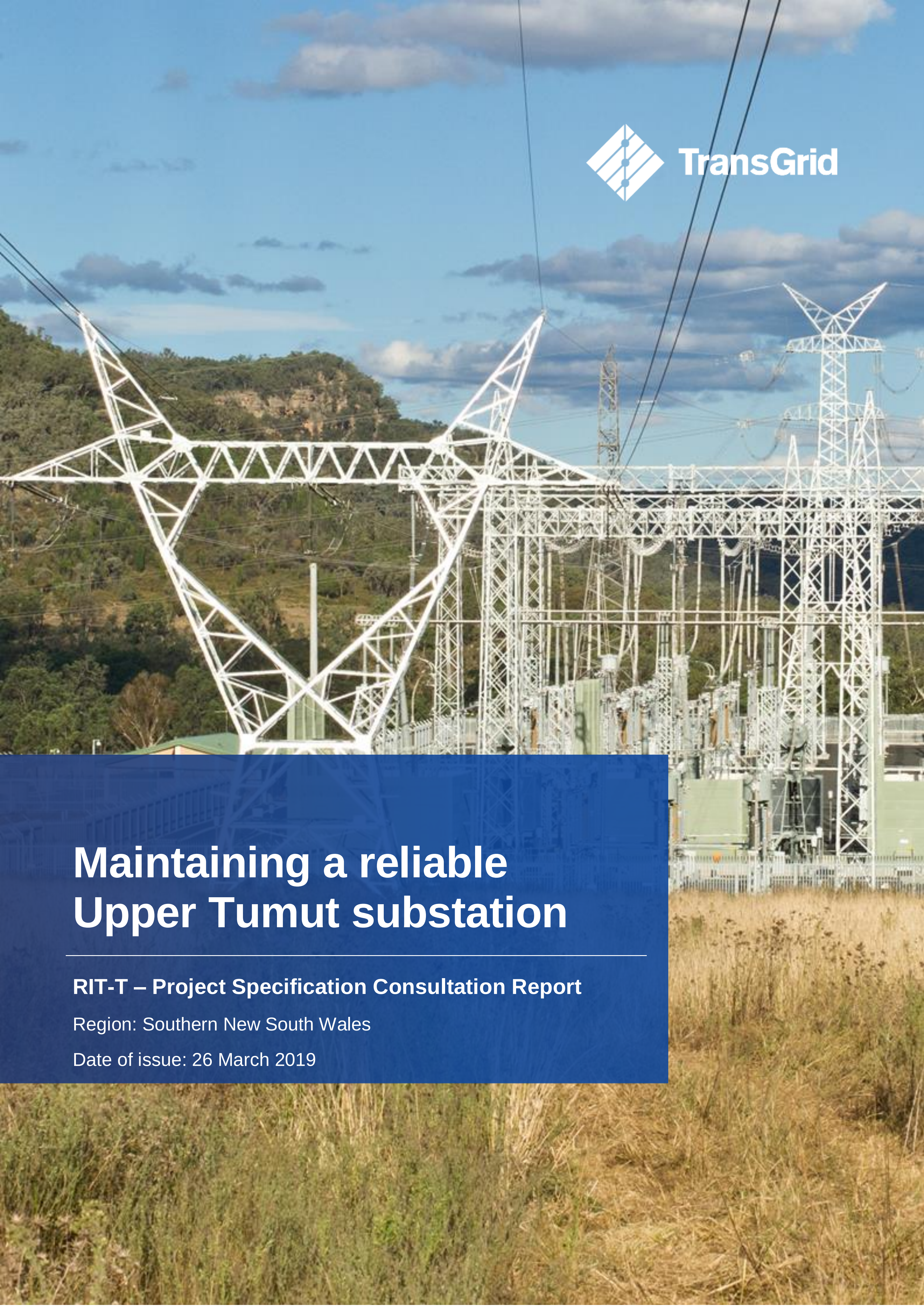

Maintaining a reliable Upper Tumut substation

RIT-T – Project Specification Consultation Report

Region: Southern New South Wales

Date of issue: 26 March 2019

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Executive summary

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating risks caused by corrosion of steelwork on gantry structural members at TransGrid's Upper Tumut substation. Publication of this Project Specification Consultation Report (PSCR) represents the first 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, and 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. Gantries 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 proportion 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 corrosion issue at this site and has been accelerated by cracking of 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.

Identified need: maintain a reliable substation to support generation and flows in southern NSW, and avoid expensive reactive replacement costs

Being one of the key substations in TransGrid's southern NSW network supporting the National Electricity Market (NEM), a substation gantry steelwork failure at Upper Tumut will:

> Decrease the total NSW hydro-electric generation capacity by at least 616 MW. In 2017/18, these units produced 1.47 TWh of electricity, enough to power 350,000 homes for a year.[1,2] This is equivalent to a probability-weighted figure of 48 GWh per year and will cost the wholesale electricity market $1.2 million per year of fuel costs from 2021/22 onward.

[1] Australian Energy Market Operator, "*Generation Information Page*," accessed 18 January 2019. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information

Australian Energy Market Operator, "*2018 ISP Assumptions Book,*" accessed 18 January 2019. https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Integrated-System-Plan/ISP-database

[2] 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

- Dispatch generation with higher variable and operating maintenance (VOM) costs. This is 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.[3]

Investment is intended to maintain a reliable substation and support generation in the southern part of the network; to provide flow paths between the Snowy Mountains, Canberra and Sydney; and to avoid expensive reactive substation replacement costs. All of these cost savings will benefit electricity consumers.

Credible options considered

In this PSCR, TransGrid has put forward for consideration credible options that would meet the identified need from a technical, commercial, and project delivery perspective.[4]

The most economical option that is commercially and technically feasible to appropriately manage the risk of a prolonged substation outage is to replace or refurbish identified corroded components (Option 1).[5] Details of the scope of works are set out below:

- For corroding gantry holding down bolts and base plates, the works include:
  - removal of concrete plinths
  - removal of corrosion, painting and repair of holding down bolts and base plates
  - reinstatement of concrete plinths.
- For corroding gantry steel members, the works include:
  - 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 (as required).

This scope of works is estimated to cost $7.99 million ± 25% (weighted present value of $6.3 million), and will be delivered by 2020/21.

Routine operating and maintenance costs are approximately $30,000 per year in 2018/19 – the same as the base case. However, TransGrid calculates significantly lower unplanned maintenance costs as Option 1 is designed to eliminate gantry failures due to corrosion – $24,000 per year.

Several other options are considered but they have proven to be economically and technically inferior to the preferred option. Table E-1 shows all options considered.

Table E-1 – Summary of options considered

Option	Description	Capital costs ($m)	Operating costs ($m per year)	Remarks
Option 1	Refurbishment of holding down bolts and identified corroded steel members as required	7.99 ± 25%	~0.030	Most economic and preferred option

[3] 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.

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

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

Option	Description	Capital costs ($m)	Operating costs ($m per year)	Remarks
Option 2	Staged delivery of Option 1 over multiple years	greater than 7.99 ± 25%	~0.030	Cost-inefficiencies by spreading the work across multiple years.
Option 3	Replacement of all substation gantries	greater than 50	~0.030	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

TransGrid considers that it will not be commercially and technically feasible for non-network options to assist with addressing the identified need for this RIT-T as a non-network option 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.

Options assessed under three different scenarios using simplified approach

TransGrid has considered three alternative scenarios – a low net economic benefits scenario, a central scenario, and a high net economic benefits scenario – all involve a number of assumptions that results in the lower bound, the expected, and the upper bound estimates for present value of net economic benefits respectively.

