TransGrid

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

RIT-T – Project Assessment Draft Report

Region: South Western NSW

Date of issue: 16 March 2021

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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 Assessment Draft Report (PADR) represents the second step in the RIT-T process.

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]

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 As it is superseded by new technology at the manufacturer level and the existing technology becomes obsolete, spare parts become scarce and the ability of any primary asset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.

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.

Provision of redundant protection schemes to ensure the transmission system is adequately protected is a Network Performance Requirement under Schedule 5.1 of the National Electricity Rules (NER), therefore the condition issues affecting the secondary systems at Broken Hill substation must be addressed.

The Network Performance Requirements, set out in Schedule 5.1 of the NER, place an obligation on Transmission Network Service Providers (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.

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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 2020*." Sydney: TransGrid, 2020. 57. Accessed 3 March, 2021. https://www.transgrid.com.au/what-we-do/Business-Planning/transmission-annual-planning/Documents/2020%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, 20 September 2019."* Melbourne: Australian Energy Market Operator, 2019.39. Accessed 15 May 2020. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715---Power-System-Security-Guidelines.pdf

Though replacement of failed secondary systems component is a possible interim measure, the approach is not sustainable as the stock of spare components will deplete due to the technology no longer being manufactured or supported. Once all spares are used, replacement will cease to be a viable option to meet performance standards stipulated in clause 4.6.1 of the NER.

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.

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.

No submissions received in response to Project Specification Consultation Report

TransGrid published a Project Specification Consultation Report (PSCR) on 17 December 2019 which presented four credible options that would meet the Identified Need from a technical, commercial, and project delivery perspective[5].The options included: complete replacement with Secondary Systems Buildings (SSBs) (Option 1); complete in-situ replacement (Option 2); strategic asset replacement (Option 3); and a complete upgrade and renewal with 22 kV switchroom and 220 kV Secondary Systems Building (SSBs) (Option 4).

TransGrid invited written submissions on the materials contained within the PSCR; particularly on the credible options presented and from potential proponents of non-network options that could meet the technical requirements set out in the PSCR.

On publication of the PSCR, TransGrid opened a 12-week consultation period, during which time no submissions were received.

Developments since publication of the PSCR

Since publication of the PSCR, TransGrid identified a need to re-scope one of the credible options (Option 4- Complete upgrade and renewal with 22 kV switchroom and 220 kV Secondary Systems Building), and identified one additional credible option (Option 5- Complete in-situ secondary systems and 22 kV AIS replacement). Consequently, as a result of this material change, TransGrid re-ran the NPV analysis including Options 1, 2 and 3[6], Option 4 (re-scoped) and the new Option 5.

In the NPV analysis, TransGrid used updated costs where applicable, as well as the latest inflation and discount rates.

The program of work to address the secondary systems at Broken Hill including complete replacement with 22 kV switchroom and 220 kV in-situ secondary systems (Option 4) is the option that was found to be the preferred option, both on the basis of net economic benefits, and being technically feasible.

Option 4 is the preferred option presented in this PADR. The other options put forward for consideration in the PSCR and the new Option 5 were estimated to have lower net economic benefits than the preferred option.

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

[6] Including $11.29m of reinvestment costs in 2025 to allow comparable assessment of the base case, Option 1, 2 and 3 with the revised Option 4 and new Option 5.

Credible options considered

In this PADR, TransGrid has put forward for consideration credible options that would meet the identified need from a technical, commercial, and project delivery perspective.[7]

These are summarised in the following table.

Table E-1 Summary of the credible options

Option	Description	Capital cost ($m 2020/21)	Operating costs ($ per year)	Remarks
Option 1	Complete replacement with Secondary Systems Building	13.8 (+/- 25%) by 2022/23 (additional $11.29 million by 2024/25*)	~ 6,000	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 22 kV switchgear being replaced 'like-for-like' and in-situ.
Option 2	Complete in-situ replacement	8.07 (+/- 25%) by 2022/23 (additional $11.29 million by 2024/25*)	~ 6,000	Technically and commercially feasible but less efficient.
Option 3	Strategic asset replacement	6.22 (+/- 25%) by 2022/23 and ~ 1.57 in 2029/30 (additional $11.29 million by 2024/25*)	~ 6,000	Technically and commercially feasible but does not address technological obsolescence beyond 2023 and is therefore not practicable.
Option 4	Complete replacement with 22 kV switchroom and 220 kV in-situ secondary systems	18.34 (+/- 25%) by 2022/23	~ 6,000	Preferred option, provides efficiencies in combining primary works with secondary works and provides the most benefit to consumers.

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

Option	Description	Capital cost ($m 2020/21)	Operating costs ($ per year)	Remarks
Option 5	Complete in-situ secondary systems and 22 kV AIS replacement	17.5 (+/- 25%) by 2022/23	~ 6,000	Provides efficiencies in combining primary works with secondary works but does not address unique site conditions.

* Renewal of some of the primary plant at Broken Hill substation is scheduled by 2024/25. This additional $11.29 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 with Options 4 and 5.

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.

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)[8] 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. 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. Sensitivity testing finds that Option 4 delivers the most net economic benefits under all sensitivities undertaken by TransGrid.

Option 4 delivers the most benefit to consumers

In this PADR TransGrid has considered five 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 22 kV switchgear which, although not part of the need being addressed by this RIT-T, has been discussed in some sections of this PADR.

Renewal of some of the primary plant at Broken Hill substation is scheduled by 2024/25. The renewal of the 22 kV 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.

[8] 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.

Under the base case, Option 1, Option 2 and Option 3, the primary plant scheduled for renewal in 2025 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 a new demountable building in a different location within the switchyard and includes all associated secondary systems within the building. 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 $430,000 per year. Option 5 has the primary plant replaced in-situ. Option 4 has a higher net economic benefit than Option 5, making it the preferred option.

Draft assessment – the preferred option

The implementation of Option 4, complete replacement with 22 kV switchroom and 220 kV in-situ 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 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 PADR.

