TransGrid

Maintaining compliance with performance standards applicable to Broken Hill substation secondary systems

RIT-T – Project Specification Consultation Report

Region: South Western NSW

Date of issue: 17 December 2019

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Executive summary

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining reliable secondary systems at Broken Hill substation. Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

TransGrid has identified that the secondary systems at Broken Hill substation have reached a condition that reflects the end of serviceable life. As it is superseded by new technology at the manufacturer level and the existing technology becomes obsolete, spare parts become scarce and the ability of any primary asset connected to the substation to reliably operate will be at risk.

Broken Hill substation is a customer connection point supplying the Essential Energy networks in the area. Silverton Wind Farm also connects at Broken Hill substation, as well as Broken Hill Solar Plant. It forms part of the wider South Western NSW network which supports renewable energy zone development and will continue to play a central role in supporting the flow of energy to the Far West region of NSW.[1] Aligned with the approach of the Integrated System Plan developed by AEMO, TransGrid has identified large-scale renewable energy zones to meet the objectives of energy security and reliability, affordability and reduced emissions.

Identified need: meet the service level required under the National Electricity Rules for protection schemes

Secondary systems are used to control, monitor, protect and secure communication to facilitate safe and reliable network operation.[2] They are necessary to operate the transmission network and prevent damage to primary assets when adverse events occur.

The Network Performance Requirements, set out in Schedule 5.1 of the NER, place an obligation on TNSPs to provide redundant protection schemes to ensure the transmission system is adequately protected. Schedule 5.1.9(c) of the NER requires a TNSP to provide sufficient primary and back-up protection systems, including any communications facilities and breaker fail protection systems, to ensure that a fault of any type anywhere on its transmission system is automatically disconnected.

Additionally, TNSPs are required to disconnect the unprotected primary systems where secondary systems fault lasts for more than eight hours (for planned maintenance) or 24 hours (for unplanned outages). TNSPs must also ensure that all protection systems for lines at a voltage above 66 kV are well-maintained so as to be available at all times other than for short periods (less than eight hours), while the maintenance of protection systems is being carried out.[3] In the event of an unplanned outage, AEMO's Power System Security Guidelines require that the primary network assets must be taken out of service within 24 hours.[4]

Furthermore, as per clause 4.11.1 of the NER, remote monitoring and control systems are required to be maintained in accordance with the standards and protocols determined and advised by AEMO.

A failure of the secondary systems would involve replacement of the failed component or taking the affected primary assets, such as lines and transformers, out of service.

Though replacement of failed secondary systems component is a possible interim measure, the approach is not sustainable as spare components will deplete due to the technology no longer being manufactured or

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1 There is over 5GW of potential wind and solar generation connections in South Western NSW and the Barrier Ranges. TransGrid. "*Transmission Annual Planning Report 2019*." Sydney: TransGrid, 2019. 45. Accessed 18 November, 2019. https://www.transgrid.com.au/what-we-do/Business-Planning/transmission-annual-planning/Documents/2019%20Transmission%20Annual%20Planning%20Report.pdf

2 As per Schedule 5.1 of the NER.

3 As per S5.1.2.1(d) of the NER.

4 Australian Energy Market Operator. *"Power System Security Guidelines, 23 April 2019."* Melbourne: Australian Energy Market Operator, 2019. Accessed 15 May 2019. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715---Power-System-Security-Guidelines.pdf

supported. Once all spares are used, replacement will cease to be a viable option to meet performance standards applicable to Broken Hill substation secondary systems.

If the failure to provide functional secondary systems due to technology obsolescence is not addressed by a technically and commercially feasible credible option in sufficient time (by 2022/23, the likelihood of not recovering from secondary systems faults and not maintaining compliance with NER performance requirements will increase).

Continued deterioration of the secondary systems at Broken Hill substation will accelerate the depletion of spares which will lead to a situation where TransGrid is unable to operate the secondary systems in accordance with clause 4.6.1 of the NER. The proposed investment will enable TransGrid to continue to meet the standards for secondary systems availability set out in the NER, and to avoid the impacts of taking primary assets out of service. Consequently, it is considered a reliability corrective action under the RIT-T.

A reliability corrective action differs from a 'market benefits'-driven RIT-T in that the preferred option is permitted to have negative net economic benefits on account of it being required to meet an externally imposed obligation on the network business.

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.[5]

These are summarised in the following table.

Table E-1 Summary of the credible options

Option	Description	Capital cost	Operating cost and maintenance	Remarks
Option 1	Complete replacement with Secondary Systems Building (SSBs)	$11.44 million by 2022/23 *(additional $1.99 million by 2022/23*)*	$6,358 per year	Technically and commercially feasible but less efficient and provides less benefit for consumers as it does not provide a reduction in reliability risk costs due to the 22kV switchgear being replaced 'like-for-like' and in-situ.
Option 2	Complete in-situ replacement	$6.25 million by 2022/23 *(additional $1.99 million by 2022/23*)*	$6,358 per year	Technically and commercially feasible but less efficient.
Option 3	Strategic asset replacement	$4.03 million by 2022/23 and	$6,358 per year	Technically and commercially feasible but does

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

Option	Description	Capital cost	Operating cost and maintenance	Remarks
		$1.57 million spread between 2023/23 and 2037/38 *(additional $1.99 million by 2022/23*)*		not address technological obsolescence beyond 2023 and is therefore not practicable.
Option 4	Complete upgrade and renewal with 22kV Switch Room and 220kV Secondary Systems Building (SSBs)	$13.03 million by 2022/23	$6,358 per year	Preferred option, provides efficiencies in combining primary works with secondary works and provides the most benefit to consumers.

* Renewal of some of the primary plant at Broken Hill substation is scheduled by 2022/23. This additional $1.99 million in capital expenditure is included in the base case, Option 1, 2 and 3, for NPV analysis purposes to enable 'like-for-like' comparison.

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

TransGrid does not consider non-network options to be commercially and technically feasible to assist with meeting the identified need for this RIT-T. Non-network options are not able to meet NER obligations to provide redundant secondary systems and ensure that the transmission system is adequately protected.

Options assessed under three different scenarios

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 scenarios

Variable/Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Discount rate	5.90%	8.95%	2.85%
Environment and safety costs	Base estimates	Base estimate - 25%	Base estimate + 25%
USE costs	Base estimates	Base estimates	Base estimates

Implementing Option 4 will meet relevant regulatory obligations

Implementation of Option 4 will enable TransGrid to meet regulatory obligations set out in Schedule 5.1 and clauses 4.11.1, 4.6.1(b)[6] of the NER to provide redundant secondary systems and ensure that the transmission system is adequately protected. Consequently, it will also ensure the performance standards applicable to Broken Hill substation secondary systems are met.

Option 4 delivers highest net economic benefits

In all scenarios, highest net economic benefits result from implementing Option 4. The gross benefits are mostly composed of reduction in reliability risks. Option 4 is the most efficient option to ensure reliability of the secondary systems at Broken Hill substation and mitigate its risks of prolonged failure.