Table E-2 – Summary of the three scenarios investigated

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	7.04%	9.48%	4.60%

As maintaining a reliable Upper Tumut substation 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.

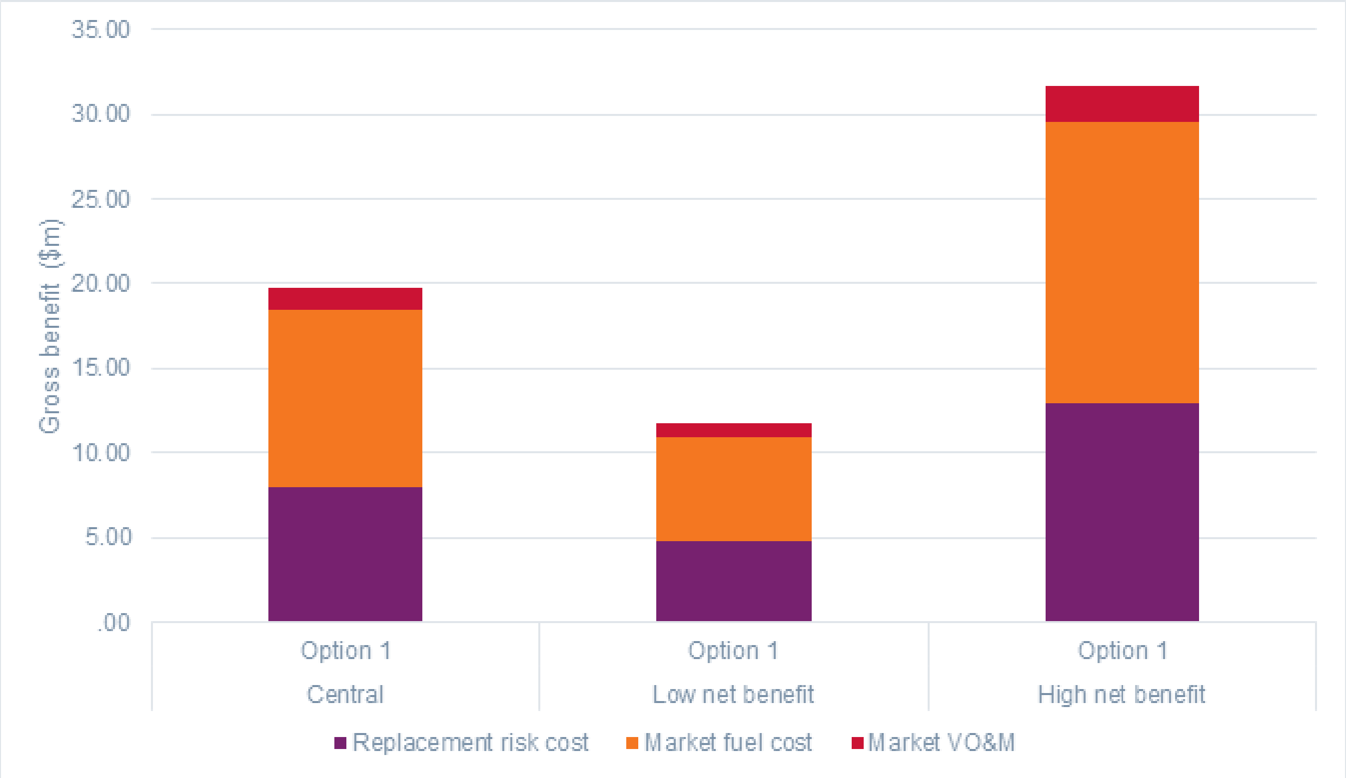
Option 1 delivers positive net economic benefits

In all scenarios, positive gross economic benefits result from implementing Option 1. The gross economic benefits are mostly composed of reduction in system fuel consumption (costs), reduction in system variable operating and maintenance costs, and avoided replacement costs.

Table E-3 – Gross economic benefits from implementing Option 1 relative to the base case, present value 2017/18 $m

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	19.7	11.7	31.6	20.7

Figure E-1 – Breakdown of gross economic benefits from implementing Option 1 relative to the base case, present value 2017/18 $m



After taking into account the costs of the options, the estimated net economic benefits from Option 1 are positive under the three scenarios, as well as on a weighted basis.

Table E-4 – Net economic benefits from implementing Option 1 relative to the base case, present value 2017/18 $m

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	13.3	4.3	26.5	14.3

Figure E-2 shows that taking into account all sensitivities, the optimal timing for the works is before 2020/21.

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

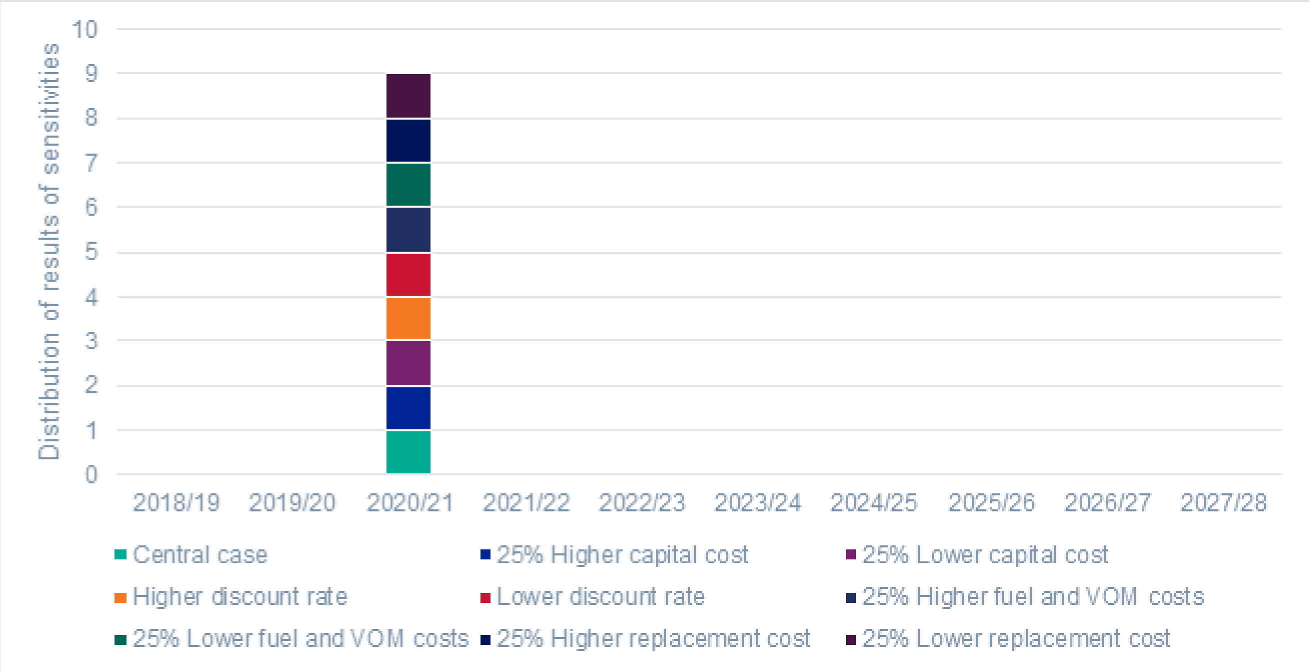


Figure E-3 – Sensitivity of the net economic benefits from Option 1

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

Draft conclusion

Option 1 involves in-situ repair of holding down bolts and in-situ gantry steelwork renewal by removing corrosion, painting and replacement of identified components is preferred at this first stage of a formal RIT-T process.