The estimated capital cost of this option is approximately $18.34 million. Routine operating and maintenance costs are approximately $6,000 per year.

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

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

Submissions and next steps

The purpose of this PADR 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;
- allow interested parties to make submissions and provide input to the RIT-T assessment; and
- provide TransGrid's draft assessment on the preferred option to address the identified need.

TransGrid welcomes written submissions on materials contained in this PADR. Submissions are due on 30 April 2021.

Submissions should be emailed to TransGrid's Regulation team via RIT-TConsultations@transgrid.com.au.[9] In the subject field, please reference 'Broken Hill secondary systems PADR.'

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

[9] 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.

The next step in this RIT-T, following consideration of submissions received via the six-week consultation period and any further analysis required, will be publication of a Project Assessment Conclusion Report (PACR). TransGrid anticipates publication of a PACR by October 2021.

Contents

List of Tables

List of Figures

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 Assessment Draft Report (PADR) represents the second step in the RIT-T process. TransGrid has commenced this RIT-T to examine and consult on options to address the need - 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 PADR[10] is to:

- set out the reasons TransGrid proposes that action be taken (the 'Identified Need');
- present the options that address the identified need;
- outline the technical characteristics that non-network options will need to provide;
- allow interested parties to make submissions and provide input to the RIT-T assessment; and
- provide TransGrid's draft assessment on the preferred option to address the identified need.

1.2 Submissions and next steps

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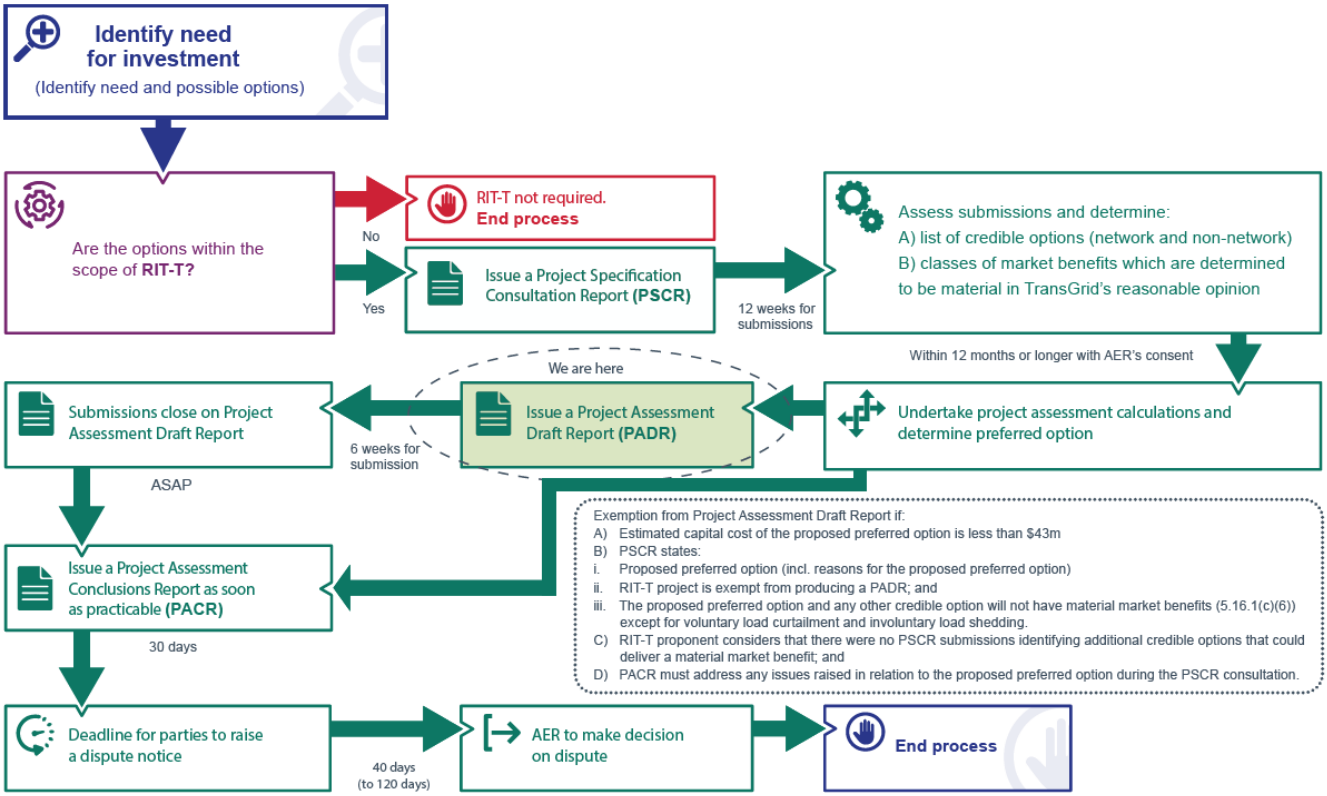
The next step in this RIT-T, following consideration of submissions received via the six-week consultation period and any further analysis required, will be publication of a Project Assessment Conclusion Report (PACR). TransGrid anticipates publication of a PACR by October 2021.

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

[11] Consultation period is for 6 weeks, additional days have been added to cover public holidays.