Option 4 delivers the most benefit to consumers

In this PSCR TransGrid has considered four credible options which have been assessed relative to the base case. Of the credible options considered, Option 4 delivers the most benefit to consumers. This includes renewal of some 22kV switchgear which, although not part of the need being addressed by this RIT-T, has been discussed in some sections of this PSCR.

Renewal of some of the primary plant at Broken Hill substation is scheduled by 2022/23. The renewal of the 22kV switchgear is not subject to the RIT-T, however there are efficiencies in completing the works required to meet the identified need for this RIT-T at the same time.

Under the base case, Option 1, Option 2 and Option 3, the primary plant scheduled for renewal in 2023 is replaced 'like-for-like'. This is due to the nature of those options; specifically, under those options the location of primary plant remains the same. However, under Option 4 the primary plant is installed within a new 22 kV switchroom as part of the modular Secondary Systems Buildings (SSBs) in a different location within the switchyard. Installing the primary plant in this location delivers more benefit to consumers than all other options where it remains in the current location. Locating the primary plant in the new location enables TransGrid to reduce reliability risk costs as the asset is physically less exposed to factors causing instances of involuntary load shedding. The estimated reduction in reliability risk costs under Option 4 is approximately $400,000 per year.

Draft conclusion

The implementation of Option 4, complete upgrade and renewal of secondary systems at the Broken Hill substation by using modular Secondary Systems Building (SSBs), new metal-clad 22kV switchgear, and installing new cable throughout, is the most efficient technically and commercially feasible option at this draft stage of the RIT-T process. Option 4 addresses the identified need and identified primary plant renewals under asset renewal programs, offers the most benefit to consumers and can be implemented in sufficient time to meet the identified need by 2022/23. It is therefore the preferred option presented in this PSCR.

The estimated capital cost of this option is approximately $13 million (weighted present value of $9 million). Routine and operating maintenance costs are approximately $6,358 per year – the same as the base case.

The work will be undertaken over the three-year period, with all works expected to be completed by 2022/23.

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

[6] As per clause 4.6.1(b) of the NER, AEMO must ensure that there are processes in place that will allow the determination of fault levels for normal operation of the power system and in anticipation of all credible contingency events and protected events that AEMO considers may affect the configuration of the power system, so that AEMO can identify any busbar which could potentially be exposed to a fault level which exceeds the fault current ratings of the circuit breakers associated with that busbar.

Submissions and next steps

The purpose of this PSCR is to set out the reasons TransGrid proposes that action be taken, present the options that address the identified need, outline the technical characteristics that non-network options will need to provide, and allow interested parties to make submissions and provide input to the RIT-T assessment.

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 16 March 2020.

Submissions should be emailed to TransGrid's Regulation team via RIT-TConsultations@transgrid.com.au.[7] In the subject field, please reference 'PSCR Broken Hill secondary systems project.'

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.

Subject to additional credible options being identified during the consultation period, 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). Production of a PADR is not required due to:

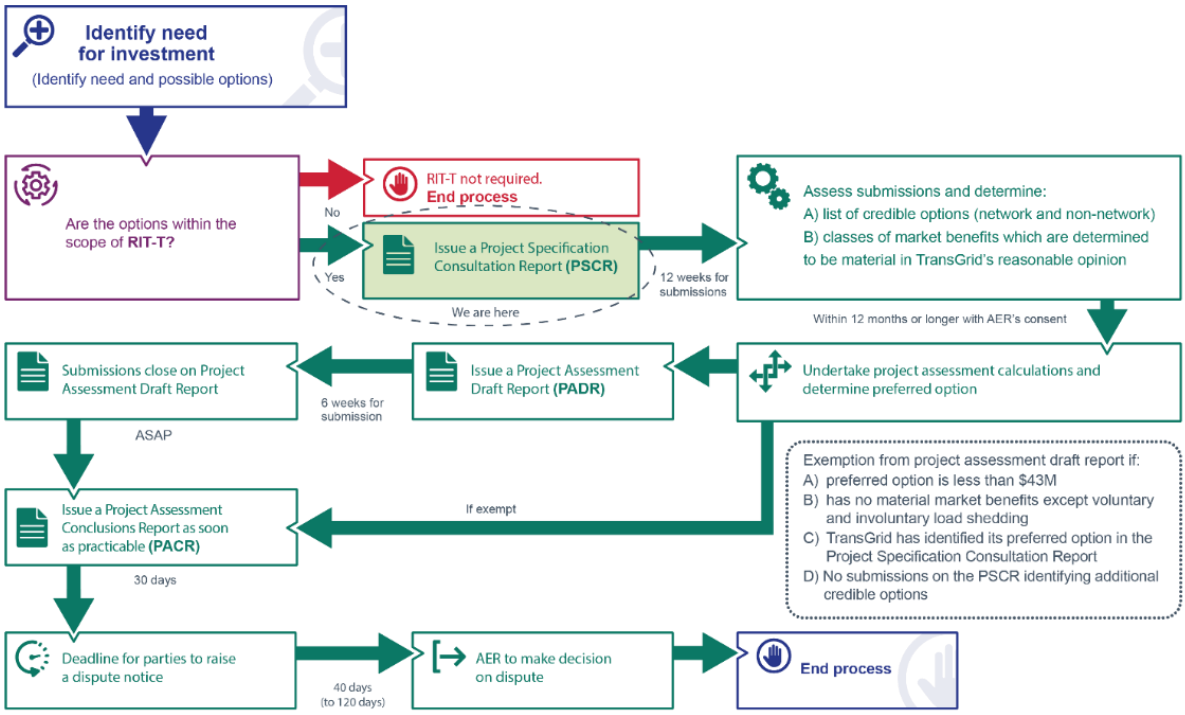
- preferred option being less than $43 million
- no market benefits except voluntary and involuntary load shedding
- preferred option has been identified in the PSCR
- no submissions on the PSCR identifying additional credible options.

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 April 2020.

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.

[7] 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 Privacy Notice within the Disclaimer for more details.

Figure E-1 This PSCR is the first stage of the RIT-T process[8]



[8] Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.65. Accessed 19 November 2019. https://www.aemc.gov.au/sites/default/files/content/89fbf559-2275-4672-b6ef-c2574eb7ce05/Final-rule-determination.pdf

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1. Introduction

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining a reliable secondary systems at Broken Hill substation. Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

TransGrid has identified that the secondary systems at Broken Hill substation have reached a condition that reflects the end of serviceable life. As it is superseded by new technology at the manufacturer level and the existing technology becomes obsolete, spare parts become scarce and the ability of the any primary asset connected to the substation to reliably operate will be at risk. Deterioration of the affected assets must be addressed to support a functional substation.

Broken Hill substation is a customer connection point supplying the Essential Energy networks in the area and also connects AGL solar farms nearby. The substation will continue to play a central role in supporting the flow of energy to the Far West region of NSW. It forms part of the wider South Western NSW network which supports renewable energy zone development.[9] Aligned with the approach of the Integrated System plan developed by AEMO, TransGrid has identified large-scale renewable energy zones to meet the objectives of energy security and reliability, affordability and reduced emissions.