The estimated nominal capital costs of Option 1 are $7.99 million ± 25% (weighted present value of $6.3 million), depending on the extent of corrosion, works required to address corrosion and the final selected remediation methods across the site.

Subject to completion of the RIT-T process, this scope of 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 occur in 2020/21. In accordance with the relevant standards, all works will be completed by 2021/22 with minimal modification to the wider transmission assets.

Submissions and next steps

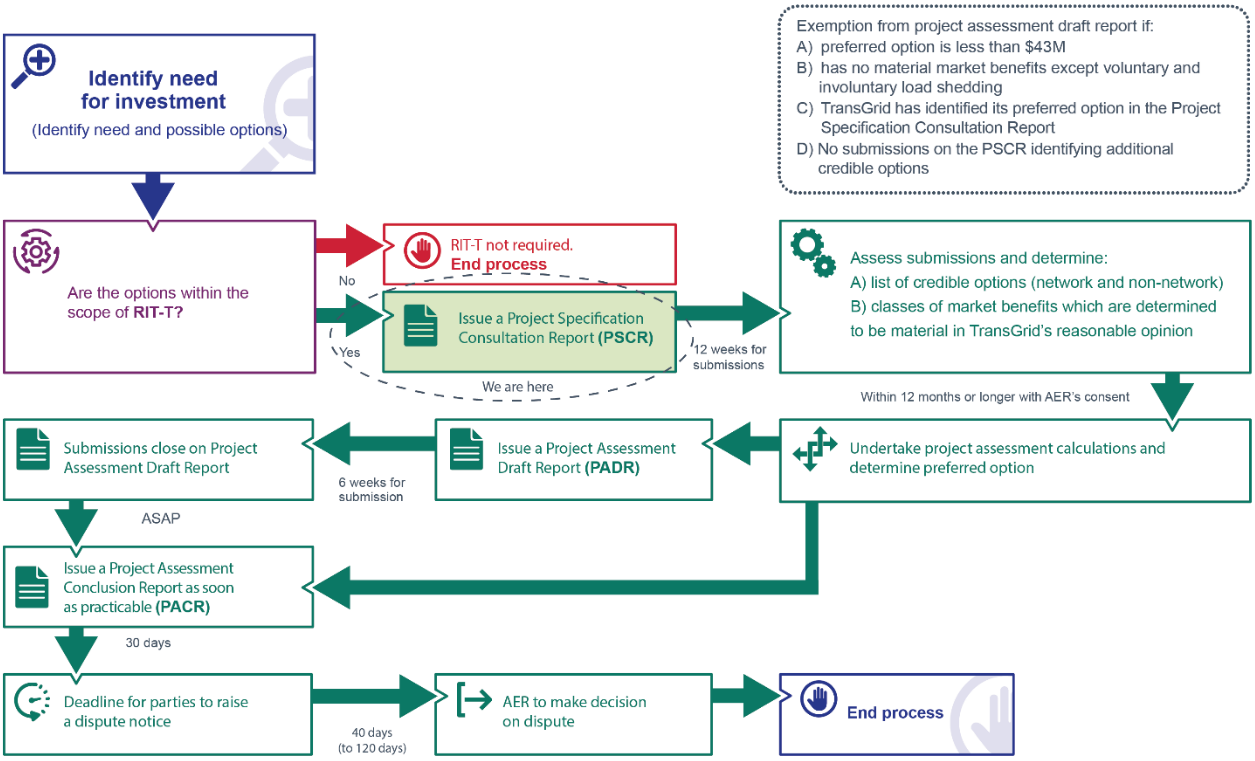
TransGrid welcomes written submissions on material contained in this PSCR. Submissions are due on or before 25 June 2019.

Submissions should be emailed to TransGrid's Prescribed Revenue & Pricing team via RIT-TConsultations@transgrid.com.au.[6] In the subject field, please reference 'Upper Tumut substation project.'

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 as per NER clause 5.16.4(z1). Therefore, the next step in this RIT-T, following consideration of submissions received via the 12-week consultation period and any further analysis required, will be publication of a Project Assessment Conclusions Report (PACR). TransGrid anticipates publication of a PACR by 25 July 2019.

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. Accordingly, if TransGrid considers that any additional credible options are identified, TransGrid will produce a PADR which includes a net present value (NPV) assessment of the net economic benefits of each additional credible option.

Figure E-4 – This PSCR is the first stage of the RIT-T process[7]



[6] TransGrid is bound by the Privacy Act 1988 (Cth). In making submissions in response to this consultation process, TransGrid will collect and hold your personal information such as your name, email address, employer and phone number for the purpose of receiving and following up on your submissions. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement. See section 1.2 for more details.

[7] 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

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1. Introduction

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for mitigating the risks caused by corrosion of steelwork on gantry structural members at TransGrid's Upper Tumut substation. Publication of this Project Specification Consultation Report (PSCR) represents the first 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, and provides electricity flow paths between the Snowy Mountains, Canberra and Sydney.

Routine asset monitoring and maintenance conducted by TransGrid found evidence of corrosion on a large proportion of gantries at Upper Tumut substation.

TransGrid has commenced this RIT-T to examine and consult on options that will enable TransGrid meet the identified need by 2021/22.

Investment is intended to maintain a reliable substation and support generation in the southern part of the network, to provide flow paths Snowy Mountains, Canberra and Sydney, and to avoid expensive reactive substation replacement costs.

1.1 Purpose of this report

The purpose of this PSCR is to:

> set out the reasons why TransGrid proposes that action be undertaken (that is, the 'identified need')

> present the options that TransGrid currently considers to address the identified need

> outline the technical characteristics that non-network options would need to provide, whilst outlining how these options are unlikely to be able to contribute to meeting the identified need for this RIT-T

> allow interested parties to make submissions and provide inputs to the RIT-T assessment.

1.2 Submissions and next steps

TransGrid welcomes written submissions on materials contained in this PSCR. Submissions are particularly sought on the credible options presented and from potential proponents of non-network options that could meet the technical requirements set out in this PSCR. Submissions are due on 25 June 2019.

Submissions should be emailed to TransGrid's Prescribed Revenue & Pricing team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Upper Tumut steelwork project.'

Subject to submissions received on this PSCR, a Project Assessment Conclusions Report (PACR), including full option analysis, is expected to be published by 25 July 2019.

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

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

At the conclusion of the consultation process, all submissions received will be published on the TransGrid's website. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement.