[12] 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 1-1 This PADR is the second stage of the RIT-T process[13]



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

2. The identified need

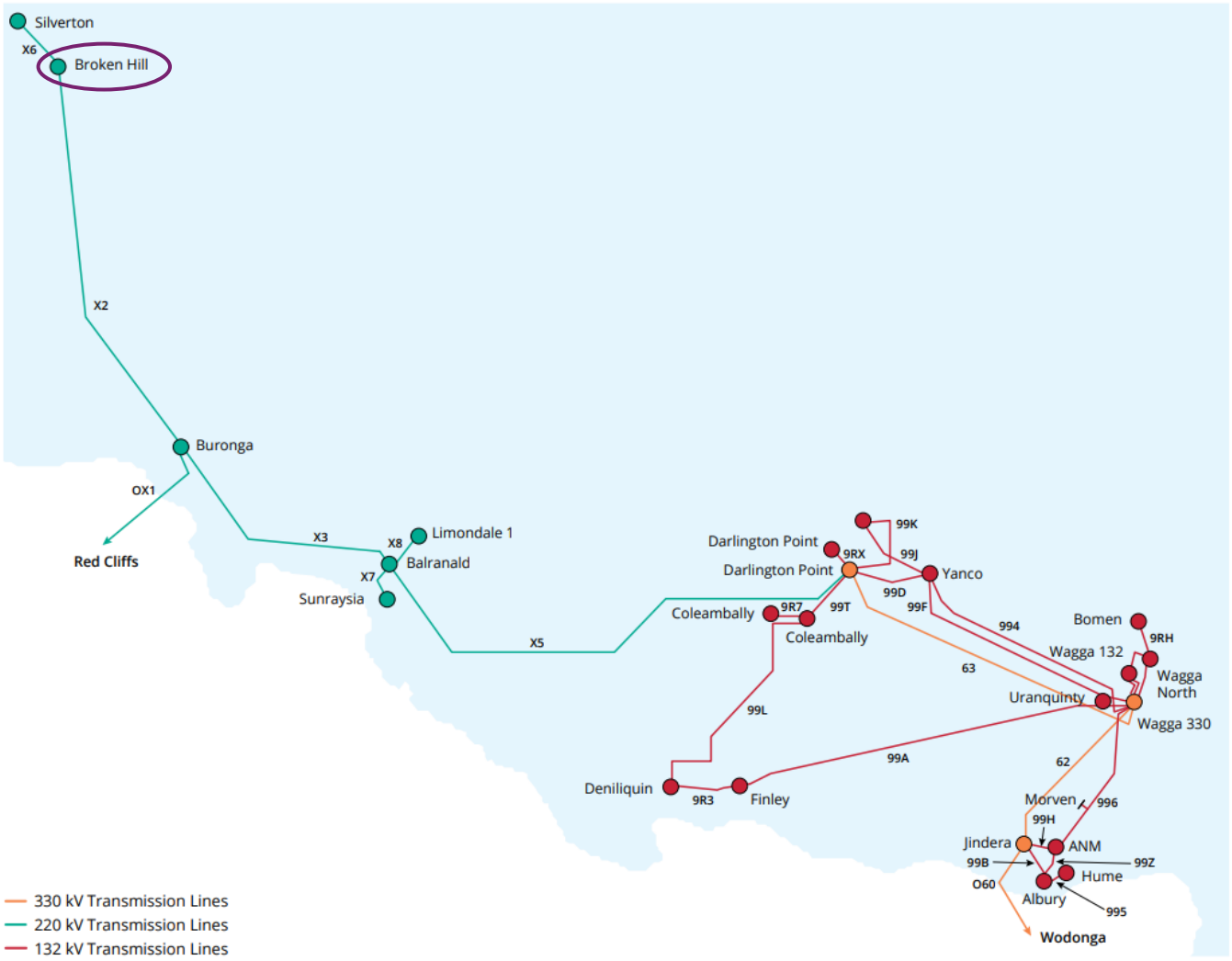
This section outlines the identified need for this RIT-T, as well as the assumptions and data underpinning it. It first sets out background information related to South Western NSW network and existing electricity supply arrangements.

2.1 Background to the identified need

Broken Hill substation was commissioned in 1979 and forms part of TransGrid's network that serves South Western NSW.

The location of Broken Hill substation on the South Western NSW transmission network is provided in **Error! Reference source not found.** below.

Figure 2-1 Location of Broken Hill substation on the South Western NSW transmission network



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).

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] The maximum load for Broken Hill substation is approximately 60 MW[16] and is currently a mix of residential, commercial[17] and industrial.

2.2 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 ensure the secure operation of 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

[14] The population of Broken Hill is 17,708, as per the 2016 Census. Australian Bureau of Statistics, "*2016 Census QuickStats*", accessed 3 March, 2021. https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/lga11250

[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 2020*." Sydney: TransGrid, 2020. 57. Accessed 3 March, 2021. https://www.transgrid.com.au/what-we-do/Business-Planning/transmission-annual-planning/Documents/2020%20Transmission%20Annual%20Planning%20Report.pdf

[16] Summation of a 17 MW customer load and 43 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 2020*." Sydney: TransGrid, 2020.108. Accessed 3 March, 2021. 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 3 March, 2021. http://www.aemo.com.au/aemo/apps/visualisations/map.html

[18] As per Schedule 5.1 of the NER.

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.

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 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.

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.

2.3 Assumptions underpinning the identified need

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

Though like-for-like replacement 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.

2.3.2 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.

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

[20] Australian Energy Market Operator. *"Power System Security Guidelines, 20 September 2019."* Melbourne: Australian Energy Market Operator, 2019.39. Accessed 15 May 2020. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715---Power-System-Security-Guidelines.pdf

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
22 kV Voltage Transformers	> Deterioration indicating assets nearing end of useful life > Significant risks associated with asset failure	100% of all 22 kV VTs
22 kV Current Transformers	> Deterioration indicating assets nearing end of useful life > Significant risks associated with asset failure	75% of all 22 kV CTs
22 kV Circuit Breakers	> Wear of mechanism components leading to unreliable operation > Low insulation resistance of the high voltage components > Lack of spares availability	50% of all 22 kV CBs

3. Potential credible options

This section describes the options explored by TransGrid to address the need, including the scope of each option and the associated costs. Refer to section 7.1 for benefits of each option.

