishment.

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



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

10 For additional information on the risk assessment methodology, refer to pages 63-69 of TransGrid's Revised Regulatory Proposal for the period 2018-23, available at: https://www.aer.gov.au/system/files/TransGrid%20-%20Revised%20Revenue%20Proposal%20-%201%20December%202017.pdf

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 based on 'conditional age' (health-adjusted chronological age), failure and defect history, and benchmarking studies. For 'wear out' failures, a Weibull curve may be fitted; while for random failures, a static failure rate may be used.

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

Appendix C – Materiality of market benefits

This section outlines the categories of market benefits prescribed in the NER and whether they are considered material for this RIT-T.[11]

C.1 Option 1 will lower reactive substation replacement costs

TransGrid estimates the reactive replacement costs for damaged infrastructure in an event of gantry failure at Upper Tumut to be significant.

C.2 Option 1 will lower NEM fuel and other generation costs

Remediating the gantries at Upper Tumut will provide two classes of market benefits. These are:

> Changes in system fuel consumption arising through different patterns of generation dispatch – implementing Option 1 will reduce the likelihood of network constraints in NEM, unplanned disconnection of eight units of hydro-electric generation from the NEM, and their electricity production replaced by higher-cost generation.

> Changes in costs for parties, other than the RIT-T proponent, due to differences in the operating and maintenance costs – implementing Option 1 prevents the change in generation patterns that would otherwise occur, avoiding the use of higher cost generation to meet demand.

C.3 Other wholesale electricity market benefits are not material

TransGrid considers that the following classes of market benefits are not material for this RIT-T assessment:

> changes in voluntary load curtailment

> changes in ancillary services costs

> changes in network losses

> competition benefits

> Renewable Energy Target (RET) penalties.

C.4 No other categories of market benefits are material

In addition to the classes of market benefits listed above, NER clause 5.16.1(c)(4) requires TransGrid to consider the following classes of market benefits, listed in Table C-1, arising from each credible option.

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

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

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

Market benefits	Reason
Involuntary load shedding	Disconnection of eight units of hydro-electric generation from the system due to Upper Tumut substation failure is unlikely to result in unserved energy as there is sufficient capacity to replace the lost generation and there are no direct downstream customers that rely solely on Upper Tumut substation for electricity supply.
Differences in the timing of expenditure	Options considered will provide an alternative to meeting reliability requirements but are unlikely to affect decisions to undertake unrelated expenditure in the network. Consequently, material market benefits will neither be gained nor lost due to changes in the timing of expenditure from any of the options considered.
Option value	TransGrid notes the AER's view that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available is likely to change in the future, and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[12] TransGrid also notes the AER's view that appropriate identification of credible options and reasonable scenarios captures any option value, thereby meeting the NER requirement to consider option value as a class of market benefit under the RIT-T. TransGrid notes that no credible option is sufficiently flexible to respond to change or uncertainty. Additionally, a significant modelling assessment would be required to estimate the option value benefit but it would be disproportionate to potential additional benefits for this RIT-T. Therefore, TransGrid has not estimated any additional option value benefit.

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

Appendix D – Overview of the assessment approach

This appendix outlines the approach that TransGrid applied in assessing the net benefits associated with the refurbishment of holding down bolts and identified corroded steel members as required at Upper Tumut substation.

The analysis presented in the corresponding PSCR for this RIT-T was conducted using an earlier discount rate. The original calculations have been re-done using the base discount rate of 5.9% (real, pre-tax), which is consistent with the commercial discount rate calculated in the Energy Network Australia's (ENA) RIT-T Economic Assessment Handbook[13].

D.1 Overview of assessment framework

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

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

TransGrid adopted a central real, pre-tax 'commercial'[14] discount rate of 5.9% as the central assumption for the NPV analysis presented in this report. TransGrid considers that this is a reasonable contemporary approximation of a commercial discount rate, consistent with the RIT-T.

TransGrid also tested the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 4.60% equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PACR[15], and an upper bound discount rate of 7.2% (a symmetrical adjustment upwards) were investigated.

D.2 Approach to estimating project costs

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

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

Reactive maintenance costs under the base case considers the:

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

The asset failures were less frequent and restoration costs were reduced in all credible options.

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

14 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.

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

D.3 Simplified assessment methodology

As maintaining a reliable substation at Upper Tumut will provide significant benefits across the NEM, TransGrid has employed a simplified assessment methodology to estimate only the economic benefits that will sufficiently outweigh the costs of the preferred option.

Additionally, TransGrid has not incorporated all benefits in the calculations as they will not have material impact on the identification of the preferred option. Furthermore, such endeavour will constitute efforts that are not commensurate with the costs of the project.