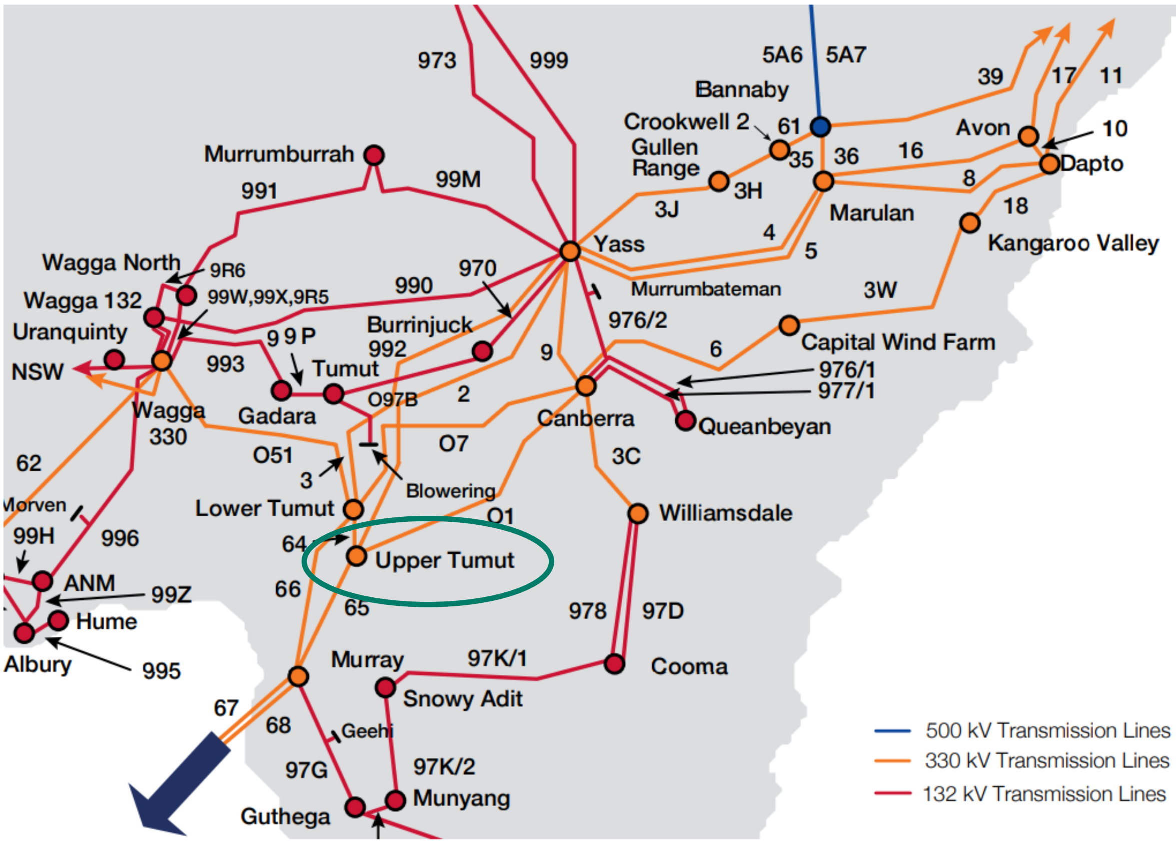
TransGrid's Privacy Policy sets out the approach to managing your personal information. In particular, it explains how you may seek to access or correct the personal information held about you, how to make a complaint about a breach of our obligations under the Privacy Act, and how TransGrid will deal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

2. The identified need

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.[8]

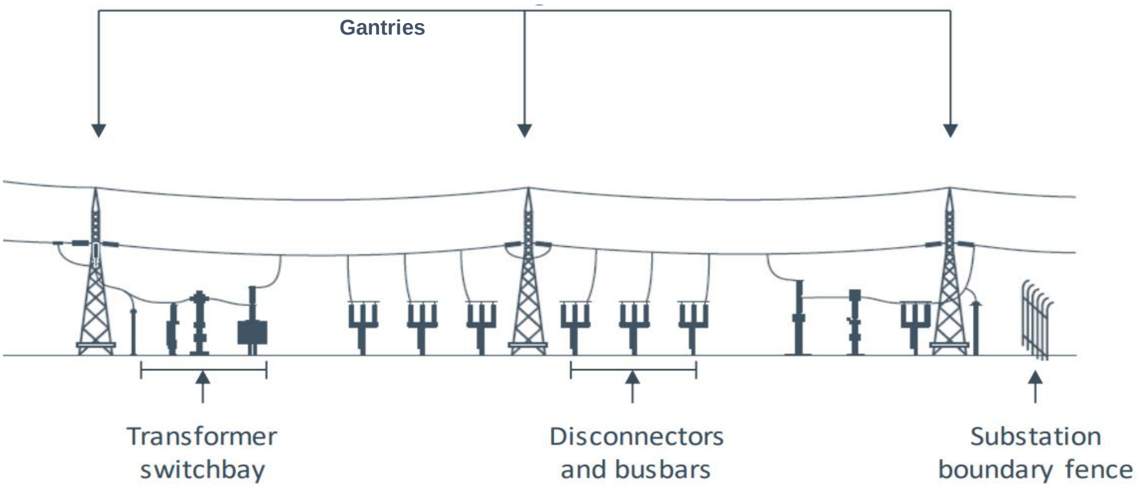
Figure 2-1 – TransGrid's southern NSW network



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 and 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.

8 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

Figure 2-2 – Simplified diagram of switching station elements highlighting the role that gantries play



Routine asset monitoring and maintenance conducted by TransGrid found evidence of corrosion on a large proportion 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 holding down bolts is the key corrosion issue at this site and has been accelerated by 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.

TransGrid’s analysis indicates that gantry structure holding down bolts and a proportion of gantry members (see Figure 2-2) 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, reduce their structual integrity, and significantly increase their probability of structural failure, especially during high wind events. Figure 2-3 and Figure 2-4 show advanced stages of corrosion of holding down bolts, base plates, and member connection bolts at Upper Tumut substation.

While some holding down bolts have yet to fully corrode, this process is already underway.

Figure 2-3 – View of gantry steel members showing corrosion

Figure 2-4 – View of corrosion to holding down bolts and baseplates

2.1 Description of the identified need

Being one of the key nodes connecting the southern NSW network to support the National Electricity Market (NEM), a substation gantry steelwork failure 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. This is 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. This is 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 of in excess of $1 million per year.[9]

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.

2.2 Assumptions underpinning the identified need

2.2.1 Likely substation failure due to corroding gantries

TransGrid's steelwork condition assessment in 2016 identified a number of corrosion-related issues on substation gantries which can be grouped into:

> corrosion on bolts, base plates and member connection bolts
> corrosion on member sections.

[9] 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.

Corrosion on a holding down bolt or a member section reduces its thickness and the capacity of the affected components to support the required structural load. Measurements taken in 2016 confirmed significant cross-sectional area lost at that time.