TransGrid has commenced this RIT-T to examine and consult on options to mitigate and alleviate the deterioration of the secondary systems at Broken Hill substation and the risk from technology obsolescence. As investment is intended to maintain compliance with NER requirement, TransGrid considers this a reliability corrective action RIT-T.

1.1 Purpose of this report

The purpose of this PSCR[10] is to:

> set out the reasons why TransGrid proposes that action be taken (the 'identified need')
> present the options that TransGrid currently considers to address the identified need
> outline how non-network options are unlikely 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 16 March 2020.

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[9] There is over 5GW of potential wind and solar generation connections in South Western NSW and the Barrier Ranges. TransGrid. "*Transmission Annual Planning Report 2019*." Sydney: TransGrid, 2019. 45. Accessed 18 November, 2019. https://www.transgrid.com.au/what-we-do/Business-Planning/transmission-annual-planning/Documents/2019%20Transmission%20Annual%20Planning%20Report.pdf

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

[11] 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 Privacy Notice within the Disclaimer for more details.

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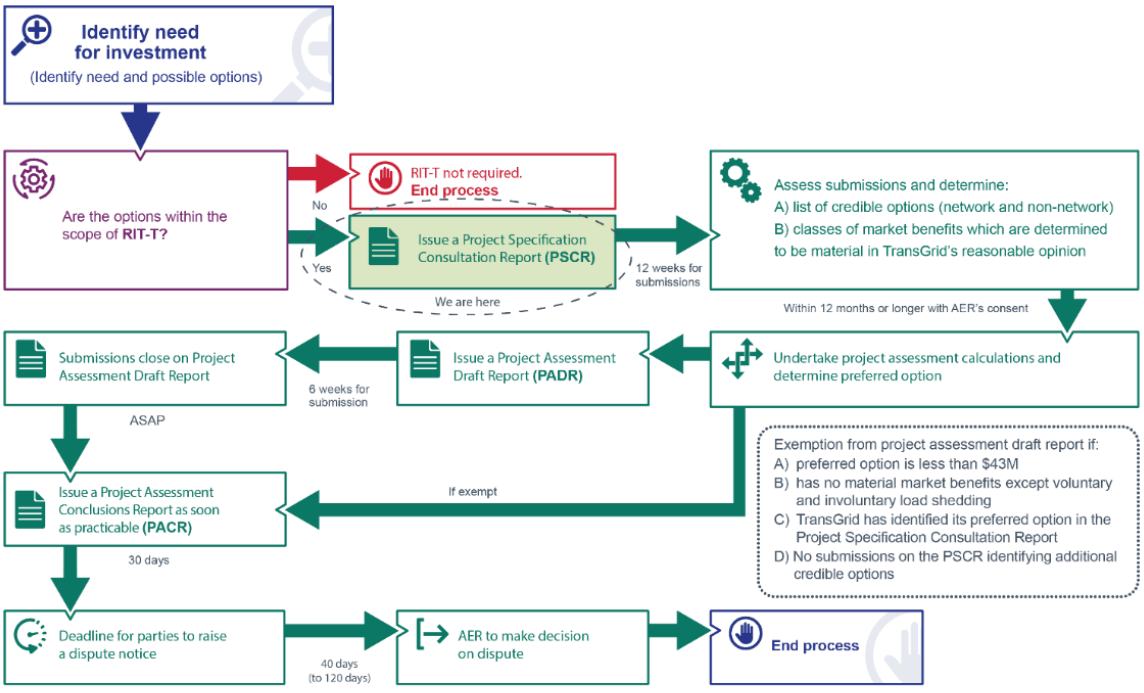
- preferred option being less than $43 million
- no market benefits except voluntary and involuntary load shedding
- preferred option has been identified in the PSCR
- no submissions on the PSCR identifying additional credible options.

Therefore, the next step in this RIT-T, following consideration of submissions received during the 12-week consultation period[12] and any further analysis required, will be publication of a Project Assessment Conclusions Report (PACR). TransGrid anticipates publication of a PACR by April 2020.

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 1-1 This PSCR is the first stage of the RIT-T process[13]



12 Additional days have been included to cover public holidays.

13 Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.65. Accessed 19 November 2019. https://www.aemc.gov.au/sites/default/files/content/89fbf559-2275-4672-b6ef-c2574eb7ce05/Final-rule-determination.pdf

2. The identified need

Broken Hill substation was commissioned in 1979 and forms part of TransGrid's network that serves South Western NSW. The substation is a customer connection point for nearby generators owned by AGL and Essential Energy. It also supports the flow of electricity to a residential population of more than 17,000[14] in Broken Hill and surrounding areas via the Essential Energy networks.

Broken Hill substation is connected to Buronga substation via a 220 kV transmission line (Line X2) owned by TransGrid. A 220 kV transmission line (Line OX1) runs between TransGrid's Buronga substation and Red Cliffs Terminal Station which is owned by AusNet Services. Red Cliffs Terminal Station is one of four points of interconnection between the NSW and Victorian transmission systems.

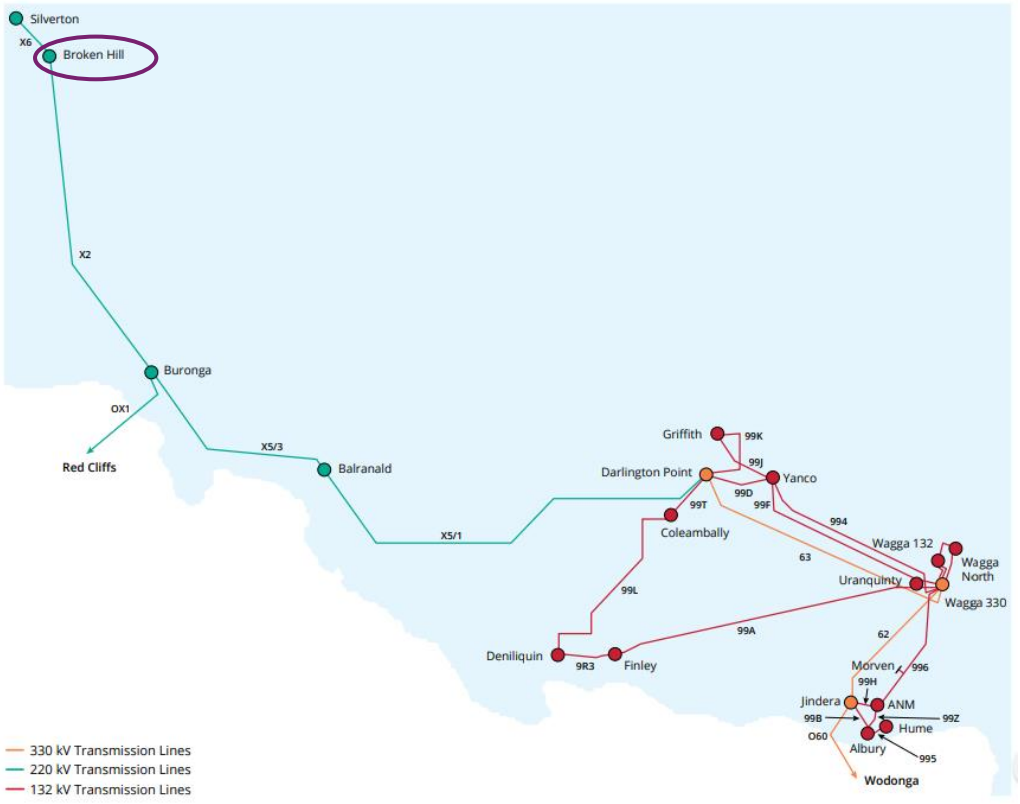
Another two 220 kV transmission lines connect at Broken Hill serving directly connected customers.