TransGrid considered five technically and commercially feasible options in this PADR:

> Option 1 – complete replacement with Secondary Systems Building (SSBs);
> Option 2 – complete in-situ replacement of protection, market metering and control systems;
> Option 3 – strategic asset replacement;
> Option 4 – complete upgrade and renewal with 22 kV switchroom and 220 kV in-situ secondary systems; and
> Option 5 – complete in-situ secondary systems and 22 kV AIS replacement

Of the credible options considered, Option 4 delivers the highest net economic benefits for consumers. This includes renewal of all 22 kV switchgear which, although not part of the need being addressed by this RIT-T, has been discussed in some sections of this PADR.

Renewal of some of the primary plant at Broken Hill substation is scheduled by 2024/25. The renewal of the 22 kV 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 2025 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 Options 4 is approximately $430,000 per year. Option 5 replaces the 22 kV AIS switchgear in-situ. Option 4 is preferred over Option 5 because while it has a marginally higher capital cost, will deliver further benefits to consumers.

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

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

3.1 Base case

The costs and benefits of each option in this PADR were compared against those of a base case[21]. Under this base case, no proactive capital investment is made to remediate the technological obsolescence, spares unavailability, discontinued manufacturer support, and components deterioration of the secondary systems. The asset will continue to operate and be maintained under the current regime.

[21] As per the RIT-T Application Guidelines, the base case provides a clear reference point for comparing the performance of different credible options. Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - August 2020."* Melbourne: Australian Energy Regulator. https://www.aer.gov.au/system/files/AER%20-%20Regulatory%20investment%20test%20for%20transmission%20application%20guidelines%20-%2025%20August%202020.pdf

Annual maintenance costs are approximately $6,000 per year. Increases to the regular maintenance regime will not be able to mitigate the risk of failure of the secondary systems at Broken Hill substation due to technological obsolescence and reduced reliability.

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

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

Item	Operating expenditure ($)
Annualised protection maintenance activities	6,000
Total operating cost	**6,000 (+/-25%)**

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. This increases the asset's risk of failure, difficulty to repair any failures, likelihood of a hazardous event, and periods of unavailability.

TransGrid calculates the annual safety, environmental and operational risk costs associated with the Broken Hill substation secondary systems under the base case to be approximately $390,000.[22]

3.2 Option 1 – Secondary Systems Buildings 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 22 kV primary assets as outlined under Options 4 and 5.

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.

The estimated capital expenditure associated with this option is approximately $13.8 million +/- 25 per cent. Under Option 1, an additional capital cost of $11.29 million in primary plant asset renewal program works identified under separate needs would need to be incurred in 2025.

The table below provides a breakdown.

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

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

Item	Capital expenditure ($m)
FY21	1.4
FY22	7.8
FY23	4.6
Total capital cost	**13.8 (+/- 25%)**

Routine operating and maintenance costs are approximately $6,000 per year. The table below provides a breakdown.

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

Item	Operating expenditure ($)
Annualised protection maintenance activities	6,000
Total operating cost	**6,000 (+/- 25%)**

TransGrid calculates the annual safety, environmental and operational risk costs associated with the Broken Hill substation secondary systems under Option 1 to be $110,000.[23]

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.

The condition of various categories of automation assets such as protection relays, control systems, AC distribution, DC supply systems, and market meters creates a need for modernisation. This will deliver benefits such as reduced preventative maintenance requirements, improved operational efficiencies, better utilisation of our high speed communications network, improved visibility of all assets using modern technologies and reduced reliance on routine maintenance and testing[24].

There are also additional operational benefits available due to improved remote monitoring, control and interrogation, efficiency gains in responding to faults, and phasing out of obsolete and legacy systems and protocols.

This option does not include works on the 22 kV primary assets as outlined under Options 4 and 5.

The work will be undertaken over the three-year period 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 existing assets will be planned appropriately in order to complete the works with minimal impact on the network.

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

[24] International Electrotechnical Commission (IEC), "IEC 61850 standard for Power Utility Automation," accessed 14 May, 2020. http://www.iec.ch/smartgrid/standards/

The estimated capital expenditure associated with this option is approximately $8.07 million +/- 25 per cent. Under Option 2, an additional capital cost of $11.29 million in primary plant asset renewal program works identified under separate needs would need to be incurred in 2025.

The table below provides a breakdown.

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

Item	Capital expenditure ($m)
FY21	1.6
FY22	3.8
FY23	2.67
Total capital cost	**8.07 (+/- 25%)**

Routine operating and maintenance costs are approximately $6,000 per year. The table below provides a breakdown.

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

Item	Operating expenditure ($)
Annualised protection maintenance activities	6,000
Total operating cost	**6,000 (+/- 25%)**

TransGrid calculates the annual safety, environmental and operational risk costs associated with the Broken Hill substation secondary systems under Option 2 to be approximately $370,000.[25]

3.4 Option 3 – Strategic asset replacement

Option 3 involves individual replacements of identified assets up to 2024/25. The option is based on a like-for-like approach whereby the asset is replaced by its modern equivalent. Additional system modifications or additional functionalities would not be deployed under this option. This option will lock TransGrid to a system 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 22 kV primary assets as outlined under Options 4 and 5.

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 existing assets will be planned appropriately in order to complete the works with minimal impact on the network.

The estimated capital expenditure associated with this option is approximately $6.22 million. Under Option 3, an additional capital cost of $11.29 million in primary plant asset renewal program works identified under separate needs would need to be incurredin 2025. A further $1.57 million in secondary plant asset renewal program works are required by 2030. The table below provides a breakdown.

[25] ibid.

Table 3-6 Capital expenditure breakdown under Option 3 ($m 2020/21)

Item	Capital expenditure ($m)
FY21	1.22
FY22	1.25
FY23	1.25
FY24	1.25
FY25	1.25
Total capital cost	**6.22 (+/- 25%)**

Routine operating and maintenance costs are approximately $6,000 per year. The table below provides a breakdown.