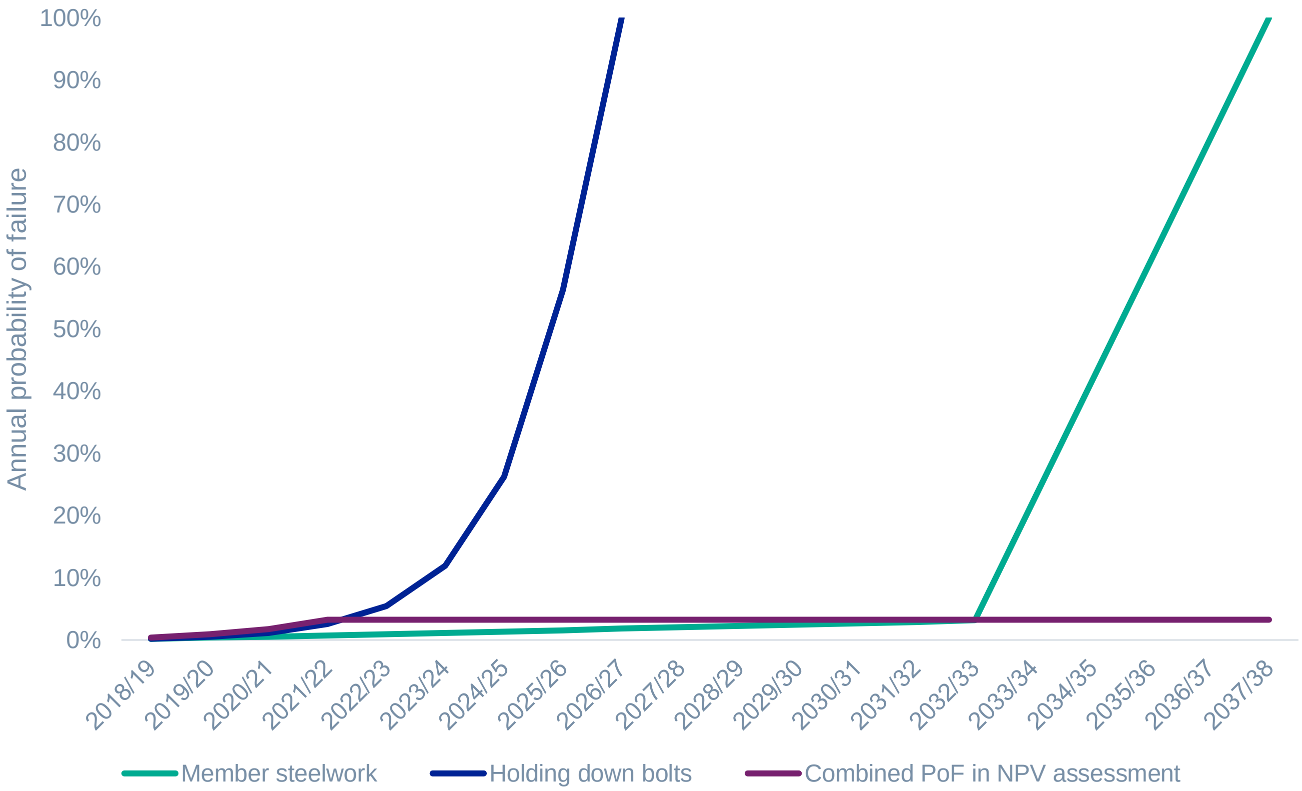
Based on the expected corrosion rates, TransGrid calculates that, without remediation, gantry holding down bolts and some members will lose sufficient cross sectional area to reach the end of serviceable life in the next 2-10 years.

After this time, the corrosion will decrease the capacity of the affected members to provide structural support, reduce structual integrity, and significantly increase the probability of structural failure, especially during high wind events.

Once 30% of their cross-sectional area are lost, minor members will no longer be able to provide lateral restraint to the major members, at which point the probability of failure is assumed to be 100%.

Figure 2-5 illustrates the average probability of failure for gantry members and holding down bolts at Upper Tumut substation between 2018/19 and 2037/38 as estimated by an independent consultant.

Figure 2-5 – Upper Tumut's probability of failure



For modelling purposes, a conservative and constant combined probability of failure of 3.26% per year from 2021/22 onwards is assumed instead of an ever-increasing estimate. TransGrid considers this conservative assumption sufficient as refining them to be more realistic requires significant exercises that will not impact the conclusion of this RIT-T.

As some holding down bolts and base plates are at advanced stages of corrosion and are nearing or at the end of serviceable life, the need must be addressed as a matter of urgency.

2.2.2 Failure of gantries will incur expensive replacement costs

As assets in the substation are located in close proximity to each other, a tower collapse from a gantry failure will cause damage to other substation assets. Consequently, repairing these assets and other affected infrastructure will incur high costs. TransGrid uses the gantries' probability of failure and the estimated cost of works to approximate the avoidable replacement costs.

2.2.3 Prolonged outage of Upper Tumut substation will increase system fuel consumption

Failure of the substation gantry holding down bolts or steelwork will lead to contact between conductors and the ground, leading to contact between the overhead earth wires and high voltage conductors, damaging critical assets that are in close proximity to gantries such as feeder conductors, busbars, circuit breakers, and transformers. All of these immediate consequences will cause substation outages.

Due to the close proximity between the assets in a substation, failure of a single gantry section will cause simultaneous damage to nearby transmission assets which will be difficult to repair, resulting in extended outages. In such an event, reduced network capability and reliability would prolong the reduction of hydro-electric generation capacity of the NEM.

This will reduce the supply of low-cost generation in the NEM and will necessitate replacement from higher-cost power stations to meet demand. This will effectively increase the total system fuel costs across the NEM.

TransGrid has adopted a simplified market modelling approach to value the increase in system fuel costs because of substation failure, as allowed under the RIT-T.[10]

This involves calculation of the average fuel cost differential between a hydro-electric power station and the marginal generator in NSW. Being renewable energy and consistent with AEMO's 2018 Integrated System Plan (ISP), hydro-electric power stations' fuel costs are assumed to be zero. The average fuel cost of the marginal generator in NSW, $25.22/MWh, is taken from the five-minute dispatch intervals in 2017/18 financial year.[11]

The volume of generation is taken from the total generation from the affected units in 2017/18 financial year weighed by the probability of substation outage due to tower collapse. This is estimated to be equal to a probability-weighted figure of 48 GWh per year.

Based on this average fuel cost differential between hydro-electric power stations and the marginal generator in NSW, and the expected generation volume reduction from the affected units, the increase in system fuel costs is estimated to be $1.2 million per year from 2021/22 onward.

In addition, gantry failure poses significant safety hazards for TransGrid field crews when attending and repairing the site and this will extend the time required to undertake any repairs.

TransGrid therefore considers that addressing the corrosion of gantry steelwork and bolts, and the risks of collapsing substation gantries, is in the long-term interests of consumers.

2.2.4 Prolonged outage of Upper Tumut substation will increase generator variable and operating maintenance costs

The same methodology described in section 2.2.3 is applied to estimate the increase in variable and operating maintenance costs due to gantry failure. Using an estimated VOM differential of $3.26/MWh, this is estimated to be $156,143 per year.

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10 Specifically, the RIT-T requires that in estimating market benefits, a market dispatch modelling methodology must be used, unless the Transmission Network Service Provider (TNSP) can demonstrate that this is not relevant. The AER RIT-T Application Guidelines recognise that in some circumstances it may be appropriate to use methods other than market dispatch modelling to estimate some classes of market benefits.

11 When there are multiple marginal generators, this figure is weighted by AEMO's measure of the materiality of each marginal generator.

3. Options that meet the identified need

TransGrid considers credible network options that would meet the identified need from a technical, commercial, and project delivery perspective.[12]

In identifying credible options, TransGrid has taken the following factors into account: energy source; technology; ownership; the extent to which the option enables intra-regional or intra-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.[13]

3.1 Base case

The costs and benefits of each option in this PSCR are compared against those of a base case. Under this 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 are incurred.

The substation failure risks under this case will increase over time. [14] This is consistent with the base case applied in this RIT-T.[15]

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

Option 1 involves the in-situ steelwork renewal by removing corrosion, painting and replacement of identified components. This options will appropriately manage the risk of prolonged substation outage. Table 3-1 gives details of the scope of works.

Table 3-1 – Scope of works for Option 1

Issue	Remediation
Corrosion of gantry holding down bolts and base plates	This includes: > 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	This includes: > 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).

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

13 As per clause 5.15.2(b) of the NER.

14 TransGrid notes that the final updated December 2018 AER RIT-T Guidelines state that the base case is where the RIT–T proponent does not implement a credible option to meet the identified need, but rather continues its 'BAU activities'. The AER define 'BAU activities' as ongoing, economically prudent activities that occur in the absence of a credible option being implemented.

15 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

This scope of 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 occur in 2020/21. In accordance with the relevant standards, all works will be completed by 2021/22.

The estimated nominal capital costs of Option 1 are $7.99 million ± 25% (weighted present value of $6.3 million) depending on the extent of corrosion, works required to address corrosion and the final selected remediation methods across the site.