A further eight feeders at 22 kV run between Broken Hill substation and connection points in the surrounding area. These connection points include: Broken Hill West, Pinacles Place (three separate connection points), Broken Hill Solar Farm No.1, and Broken Hill Solar Farm No.2.

In addition to the feeders, Broken Hill substation comprises two 220/22 kV transformers, four 22 kV capacitor banks and two 22 kV Static Var Compensators (SVCs).

An overview of the South Western NSW transmission network is provided in Figure 2-1 below.

Figure 2-1 South Western NSW transmission network



[14] The population of Broken Hill is 17,814, as per the 2016 Census. Australian Bureau of Statistics, "*2016 Census QuickStats*", accessed 6 June, 2019. https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/SSC11237

The secondary systems components at Broken Hill were installed between 1979 and 2015 to support the safe and reliable operation of the substation. This arrangement is necessary to ensure that all electricity users in the Broken Hill area, whether they be large industrial customers directly connected to TransGrid's network or residential consumers connected via Essential Energy's distribution network, are able to receive the level of support they require.

Broken Hill substation will continue to play a central role in supporting the flow of energy to the Far West region of NSW. It forms part of the wider South Western NSW network which supports renewable energy zone development.[15] Aligned with the approach of the Integrated System plan developed by AEMO, TransGrid has identified large-scale renewable energy zones to meet the objectives of energy security and reliability, affordability and reduced emissions. The maximum load for Broken Hill substation is approximately 53 MW[16] and is currently a mix of residential, commercial[17] and industrial.

2.1 Description of the identified need

Secondary systems are used to control, monitor, protect and secure communication to facilitate safe and reliable network operation.[18] They are necessary to operate the transmission network and prevent damage to primary assets when adverse events occur.

The Network Performance Requirements, set out in Schedule 5.1 of the NER, place an obligation on TNSPs to provide redundant protection schemes to ensure the transmission system is adequately protected. Schedule 5.1.9(c) of the NER requires a TNSP to provide sufficient primary and back-up protection systems, including any communications facilities and breaker fail protection systems, to ensure that a fault of any type anywhere on its transmission system is automatically disconnected.

Additionally, TNSPs are required to disconnect the unprotected primary systems where secondary systems fault lasts for more than eight hours (for planned maintenance) or 24 hours (for unplanned outages). TNSPs must also ensure that all protection systems for lines at a voltage above 66 kV are well-maintained so as to be available at all times other than for short periods (less than eight hours), while the maintenance of protection systems is being carried out.[19] In the event of an unplanned outage, AEMO's Power System Security Guidelines require that the primary network assets must be taken out of service within 24 hours.[20]

Furthermore, as per clause 4.11.1 of the NER, remote monitoring and control systems are required to be maintained in accordance with the standards and protocols determined and advised by AEMO.

TNSPs, as per clause 4.11.2 of the NER, are also required to provide and maintain necessary primary and back-up communications facilities for control, operational metering and indication from the relevant local sites to the appropriate interfacing termination as nominated by AEMO.[21]

In general, failures are becoming more difficult to diagnose and rectify due to obsolescence of equipment and supporting tools, leading to longer recovery times. TransGrid estimates that the amount of time it takes to

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15 There is over 5GW of potential wind and solar generation connections in South Western NSW and the Barrier Ranges. TransGrid. "*Transmission Annual Planning Report 2019*." Sydney: TransGrid, 2019. 45. Accessed 18 November, 2019. https://www.transgrid.com.au/what-we-do/Business-Planning/transmission-annual-planning/Documents/2019%20Transmission%20Annual%20Planning%20Report.pdf

16 Summation of a 17 MW customer load and 36 MW Essential Energy load, based on projections for Essential Energy's Broken Hill 22 kV bulk supply point for summer 2023/24. TransGrid. "*Transmission Annual Planning Report 2019*." Sydney: TransGrid, 2019.84. Accessed 25 July, 2019. https://www.transgrid.com.au/what-we-do/Business-Planning/transmission-annual-planning/Documents/2019%20Transmission%20Annual%20Planning%20Report.pdf

17 Australian Energy Market Operator, *"AEMO Visualisations Map,"* accessed 5 June, 2019. http://www.aemo.com.au/aemo/apps/visualisations/map.html

18 As per Schedule 5.1 of the NER.

19 As per S5.1.2.1(d) of the NER.

20 Australian Energy Market Operator. *"Power System Security Guidelines, 23 April 2019."* Melbourne: Australian Energy Market Operator, 2019. Accessed 15 May 2019. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715---Power-System-Security-Guidelines.pdf

21 Australian Energy Market Operator. "*Power System Data Communication Standard*." Melbourne: Australian Energy Market Operator, 2018. Accessed 20 March 2019. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Network_Connections/Transmission-and-Distribution/AEMO-Standard-for-Power-System-Data-Communications.pdf

recover from secondary systems failure (malfunction of the 132 kV low impedance busbar protection relays) once spares are depleted, is estimated to exceed 16 hours – longer than acceptable.[22] During this period, the failed component of the secondary systems would need to be replaced with a new design and primary assets such as the lines or transformers connected to the substation would have to be taken out of service.

Though replacement of failed secondary systems component is a possible interim measure, the approach is not sustainable as spare components will deplete due to the technology no longer being manufactured or supported. Sourcing spares will continue to be a challenge as the technology and its supporting software has become obsolete. Cybersecurity risks from using unsupported and un-patchable configuration and diagnostic software are also present.

TransGrid considers spare parts will be exhausted by 2022/23. However, continued deterioration of the secondary systems at Broken Hill substation will accelerate the depletion of spares. Once all spares are used and the asset becomes unserviceable, repair will cease to be a viable option to meet performance standards applicable to Broken Hill substation secondary systems.

Therefore, a technically and commercially feasible credible option must be implemented in sufficient time (by 2022/23) to maintain compliance with the NER requirement.

Option 4 addresses the identified need and identified primary plant renewals under asset renewal programs and can be implemented in sufficient time to meet the identified need by 2022/23. Of the credible options considered, it is the most efficient and therefore is the preferred option presented in this PSCR.

The proposed investment will enable TransGrid to continue to meet the standards for secondary systems availability set out in the NER, and to avoid the impacts of taking primary assets out of service. Consequently, it is considered a reliability corrective action under the RIT-T.

A reliability corrective action differs from a 'market benefits'-driven RIT-T in that the preferred option is permitted to have negative net economic benefits on account of it being required to meet an externally imposed obligation on the network business.