Table 3-7 Operating expenditure breakdown under Option 3 ($ 2020/21)

Item	Operating expenditure ($)
Annualised protection maintenance activities	6,000
Total operating cost	**6,000 (+/- 25%)**

TransGrid calculates the annual safety, environmental and operational risk costs associated with the Broken Hill substation secondary systems under Option 3 to be approximately $370,000.[26]

3.5 Option 4 – Complete replacement with 22 kV switchroom and 220 kV in-situ Secondary Systems

Option 4 involves a complete upgrade and renewal of secondary systems at the Broken Hill substation by using new metal clad 22 kV switchgear in a demountable building inclusive of 22 kV secondary systems. 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 220 kV 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.

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 22 kV high voltage components. The option further addresses an ongoing bird strike issue resulting in high rates of 22 kV outages.

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

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

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

The estimated capital expenditure associated with this option is approximately $18.34 million. The table below provides a breakdown.

Table 3-8 Capital expenditure breakdown under Option 4 ($m 2020/21)

Item	Capital expenditure ($m)
FY21	1.84
FY22	9.90
FY23	6.60
Total capital cost	**18.34 (+/- 25%)**

Routine operating and maintenance costs are approximately $6,000 per year. The table below provideds a breakdown.

Table 3-9 Operating expenditure breakdown under Option 4 ($ 2020/21)

Item	Operating expenditure ($)
Annualised protection maintenance activities	6,000
Total operating cost	**6,000 (+/- 25%)**

TransGrid calculates the annual safety, environmental and operational risk costs associated with the Broken Hill substation secondary systems under Option 4 to be approximately $20,000.[27]

3.6 Option 5 – Complete in-situ secondary systems replacement and 22 kV AIS replacement

Option 5 involves an in-situ replacement of secondary systems at the Broken Hill Substation with in-situ replacement of the 22 kV AIS switchgear, and minimal installation of new cable throughout. This option will modernise the automation philosophy to current design standards and practices and will provide additional operational benefits.

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 22 kV 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.

The estimated capital expenditure associated with this option is approximately $17.5 million. The table below provides a breakdown.

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

Table 3-10 Capital expenditure breakdown under Option 5 ($m 2020/21)

Item	Capital expenditure ($m)
FY21	1.80
FY22	9.40
FY23	6.20
Total capital cost	**17.5 (+/- 25%)**

Routine operating and maintenance costs are approximately $6,000 per year. The table below provideds a breakdown.

Table 3-11 Operating expenditure breakdown under Option 5 ($ 2020/21)

Item	Operating expenditure ($)
Annualised protection maintenance activities	6,000
Total operating cost	**6,000 (+/- 25%)**

TransGrid calculates the annual safety, environmental and operational risk costs associated with the Broken Hill substation secondary systems under Option 5 to be approximately $20,000.[28]

3.7 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.

3.8 No material inter-network impact is expected

TransGrid has considered whether the credible options listed above is expected to have material inter-regional impact.[29] 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:[30]

- a decrease in power transfer capability between transmission networks or in another TNSP's network of no more than the minimum of 3 per cent 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 per cent 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

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

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

[30] Inter-Regional Planning Committee. *"Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations."* Melbourne: Australian Energy Market Operator, 2004. Appendix 2 and 3. Accessed 14 May 2020. https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf

> 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.

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 categories of market benefits prescribed in the National Electricity Rules (NER) and whether they are considered material for this RIT-T.[31]

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 so do not need to be estimated.[32]

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

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

5.2 No other classes of market benefits are material

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

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

Market benefits	Reason
Changes in voluntary and involuntary load shedding	A failure of secondary system element results in an extremely low chance of unserved energy.
Differences in the timing of expenditure	Options considered are unlikely to affect decisions to undertake unrelated expenditure in the network. Consequently, material market benefits will neither be gained nor lost due to changes in the timing of expenditure from any of the options considered.

[31] 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.

[32] Australian Energy Regulator. "Application guidelines Regulatory Investment Test for Transmission - August 2020." Melbourne: Australian Energy Regulator. https://www.aer.gov.au/system/files/AER%20-%20Regulatory%20investment%20test%20for%20transmission%20application%20guidelines%20-%2025%20August%202020.pdf

Market benefits	Reason
	Options are 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.[33] 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 benefits but it would be disproportionate to potential additional benefits for this RIT-T. Therefore, TransGrid has not estimated additional option value benefit.

[33] Australian Energy Regulator. "Application guidelines Regulatory Investment Test for Transmission - August 2020." Melbourne: Australian Energy Regulator. https://www.aer.gov.au/system/files/AER%20-%20Regulatory%20investment%20test%20for%20transmission%20application%20guidelines%20-%2025%20August%202020.pdf

6. Overview of the assessment approach

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

6.1 Description of the base case

The costs and benefits of each option in this document are compared against the base case. Under this base case, TransGrid has assumed a reinvestment of $11.29 million in 2025 is undertaken and incurs regular and reactive maintenance costs, operational and safety related risks costs that are caused by the failure of secondary systems to operate when required. This has been done to enable a comparison between all feasible secondary system options, compared to those which also include primary plant replacements.

6.2 Assessment period and discount rate

A 15-year assessment period from 2022/23 to 2036/37 was considered in this analysis. This period takes into account the size, complexity and expected asset life of the secondary systems. TransGrid took a terminal value approach to ensure that the capital costs of all assets are appropriately captured in the 15-year assessment period.

TransGrid adopted a central real, pre-tax 'commercial' discount rate[34] of 5.90 per cent as the central assumption for the NPV analysis presented in this report. TransGrid considers that this is a reasonable contemporary approximation of a commercial discount rate and it is consistent with the commercial discount rate calculated in the RIT-T Economic Assessment Handbook (Version 2.0) published by Energy Networks Australia (ENA) in October 2020[35].

TransGrid also tested the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 2.23 per cent equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this document[36], and an upper bound discount rate of 9.57 per cent (a symmetrical adjustment upwards) were used.

6.3 Approach to estimating option costs

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

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

[34] 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.