Once remediation of corroded bolts and affected members has been completed under Option 1, planned operating costs will not materially differ from the base case – approximately $30,000 per year. However, TransGrid calculates significantly lower unplanned maintenance costs as Option 1 is designed to mitigate gantry failures due to corrosion – $24,000 per year.

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

Components shall be replaced or refurbished in accordance with the relevant standards and with minimal modification to the wider transmission assets.

3.3 Options considered but not progressed

Table 3-2 summarises the reasons the following credible options were not progressed further.

Table 3-2 – 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. 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 is not feasible as it requires prolonged planned substation outages and will not enable TransGrid to meet the standard.
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.

3.4 No expected material inter-network impact

TransGrid has considered whether the credible options listed above is expected to have material inter-regional impact.[16] 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:[17]

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

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

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

17 Inter-Regional Planning Committee. *"Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations."* Melbourne: Australian Energy Market Operator, 2004. Appendix 2 and 3. Accessed 15 March 2019. https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf.pdf

4. Non-network options

TransGrid does not consider that non-network options can assist with meeting the identified need for this RIT-T. The substation, supported by the gantries, performs several roles that non-network options cannot provide, such as:

> Connects substations and transmission lines in the southern NSW network which also serves several power stations.
> Connects eight existing hydro-electric generator units to the NEM, which produce about 616 MW of low-cost energy. A non-network option would have to economically replace significant amount of low-cost, zero emission, and dispatchable hydro generation.
> Provides southern flow paths Snowy Mountains, Canberra and Sydney.

The relatively low costs of refurbishment of the gantries, and the fact that non-network options are unable to directly substitute the role of the substation, makes non-network options infeasible to assist with meeting the identified need.

5. 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.[18]

5.1 Option 1 will lower reactive substation replacement costs

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

5.2 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 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.

5.3 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 (since there is no material impact on pool price)
- changes in ancillary services costs
- changes in network losses
- competition benefits
- Renewable Energy Target (RET) penalties.

5.4 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 5-1, arising from each credible option.

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

[18] 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 5-1 – 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.[19] 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.

[19] 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

6. Overview of the assessment approach

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

The analysis presented in this RIT-T considered a 20-year period, from 2018/19 to 2038/39. TransGrid considers that a 20-year period takes into account the size, complexity and expected lives of the options and provide a reasonable indication of the costs and benefits over a long outlook period. Since the capital components have asset lives greater than 20 years, TransGrid has taken a terminal value approach to ensure that the capital costs of long-lived assets is appropriately captured in the 20-year assessment period.

TransGrid has adopted a central real, pre-tax 'commercial'[20] discount rate of 7.04% 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 has 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 PSCR,[21] and an upper bound discount rate of 9.48% (a symmetrical adjustment upwards) are investigated.

6.1 Approach to estimating project costs

TransGrid has 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 are based on similar to 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.

In either credible option, the asset failures are less frequent and restoration costs are reduced.

6.2 Three different scenarios have been modelled to address uncertainty

RIT-T assessments are based on cost-benefit analysis that includes assessment under reasonable scenarios which are designed to test alternate sets of key assumptions and their impact on the ranking and feasibility of options.

TransGrid has considered three alternative scenarios, summarised in Table 6-1, to address uncertainty – namely:

> a 'low net economic benefits' scenario, involving a number of assumptions that gives a lower bound and conservative estimates of net present value of net economic benefits
> a 'central' scenario which consists of assumptions that reflect TransGrid's central set of variable estimates that provides the most likely scenario
> a 'high net economic benefits' scenario that reflects a set of assumptions which have been selected to investigate an upper bound of net economic benefits.

20 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.

21 See TransGrid's Post-tax Revenue Model (PTRM) for the 2018-23 period, available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/transgrid-determination-2018-23

Table 6-1 – Summary of the three scenarios investigated

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 VOM costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Discount rate	7.04%	9.48%	4.60%

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

6.3 Simplified assessment methodology

As maintaining a reliable Upper Tumut substation 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.

7. Assessment of credible options

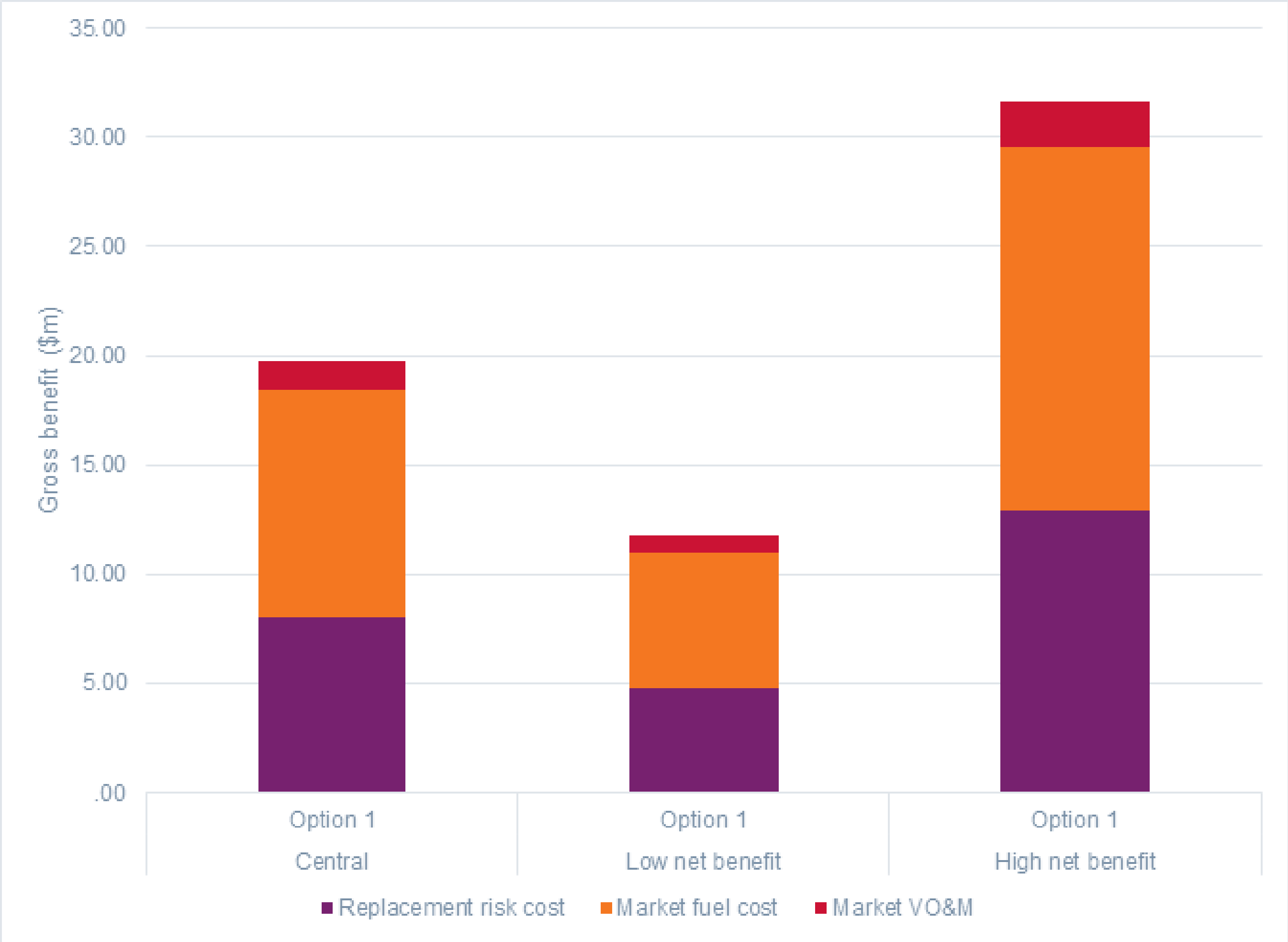
7.1 Estimated gross economic benefits

Table 7-1 summarises the present values 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. The components of these benefits are shown in Figure 7-1. They are mostly comprised of reduction in system fuel consumption (costs) and variable operating and maintenance costs.