2.2 Assumptions underpinning the identified need

2.2.1 Depletion of available spares due to no manufacturer support for technologically obsolete components

Though repair of a failed secondary systems at Broken Hill substation is possible as an interim measure, the approach is not sustainable as spare components will deplete due to the technology no longer being manufactured or supported. Once all spares are used, repair will cease to be a viable option and will not enable performance standards applicable to Broken Hill substation secondary systems to be met.

2.2.2 Deterioration of control systems increases the risk of substation failure

Appendix B provides an overview of the Risk Assessment Methodology adopted by TransGrid. TransGrid has identified several critical issues with the secondary systems at Broken Hill substation. The issues are outlined in Table 2-1 are expected to escalate until the asset is fully inoperable.

[22] As per S5.1.2.1(d) of the NER.

Table 2-1 Identified condition of Broken Hill substation secondary systems

Asset components	Issues	% of services at site
Line/Feeder Protection Relays	> Component technology obsolescence resulting in a lack of spares and no manufacturer support > Relays known to become trapped in a logic loop, rendering the relay non-auto and initiating the relay inoperative alarm	75% of all line/feeder protection relays on site
Transformer Protection Relays	> Component technology obsolescence resulting in a lack of spares and no manufacturer support > Faulty harmonic bias circuitry due to component failure > Internal wiring connection problems	100% of all transformer protection relays on site
Market Meters	> Microprocessor Energy Meters failing as they approach end of technical service life > Component technology obsolescence resulting in a lack of spares and no manufacturer support	79% of all market meters on site
Capacitor Protection Relays	> Component technology obsolescence resulting in a lack of spares and no manufacturer support > Inaccurate measurement of faults due to deteriorated internal components	100% of all capacitor protection relays on site
SVC Protection Relays	> Component technology obsolescence resulting in a lack of spares and no manufacturer support > Inaccurate measurement of faults due to deteriorated internal components	100% of all SVC protection relays on site
22kV Voltage Transformers	> Deterioration indicating assets nearing end of useful life > Significant risks associated with asset failure	100% of all 22kV VTs
22kV Current Transformers	> Deterioration indicating assets nearing end of useful life > Significant risks associated with asset failure	75% of all 22kV CTs
22kV Circuit Breakers	> Wear of mechanism components leading to unreliable operation > Low insulation resistance of the high voltage components > Lack of spares availability	12.5% of all 22kV CBs

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.[23]

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 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.[24]

All costs presented in this PSCR are in 2019/20 dollars.

In this PSCR TransGrid has considered four credible options which have been assessed relative to the base case. Of the credible options considered, Option 4 delivers the most benefit to consumers. This includes renewal of some 22kV switchgear which, although not part of the need being addressed by this RIT-T, has been discussed in some sections of this PSCR.

Renewal of some of the primary plant at Broken Hill substation is scheduled by 2022/23. The renewal of the 22kV switchgear is not subject to the RIT-T, however as the timing of the work already scheduled for the primary plant coincides with the need date for this RIT-T there are efficiencies in completing the works required to meet the identified need for this RIT-T concurrently.

Under the base case, Option 1, Option 2 and Option 3, the primary plant scheduled for renewal in 2023 is replaced 'like-for-like'. This is due to the nature of those options; specifically, under those options the location of primary plant remains the same. However, under Option 4 the primary plant is installed within a new 22 kV switchroom as part of the modular Secondary Systems Buildings (SSBs) in a different location within the switchyard. Installing the primary plant in this location delivers more benefit to consumers than all other options where it remains in the current location. Locating the primary plant in the new location enables TransGrid to reduce reliability risk costs as the asset is physically less exposed to factors causing instances of involuntary load shedding. The estimated reduction in reliability risk costs under Option 4 is approximately $400,000 per year.

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 to remediate the technological obsolescence, spares unavailability, manufacturer non-support, and components deterioration of the secondary systems. The asset will continue to operate and be maintained under the current regime. However the primary plant of $1.99 million scheduled for renewal in 2023 is included under the base case to be able to compare all options in the NPV analysis on a 'like-for-like' basis.

The majority of protection relays, remote control and monitoring devices at this site have limited spares, no manufacturer support, and will reach end of serviceable life by 2022/23. Repairs will become more difficult due to limited spares and this will lead to periods of unavailability. As a result, the likelihood of a hazardous event will increase.

Annual operating and maintenance costs are approximated at $6,358. However, increases to the regular maintenance regime will not be able to mitigate the risk of failure of the secondary systems at Broken Hill substation.

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

[24] As per clause 5.15.2(b) of the NER.

3.2 Option 1 – Secondary Systems Building replacement

Option 1 involves a complete upgrade and renewal of secondary systems at Broken Hill substation by using modular Secondary Systems Buildings (SSB) and installing new cable throughout. This option will modernise the automation philosophy to current design standards and practices.

This option assumes that the new secondary systems will be designed to be accommodated within a similar panel arrangement as the existing installation. Redundant panels and tunnel boards in the Auxiliary Services Building's (ASB) relay room will need to be progressively decommissioned and removed as the new secondary systems are cut-over and commissioned. This option does not include works on the 22kV primary assets as outlined under Option 4.

The estimated capital costs for the option total $11.44 million. Routine operating and maintenance costs are approximately $6,358 per year.

Under Option 1, an additional capital cost of $1.99 million in primary plant asset renewal program works identified under separate needs would need to be incurred.

The work will be undertaken over the three-year period until 2022/23, with all works expected to be completed by 2022/23.

All works under all options will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission network.

3.3 Option 2 – Complete in-situ replacement of protection and control systems

Option 2 involves replacement of all secondary systems assets at Broken Hill substation. This option will modernise the automation philosophy to current design standards and practices. This option also includes replacement of Direct Current (DC) supplies to account for an increase in secondary systems power requirements and remediation of the 415V Alternating Current (AC) distribution in the building and the switchyard. This option does not include works on the 22kV primary assets as outlined under Option 4.

The estimated capital costs for the option total $6.25 million. Routine operating and maintenance costs are approximately $6,358 per year.

Under Option 2, an additional capital cost of $1.99 million in primary plant asset renewal program works identified under separate needs would need to be incurred.

The work will be undertaken over the three-year period until 2022/23, with all works expected to be completed by 2022/23.

All works under all options will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission network.

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

3.4 Option 3 – Strategic asset replacement

Option 3 involves individual replacements of identified assets up to 2022/23. The option is based on a like-for-like approach whereby the assets is replaced by its modern equivalent. Additional systems modifications or additional functionalities would not be deployed under this option. This option will lock TransGrid to a systems architecture that cannot be expanded to match modern technology capabilities into the future. This option only includes the targeted assets highlighted in Table 2-1. The remaining assets will require additional expenditure in the next 5 -10 years. This option does not include works on the 22kV primary assets as outlined under Option 4.

The estimated capital costs for the option total $4.03 million. Routine operating and maintenance costs are approximately $6,358 per year — the same as the base case.

Under Option 3, an additional capital cost of $1.99 million in primary plant asset renewal program works identified under separate needs would need to be incurred.

The work will be undertaken over the three-year period until 2022/23, with all works expected to be completed by 2022/23.

All works under all options will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission network.