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

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

6.4 Three different scenarios have been modelled to address uncertainty

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

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

Table 6-1 Summary of scenarios

Variable / Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Discount rate	5.90%	9.57%	2.23%
Costs			
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Operating and maintenance costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Benefits (negative benefits)			
Reduction in safety and environmental risk costs	Base estimate	Base estimate - 25%	Base estimate + 25%
Reduction in operational risks	Base estimate	Base estimate - 25%	Base estimate + 25%

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

7. Assessment of credible options

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

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

7.1 Estimated gross benefits

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

The benefits included in this assessment are:

> reduction in safety and environmental risks (increases in Option 3 resulting in negative benefits)
> reduction in operational risks[37]

Table 7-1 Estimated gross benefits from credible options relative to the base case, present value ($m 2020/21)

Option/scenario	Central	Low benefit scenario	High benefit scenario	Weighted
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	2.2	1.3	3.7	2.4
Option 2	0.2	0.1	0.3	0.2
Option 3	0.2	0.1	0.3	0.2
Option 4	6.3	3.5	10.9	6.8
Option 5	2.9	1.7	4.9	3.1

7.2 Estimated costs

The table below summarises the capital and operating and maintenance costs of the options, relative to the base case, in present value terms. The cost of each credible option has been calculated for each of the three reasonable scenarios outlined in section 0.

Table 7-2 Estimated costs of credible options relative to the base case, present value ($m 2020/21)

Option/Scenario	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	12.5	15.1	9.6	12.4

[37] There are benefits associated with operational efficiencies through greater operational visibility, remote operational switching and remote diagnostic capability.

Option 2	7.3	8.9	5.6	7.3
Option 3	5.9	6.9	4.6	5.8
Option 4	8.5	11.0	6.2	8.6
Option 5	7.7	10.0	5.5	7.7

7.3 Estimated net economic benefits

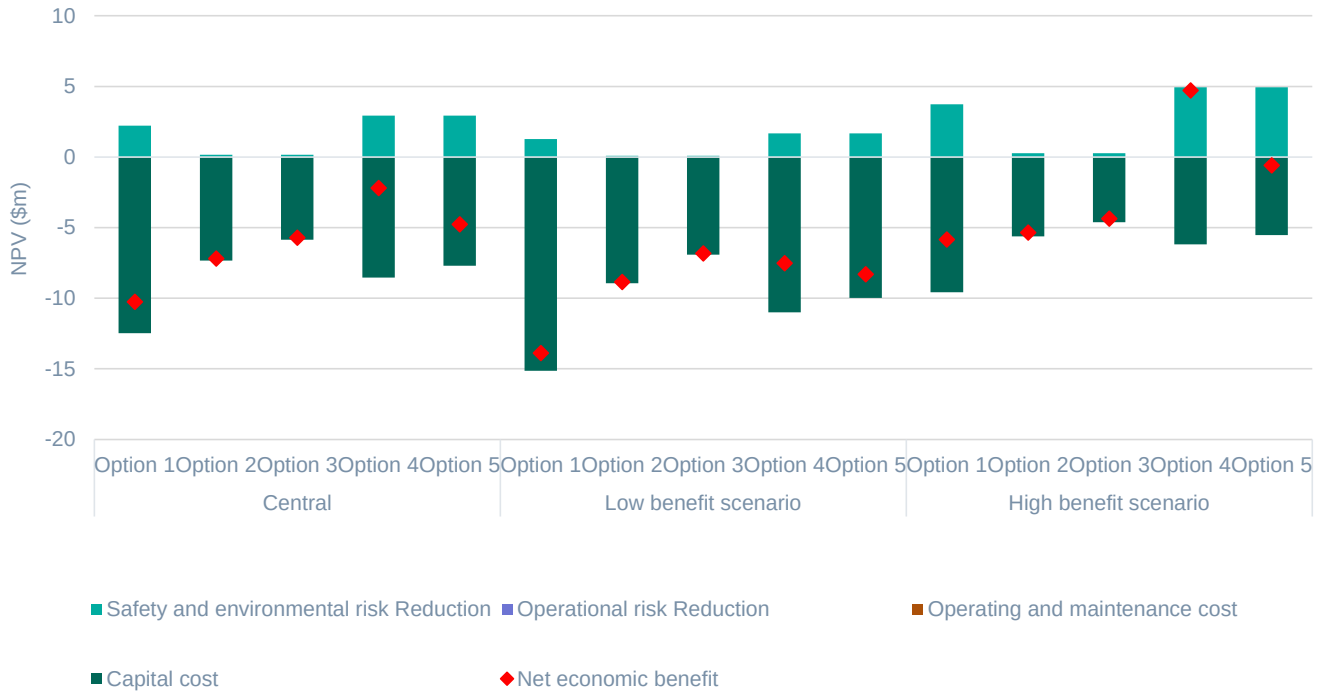
The net economic benefits are the differences between the estimated gross benefits less the estimated costs. The table below summarises the present value of the net economic benefits for each credible option across the three scenarios and the weighted net economic benefits.

As shown in the table and figure below Option 4 has the highest net economic benefit or least cost while also maintaining compliance with regulatory and safety obligations. TransGrid finds that under all sensitivities, except the low benefit scenario where the difference is marginal, Option 4 delivers the highest net economic benefits.

Table 7-3 Estimated net economic benefits relative to the base case, present value ($m 2020/21)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value	Ranking
Scenario weighting	*50%*	*25%*	*25%*		
Option 1	-10.3	-13.9	-5.8	-10.1	5
Option 2	-7.2	-8.9	-5.3	-7.1	4
Option 3	-5.7	-6.8	-4.4	-5.6	3
Option 4	-2.2	-7.5	4.7	-1.8	1
Option 5	-4.8	-8.3	-0.6	-4.6	2

Figure 7-1 Net economic benefits, present value ($m 2020/21)



7.4 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)[38] 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 and mitigate its risks of prolonged failure.

7.5 Sensitivity testing

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

> Step 1 – testing the sensitivity of the optimal timing of the project ('trigger year') to different assumptions in relation to key variables

> Step 2 – once a trigger year has been determined, testing the sensitivity of the total NPV benefit associated with the investment proceeding in that year, in the event that actual circumstances turn out to be different.