Table 7-1 – Gross economic benefits from implementing Option 1 relative to the base case, present value 2017/18 $m

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	19.7	11.7	31.6	20.7

Figure 7-1 – Breakdown of gross economic benefits from implementing Option 1 relative to the base case, present value 2017/18 $m



7.2 Estimated costs

Table 7-2 summarises the present values of the costs of Option 1 relative to the base case under the three reasonable scenarios.

Table 7-2 – Costs of implementing Option 1 relative to the base case, present value 2017/18 $m

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	6.4	7.5	5.1	6.3

7.3 Estimated net economic benefits

The estimated net economic benefits from Option 1 are all positive under the three scenarios, as well as on a weighted basis. Presented in Table 7-3, the estimated net economic benefits are the estimated gross economic benefits less the estimated costs.

Table 7-3 – Net economic benefits from implementing Option 1 relative to the base case, present value 2017/18 $m

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Option 1	13.3	4.3	26.5	14.3

7.4 Sensitivity testing

TransGrid has undertaken 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 – tests the sensitivity of the optimal timing of the project (‘trigger year’) to different assumptions on key variables
> Step 2 – once a trigger year is determined, tests the sensitivity of the present value of the net economic benefits to different assumptions on key variables such as lower or higher bushfire risks.

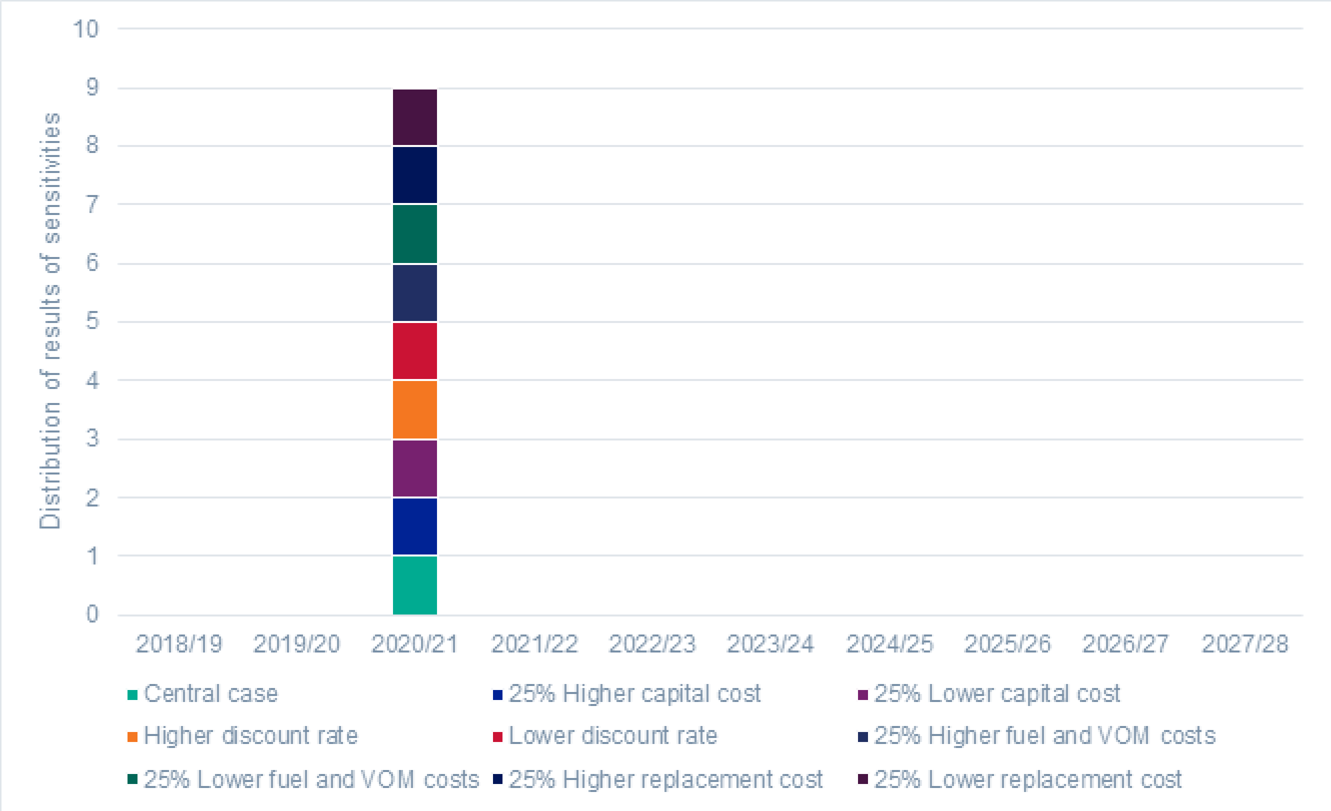
7.4.1 Step 1 – Sensitivity test of optimal timing

The optimal timing for each option is the year in which the present value of the net economic benefits are maximised. Shown on Figure 7-2, 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 9.48%
> 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 7-2 – Distribution of optimal delivery year for Option 1



7.4.2 Sensitivity of the net economic benefits

TransGrid has also conducted sensitivity analysis around the present value of the net economic benefits assuming the optimal timing established in Step 1. TransGrid has investigated the same sensitivities under this step.

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

Figure 7-3 – Sensitivity of the net economic benefits from Option 1

8. Draft conclusion and exemption from preparing a PADR

Option 1 is preferred at this draft stage and will involve in-situ steelwork renewal by removing corrosion, painting and replacement of identified components. Details of the scope of works are:

> For corroding gantry holding down bolts and base plates, the works include:
  - removal of concrete plinths
  - removal of corrosion, painting and repair of holding down bolts and base plates
  - reinstatement of concrete plinths.
> For corroding gantry steel members, the works include:
  - 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 (as required).

A net economic benefits of $14.3 million will result from implementing this option.

The estimated nominal capital costs of Option 1 are $7.99 million ± 25% (weighted present value of $6.3 million), depending on the extent of corrosion, works required to address corrosion and the final selected remediation methods across the site.

Once remediation of corroded members and bolts have been completed under Option 1, planned operating costs will not materially differ from the base case – approximately $30,000. However, there will be significantly lower unplanned maintenance costs as Option 1 is designed to eliminate gantry failures due to corrosion. Subject to completion of the RIT-T process, this scope of 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 occur in 2020/21. In accordance with the relevant standards, all works will be completed by 2021/22 with of minimal modification to the wider transmission assets.

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 as per NER clause 5.16.4(z1). Therefore, the next step in this RIT-T, following consideration of submissions received during the 12-week consultation period and any further analysis required, will be publication of a Project Assessment Conclusions Report (PACR). TransGrid anticipates publication of a PACR by 25 July 2019.

TransGrid welcomes written submissions on material contained in this PSCR. Submissions are due on or before 25 June 2019. Submissions should be emailed to TransGrid's Prescribed Revenue & Pricing team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Upper Tumut substation project.'