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

3.5 Option 4 – 22 kV switch room and 220 kV Secondary Systems Building

Option 4 involves a complete upgrade and renewal of secondary systems at the Broken Hill Substation by using modular Secondary Systems Building (SSBs), new metal clad 22 kV switchgear, and installing new cable throughout. This option will modernise the automation philosophy to current design standards and practices and will provide additional operational benefits.

This option assumes that the new secondary systems will be designed to be accommodated within a similar panel arrangement as the existing installation. Redundant panels and tunnel boards in the ASB relay room will need to be progressively decommissioned and removed as the new secondary systems are cut-over and commissioned.

The estimated capital costs for the option total $13.03 million. Routine operating and maintenance costs are approximately $6,358 per year — the same as the base case.

This option identified efficiency gains in incorporating planned primary plant renewals to provide the best value for energy consumers by not revisiting the site in the next regulatory period to address the remaining 22kV high voltage components.

The work will be undertaken over the three-year period until 2022/23, with all works expected to be completed by 2022/23.

All works under all options will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission network.

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

3.6 Options considered but not progressed

At this draft stage of the RIT-T process, TransGrid determines that there is no other commercially and technically feasible option to meet the identified need.

3.7 No material inter-network impact is expected

TransGrid has considered whether the credible options listed above is expected to have material inter-regional impact.[25] A 'material inter-network impact' is defined in the NER as:

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

AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following:[26]

- 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.

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

[26] 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

4. Non-network options

TransGrid does not consider non-network options to be commercially and technically feasible to assist with meeting the identified need for this RIT-T. The objective of this identified need is to meet service level requirements in the NER for secondary systems and protection. Non-network options are unable to technically meet regulatory obligations under Schedule 5.1 and clause 4.11 of the NER to provide redundant secondary systems, and ensure that the transmission system is adequately protected.

In summary, TransGrid considers that non-network options are unable to contribute to meeting the identified need for this RIT-T – this is based on:

- the fact that the identified need for this investment cannot be satisfied by non-network options – irrespective of the size, operating profile, and location of the non-network option
- any non-network solution for this need is expected to only add to the costs of this option. That is, non-network options would not provide any net benefits.

5. Materiality of market benefits

This section outlines the classes of market benefits prescribed in the NER and whether they are considered material for this RIT-T[27].

5.1 Wholesale electricity market benefits are not material

The AER has recognised that if the credible options considered will not have an impact on the wholesale electricity market, then a number of classes of market benefits will not be material in the RIT-T assessment, and therefore do not need to be estimated.[28]

TransGrid determines that the credible options considered in this RIT-T will not have an impact on the wholesale electricity market, therefore considers that the following classes of market benefits are not material for this RIT-T assessment:

- changes in fuel consumption arising through different patterns of generation dispatch
- changes in costs for parties other than the RIT-T proponent
- changes in ancillary services costs
- changes in network losses
- competition benefits
- Renewable Energy Target (RET) penalties.

5.2 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.

Table 5-1 Reasons non-wholesale electricity market benefits are considered immaterial

Market benefits	Reason
Changes in voluntary and involuntary load curtailment	A failure of secondary system element results in an extremely low chance of unserved energy.
Differences in the timing of expenditure	Either option is being undertaken to mitigate, in isolation, the rising risk caused by the existing asset nearing its end of serviceable life.
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.[29] TransGrid also notes the AER's view that appropriate identification of credible options and reasonable scenarios captures any option value,

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

[28] As per clause 5.16.1(c)(5)-(6) of the NER.

[29] 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

Market benefits	Reason
	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.

6. Overview of the assessment approach

This section outlines the approach that TransGrid has applied in assessing the net benefits associated with maintaining compliance with performance standards applicable to Broken Hill substation secondary systems.

6.1 General overview of the 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 18-year period, from 2019/20 to 2036/37. TransGrid considers that a 18-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.

TransGrid has adopted a central real, pre-tax 'commercial' discount rate[30] of 5.90% as the central assumption for the NPV analysis presented. TransGrid considers that this is a reasonable contemporary approximation of a commercial discount rate and it is consistent with the commercial discount rate calculated in the RIT-T Economic Assessment Handbook published by Energy Networks Australia (ENA) in March 2019[31].

TransGrid has also tested the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 2.85% equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PSCR[32], and an upper bound discount rate of 8.95% (a symmetrical adjustment upwards) were investigated.

6.2 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.

[30] 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.

[31] Available at https://www.energynetworks.com.au/rit-t-economic-assessment-handbook Note the lower bound discount rate of 2.85% is based on the most recent final decision for a TNSP revenue determination which was TasNetworks in April 2019.

[32] See 2019-24 TasNetworks' Transmission Post-tax Revenue Model (PTRM) cashflow derived pre-tax real WACC available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/tasnetworks-determination-2019-24/final-decision

6.3 Three different scenarios have been modelled to address uncertainty

RIT-T assessments are required to be based on cost-benefit analysis that includes an assessment of 'reasonable scenarios', which are designed to test alternate sets of key assumptions and whether they affect identification of the preferred option.

TransGrid has constructed three alternative scenarios for this PADR assessment – namely:

- a 'low benefit' scenario, involving a number of assumptions that give rise to a lower bound NPV estimate for the refurbishment option, in order to represent a conservative future state of the world with respect to potential benefits that could be realised
- a 'central' scenario, which consists of assumptions that reflect TransGrid's central set of variable estimates which, in TransGrid's opinion, provides the most likely scenario
- a 'high benefit' scenario – this scenario reflects an optimistic set of assumptions, which have been selected to investigate an upper bound on reasonably expected net benefits.

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

Table 6-1 Summary of the scenarios

Variable/Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Discount rate	5.90%	8.95%	2.85%
Environment and safety costs	Base estimates	Base estimate - 25%	Base estimate + 25%
USE costs	Base estimates	Base estimates	Base estimates

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.