TransGrid has not undertaken Step 1 of the sensitivity analysis to determine the optimal timing of the project as the investment is required to be undertaken as reliability corrective action by 2022/23. 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.

[38] 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.

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.

Having assumed to have committed to the project by this date, TransGrid has also looked at the consequences of 'getting it wrong' under step 2 of the sensitivity testing. That is, if expected safety risks are not as high as expected, for example, the impact on the net economic benefit associated with the project continuing to go ahead on that date. The application of the second step to test the sensitivity of the key findings is outlined below.

The application of the second step to test the sensitivity of the key findings is outlined below.

7.5.1 Step 2 – Sensitivity of the overall net benefit

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

> a 25 per cent increase/decrease in the assumed network capital costs

> lower discount rate of 2.23 per cent as well as a higher rate of 9.57 per cent

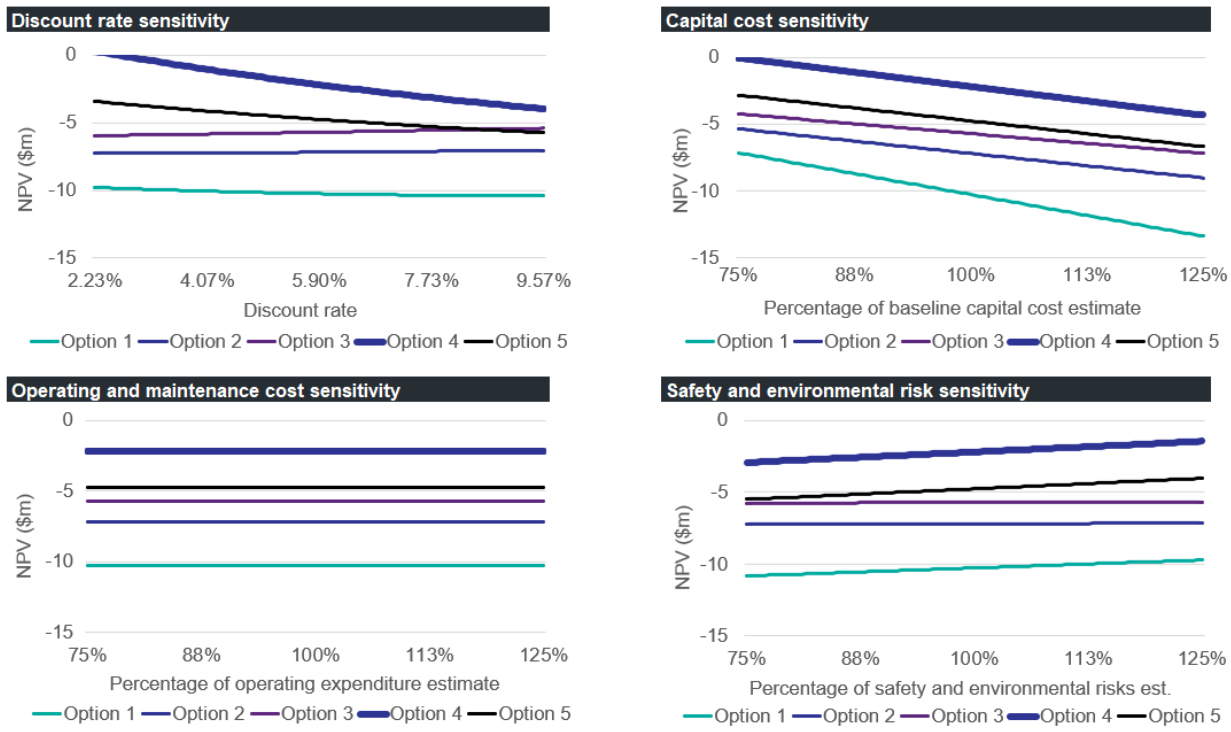
> lower (or higher) assumed operation and maintenance costs

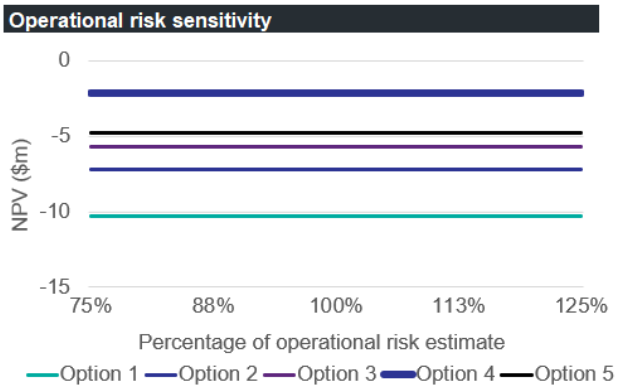
> lower (or higher) assumed safety and environmental risks

> lower (or higher) assumed operational risk

All these sensitivities investigate the consequences of 'getting it wrong' having committed to a certain investment decision. The figures below illustrate the estimated net economic benefits for each option if separate key assumptions in the central scenario are varied individually. Option 1 delivers the most benefit under all scenarios.

Figure 7-2 Sensitivities




Operational risk sensitivity
0
-5
-10
-15
NPV ($m)
75%
88%
100%
113%
125%
Percentage of operational risk estimate
Option 1
Option 2
Option 3
Option 4
Option 5

8. Draft Assessment

The implementation of Option 4, a complete upgrade and renewal of secondary systems at the Broken Hill substation by using new metal clad 22 kV switchgear in a demountable building inclusive of 22 kV and 220 kV secondary systems 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 PADR.

Option 4 is the most prudent and economically efficient solution to enable TransGrid to continue meeting its regulatory obligations set out in clauses 4.11.1, 4.6.1(b),[39] and Schedule 5.1 of the NER. Consequently, it will ensure the performance standards applicable to Broken Hill substation secondary systems are met.