NER clause 5.16.4(z1) provides for a TNSP to be exempt from producing a PADR for a particular RIT-T application, in the following circumstances:

(a) if the estimated capital cost of the preferred option is less than $43 million;
(b) if the TNSP identifies in its PSCR its proposed preferred option, together with its reasons for the preferred option and notes that the proposed investment has the benefit of the clause 5.16.4(z1) exemption; and
(c) if the TNSP considers that the proposed preferred option and any other credible options in respect of the identified need will not have a material market benefit for the classes of market benefits specified in clause 5.16.1(c)(4), with the exception of market benefits arising from changes in voluntary and involuntary load shedding.

TransGrid considers that the preferred option is exempt from producing a PADR under NER clause 5.16.4(z1).

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.

Accordingly, if TransGrid considers that any additional credible options are identified, TransGrid will produce a PADR which includes an NPV assessment of the net economic benefits of each additional credible option.

Should TransGrid consider that no additional credible options were identified during the consultation period, TransGrid intends to produce a PACR that addresses all submissions received including any issues in relation to the proposed preferred option raised during the consultation period.[22]

[22] As per clause 5.16.4(z2) of the NER.

Appendix A – Compliance checklist

This appendix sets out a compliance checklist which demonstrates the compliance of this PSCR with the requirements of clause 5.16.4(b) of the Rules version 111.

Rules clause	Summary of requirements	Relevant section(s) in PSCR
5.16.4 (b)	A RIT-T proponent must prepare a report (the project specification consultation report), which must include:	–
	(1) a description of the identified need;	2
	(2) the assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, why the RIT-T proponent considers reliability corrective action is necessary);	2
	(3) the technical characteristics of the identified need that a non- network option would be required to deliver, such as: (i) the size of load reduction of additional supply; (ii) location; and (iii) operating profile;	NA
	(4) if applicable, reference to any discussion on the description of the identified need or the credible options in respect of that identified need in the most recent National Transmission Network Development Plan;	NA
	(5) a description of all credible options of which the RIT-T proponent is aware that address the identified need, which may include, without limitation, alterative transmission options, interconnectors, generation, demand side management, market network services or other network options;	3
	(6) for each credible option identified in accordance with subparagraph (5), information about: (i) the technical characteristics of the credible option; (ii) whether the credible option is reasonably likely to have a material inter-network impact; (iii) the classes of market benefits that the RIT-T proponent considers are likely not to be material in accordance with clause 5.16.1(c)(6), together with reasons of why the RIT-T proponent considers that these classes of market benefits are not likely to be material; (iv) the estimated construction timetable and commissioning date; and (v) to the extent practicable, the total indicative capital and operating and maintenance costs.	3,5

Rules clause	Summary of requirements	Relevant section(s) in PSCR
5.16.4(z1)	A RIT-T proponent is exempt from paragraphs (j) to (s) if: 1. the estimated capital cost of the proposed preferred option is less than $35 million (as varied in accordance with a cost threshold determination); 2. the relevant Network Service Provider has identified in its project specification consultation report: (i) its proposed preferred option; (ii) its reasons for the proposed preferred option; and (iii) that its RIT-T project has the benefit of this exemption; 3. the RIT-T proponent considers, in accordance with clause 5.16.1(c)(6), that the proposed preferred option and any other credible option in respect of the identified need will not have a material market benefit for the classes of market benefits specified in clause 5.16.1(c)(4) except those classes specified in clauses 5.16.1(c)(4)(ii) and (iii), and has stated this in its project specification consultation report; and 4. the RIT-T proponent forms the view that no submissions were received on the project specification consultation report which identified additional credible options that could deliver a material market benefit.	8

Appendix B – Risk cost framework

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.[23]

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:

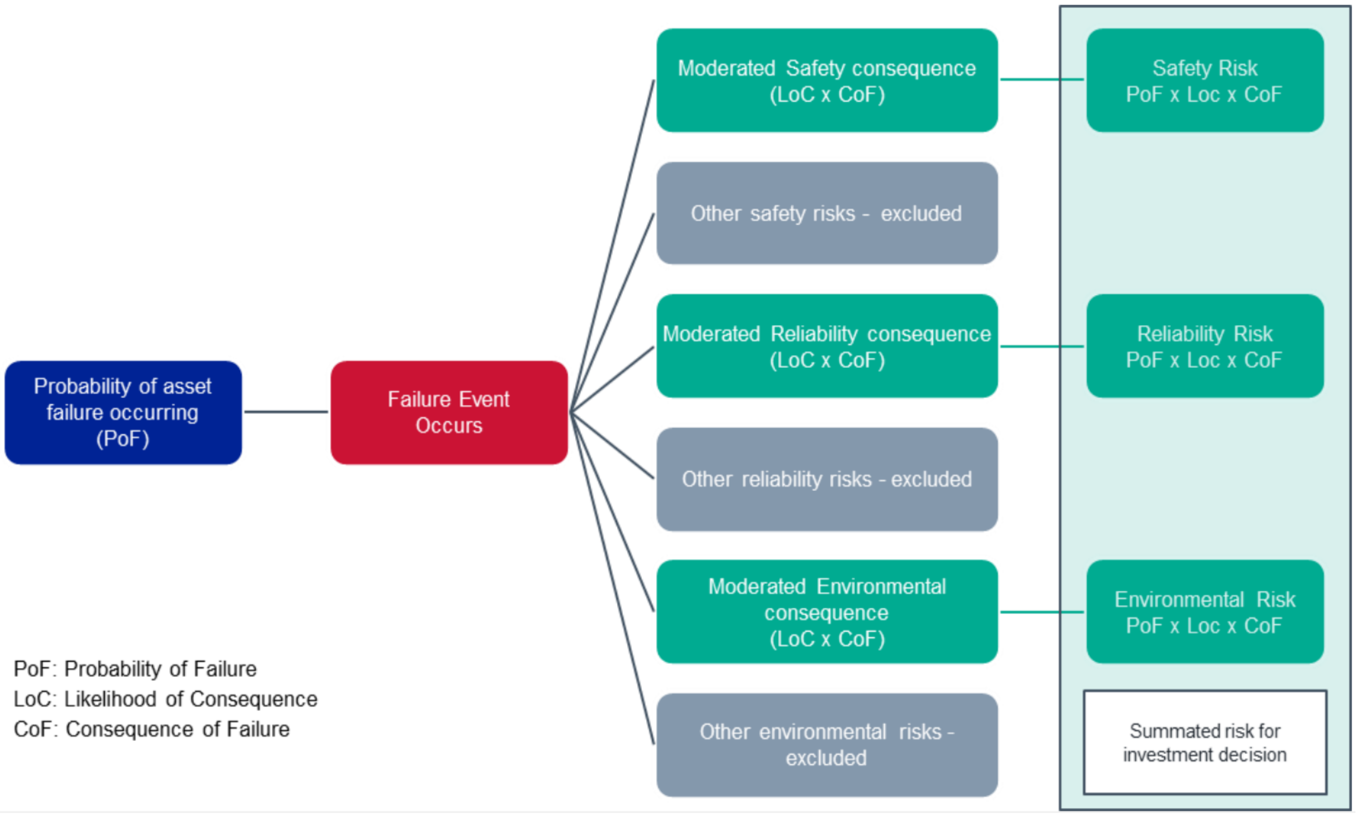
> uses externally verifiable parameters to calculate asset health and failure consequences
> assesses and analyses asset condition to determine remaining life and probability of failure
> applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence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

B.1 Overview of 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 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



[23] 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. But it excludes the risk costs of low impact, high probability (LIHP) which would results in lower calculated risk.