7. Assessment of credible options

7.1 Estimated gross benefits

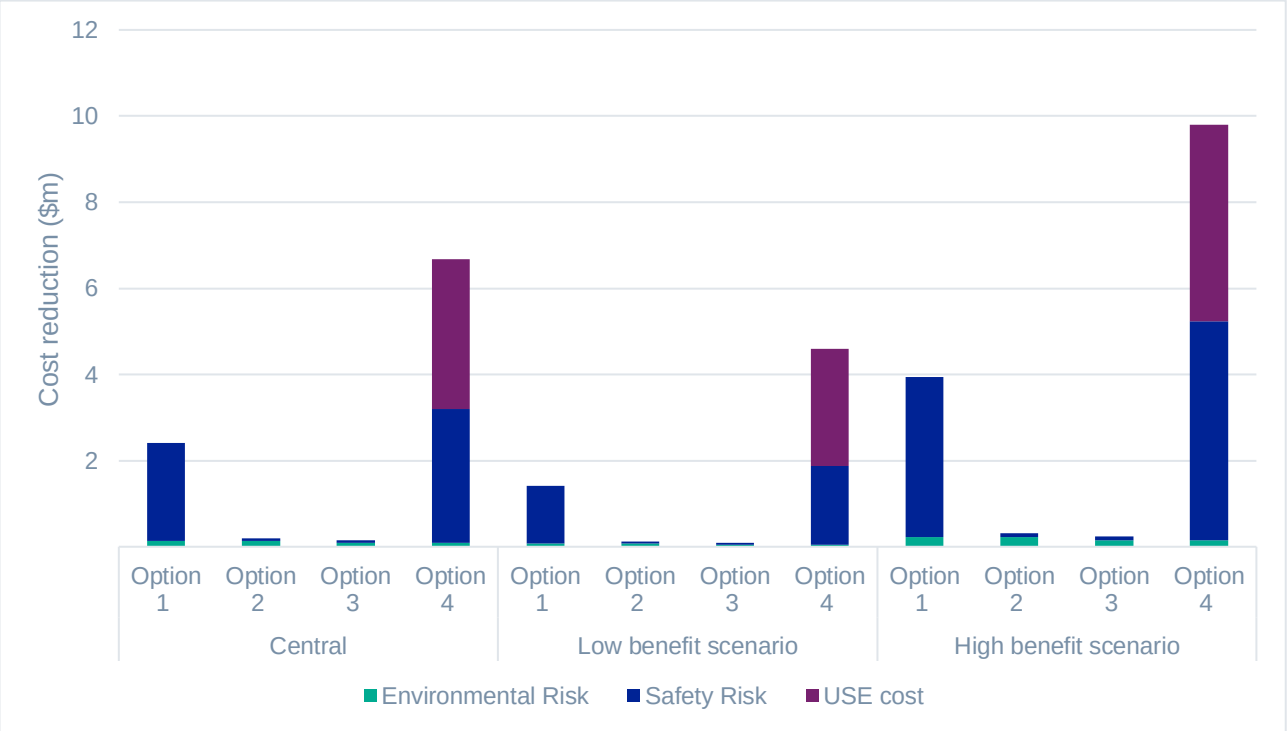
Table 7-1 below summarises the present values of gross benefits estimated for each credible option under the three scenarios.

Table 7-1 Gross benefits from credible options relative to the base case, present value ($m 2019/20)

Option/scenario	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	2.4	1.4	3.9	2.5
Option 2	0.2	0.1	0.3	0.2
Option 3	0.1	0.1	0.2	0.2
Option 4	6.7	4.6	9.8	6.9

Figure 7-1 provides a breakdown of estimated gross benefits for each credible option.

Figure 7-1 Components of gross benefits, present value ($m 2019/20)



7.2 Estimated costs

Table 7-2 summarises the present value of costs of all options relative to the base case under the three scenarios.

Table 7-2 Present value of costs of all options relative to the base case, present value ($m 2019/20)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	9.6	11.1	7.9	9.6
Option 2	5.3	6.0	4.3	5.2
Option 3	4.3	4.7	3.7	4.2
Option 4	9.3	10.7	7.6	9.2

7.3 Meeting relevant regulatory obligations

Implementation of Option 4 will enable TransGrid to meet regulatory obligations set out under Schedule 5.1 and clauses 4.11.1 and 4.6.1(b)[33] of the NER to provide redundant secondary systems and ensure that the transmission system is adequately protected. Consequently, it will also ensure the performance standards applicable to Broken Hill substation secondary systems are met.

Implementation of Option 4 is the most efficient option to ensure reliability of the secondary systems at Broken Hill substation and mitigate its risks of prolonged failure.

7.4 Estimated net economic benefits

Table 7-3 summarises the present value of the net economic benefits for each credible option across the three scenarios and the weighted net economic benefits. These net economic benefits are the differences between the estimated gross benefits less the estimated costs.

Option 4 has the highest net economic benefit while also maintaining compliance with regulatory and safety obligations.

[33] As per clause 4.6.1(b) of the NER, AEMO must ensure that there are processes in place, which will allow the determination of fault levels for normal operation of the power system and in anticipation of all credible contingency events and protected events that AEMO considers may affect the configuration of the power system, so that AEMO can identify any busbar which could potentially be exposed to a fault level which exceeds the fault current ratings of the circuit breakers associated with that busbar.

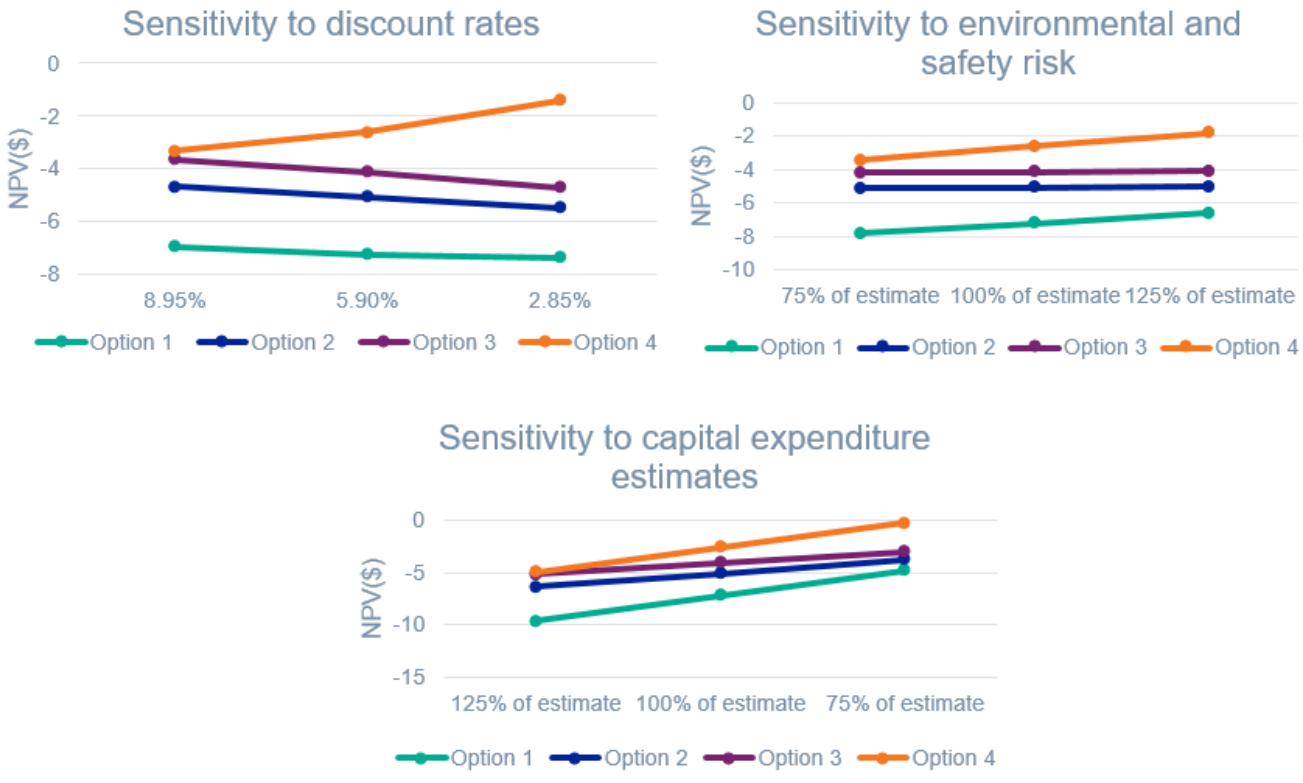
Table 7-3 Net economic benefits for each credible option relative to the base case, present value ($m 2019/20)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	-7.2	-9.6	-3.9	-7.0
Option 2	-5.1	-5.9	-4.0	-5.0
Option 3	-4.1	-4.6	-3.4	-4.1
Option 4	-2.6	-6.1	2.2	-2.3

7.5 Sensitivity of the overall net economic benefit

TransGrid has undertaken thorough sensitivity testing exercise to understand the robustness of the conclusion to underlying assumptions about key variables. The figures below illustrate Option 4 always has the highest net economic benefits while also maintaining compliance with regulatory and safety obligations.