The estimated capital cost of this option is approximately $18.34 million. Routine operating and maintenance costs are approximately $6,000 per year.

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

TransGrid welcomes written submissions on material contained in this PADR. Submissions are due 30 April 2021[40]. Submissions should be emailed to TransGrid's Regulation team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Broken Hill secondary systems PADR.'

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.

The next step in this RIT-T, following consideration of submissions received via the six-week consultation period and any further analysis required, will be publication of a Project Assessment Conclusion Report (PACR). TransGrid anticipates publication of a PACR by October 2021.

[39] 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.

[40] Consultation period is for six weeks, additional days have been added to cover public holidays.

Appendix A – Compliance checklist

This appendix sets out a checklist which demonstrates the compliance of this PADR with the requirements of the National Electricity Rules version 158.

Rules clause	Summary of requirements	Relevant section
5.16.4 (k)	A RIT-T proponent must prepare a report (the project specification consultation report), which must include:	–
	(1) a description of each credible option assessed;	3
	(2) a summary of, and commentary on, the submissions to the project specification consultation report;	No submissions were received
	(3) a quantification of the costs, including a breakdown of operating and capital expenditure, and classes of material market benefit for each credible option;	3
	(4) a detailed description of the methodologies used in quantifying each class of material market benefit and cost;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;	6 & 7
	(5) reasons why the RIT-T proponent has determined that a class or classes of market benefit are not material;	5
	(6) the identification of any class of market benefit estimated to arise outside the region of the Transmission Network Service Provider affected by the RIT-T project, and quantification of the value of such market benefits (in aggregate across all regions);	5
	(7) the results of a net present value analysis of each credible option and accompanying explanatory statements regarding the results;	7
	(8) the identification of the proposed preferred option;	8
	(9) for the proposed preferred option identified under subparagraph (8), the RIT-T proponent must provide: (i) details of the technical characteristics; (ii) the estimated construction timetable and commissioning date; (iii) if the proposed preferred option is likely to have a material inter-network impact and if the Transmission Network Service Provider affected by the RIT-T project has received an augmentation technical report, that report; and (iv) a statement and the accompanying detailed analysis that the preferred option satisfies the regulatory investment test for transmission.	3 & 8

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[41].

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

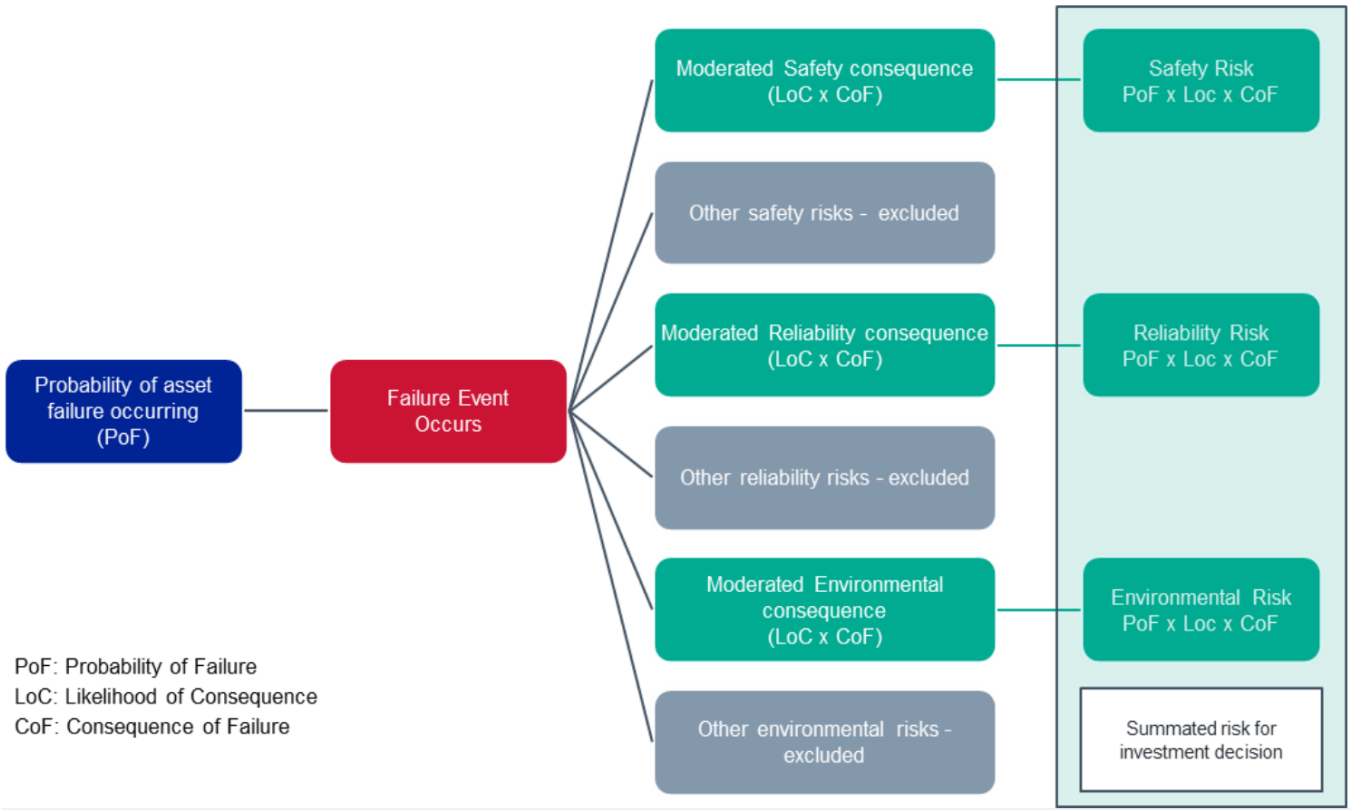
- uses externally verifiable parameters to calculate asset health and failure consequences
- assesses and analyses asset condition to determine remaining life and probability of failure
- applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence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

B.1 Overview of the risk assessment methodology

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

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

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



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

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

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

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