Figure 7-2 Sensitivity of the net economic benefits from Option 4 ($m 2019/20)



8. Draft conclusion and exemption from preparing a PADR

The implementation of Option 4, a complete upgrade and renewal of secondary systems at the Broken Hill substation by using modular Secondary Systems Building (SSBs), new metal clad 22 kV switchgear, and installing new cable throughout, is the most efficient technically and commercially feasible option to continue meeting NER requirements at this draft stage of the RIT-T process. Option 4 can be implemented in sufficient time to meet the identified need by 2022/23, and is therefore the preferred option presented in this PSCR. The estimated reduction in reliability risk costs under Option 4 is approximately $400,000 per year.

The estimated capital cost of this option is approximately $13 million (weighted present value of $9 million). Routine and operating maintenance costs are approximately $6,358 per year – the same as the base case.

The work will be undertaken over the three-year period until 2022/23, with all works expected to be completed by 2022/23.

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

Subject to additional credible options being identified during the consultation period, 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). 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.

Therefore, the next step in this RIT-T, following consideration of submissions received during the 12-week consultation period[34] and any further analysis required, will be publication of a Project Assessment Conclusions Report (PACR). TransGrid anticipates publication of a PACR by April 2020.

As the investments are intended to continue meeting Rules obligations and will not have material market benefit, TransGrid is exempt from producing a PADR for this RIT-T.

TransGrid welcomes written submissions on material contained in this PSCR. Submissions are due on or before 16 March 2020. Submissions should be emailed to TransGrid's Regulation team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'PSCR Broken Hill secondary systems project.'

[34] Additional days have been included to cover public holidays.

Appendix A – Compliance checklist

This appendix sets out a compliance checklist which demonstrates the compliance of this PSCR with the requirements of the National Electricity Rules version 129.

Rules clause	Summary of requirements	Relevant section
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 benefit 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

5.16.4(z1)	A RIT-T proponent is exempt from [preparing a PADR] (paragraphs (j) to (s)) if: 1. the estimated capital cost of the proposed preferred option is less than $35 million[35] (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 benefit specified in clause 5.16.1(c)(4) except those classes specified in clauses 5.16.1(c)(4)(ii) and (iii), and has stated this in its project specification consultation report; and 4. the RIT-T proponent forms the view that no submissions were received on the project specification consultation report which identified additional credible options that could deliver a material market benefit.	8

[35] Varied to $43m based on the AER Final Determination: Cost threshold review November 2018.14. Accessed 19 November 2019 https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/cost-thresholds-review-for-the-regulatory-investment-tests-2018

Appendix B – Risk Assessment Methodology

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

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

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

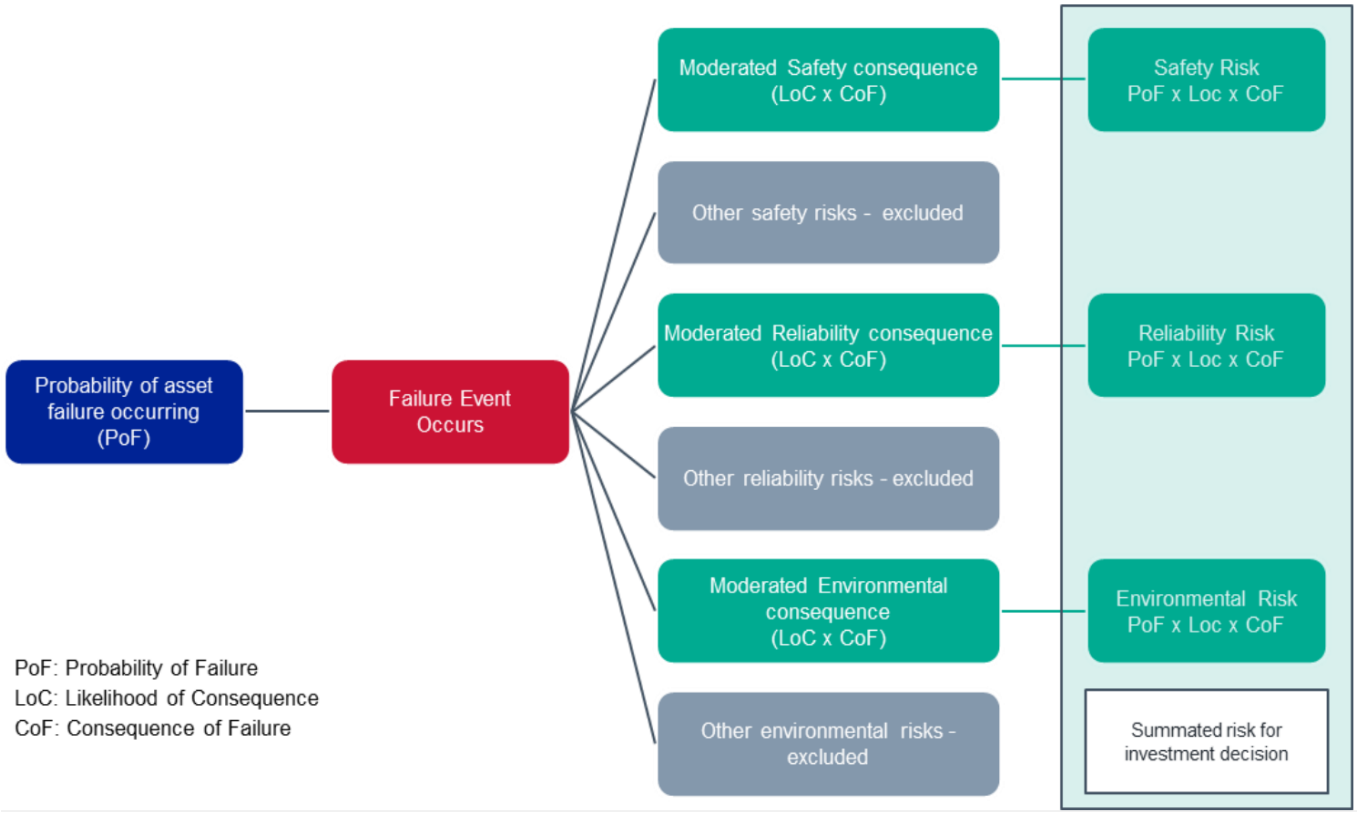
B.1 Overview of risks assessment methodology

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.

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

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

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 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.