TransGrid

Maintaining compliance with performance standards applicable to Haymarket substation secondary systems

RIT-T Project Assessment Conclusions Report

Region: Greater Sydney

Date of issue: 3 June 2020

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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 Haymarket substation. Publication of this Project Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

Along with other key substations including Rookwood Road and Beaconsfield, Haymarket substation forms part of TransGrid's network that serves the Sydney Central Business District (CBD). It will continue to play a central role in supporting the growing need[1] of Australia's largest commercial district.

TransGrid has identified that the secondary systems at Haymarket 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 As it is superseded by new technology at the manufacturer level and the existing technology becomes obsolete, spare parts become scarce and the ability of any primary asset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 Haymarket 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 TransGrid. "Transmission Annual Planning Report 2019." Sydney: TransGrid, 2019. 81. Accessed 18 February, 2020. 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, 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 27 May 2019 and invited written submissions on the material presented within the document. No submissions were received in response to the PSCR.

No material developments since publication of the PSCR

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

The following changes have occurred since the PSCR which have not made an impact on the preferred option:

- updated the discount rates used
- inflation escalation update (including capex)
- included benefits associated with reductions in risk costs in the NPV analysis

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

Combined on-site replacement of protection and control systems remains the most prudent and economically efficient option to meet regulatory obligations

In the PSCR TransGrid put forward for consideration two technically and commercially feasible options:

- **Option 1** – combined on-site replacement of protection and control systems; and
- **Option 2** – independent on-site replacement of protection and control systems

Option 1 remains the most prudent and economically efficient option to address the identified need. Implementation of Option 1 will enable TransGrid to continue meeting its regulatory obligations set out in clauses 4.11.1, 4.6.1(b),[5] and Schedule 5.1 of the NER. Consequently, it will ensure the performance standards applicable to Haymarket substation secondary systems are met and is therefore the preferred option for this RIT-T.

[5] 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.

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

All costs presented in this PACR are in 2019/20 dollars. The options are summarised in the table below.

Table E-1 Options considered

Option	Description	Capital costs ($m 2019/20)	Operating costs ($ per year)	Remarks
Option 1	**Combined on-site replacement of protection and control systems**	**~12.1 (+/-25%)**	**~7,000**	**Preferred option, would maintain regulatory obligations and provide highest net economic benefits**
Option 2	Independent on-site replacement of protection and control systems	~12.7 (+/-25%)	~7,000	Would maintain regulatory obligations but provide less benefits

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

In the PSCR, TransGrid noted that non-network options are not considered to be commercially and technically feasible to assist with meeting the identified need for this RIT-T. This is because non-network options will not enable TransGrid to continue meeting its NER obligation to provide redundant secondary systems and ensure that the transmission system is adequately protected.

Conclusion: combined on-site replacement of protection and control systems is optimal

The optimal commercially and technically feasible option presented in the PSCR – Option 1 (combined on-site replacement of protection and control systems) – remains the preferred option to meet the identified need. Option 1 can be implemented in sufficient time to meet the identified need by 2022/23, and is therefore the preferred option presented in this PACR.

Moving forward with this option 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),[6] and Schedule 5.1 of the NER. Consequently, it will ensure the performance standards applicable to Haymarket substation secondary systems are met.

Option 1 involves an on-site upgrade and renewal (replacement) of the protection and control systems at Haymarket substation to combined systems which eliminates the need for standalone remote monitoring and control units. Efficiencies will be leveraged by reusing the existing building, tunnel boards, and the cabling where practicable.

[6] 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 estimated capital cost of this option is approximately $12.1 million. Routine and operating maintenance costs are approximately $7,000 per year.

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

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

The analysis undertaken and the identification of Option 1 as the preferred option satisfies the RIT-T. Option 1 is the preferred option in accordance with NER clause 5.16.1(b) because it is the credible option that maximises the net present value of the net economic benefit to all those who produce, consume and transport electricity in the market. This preferred option, Option 1, was found to have the highest net economic benefit or least cost while also maintaining compliance with regulatory and safety obligations. TransGrid also conducted sensitivity analysis on the net economic benefit to investigate the robustness of the conclusion to key assumptions. TransGrid finds that under all sensitivities, Option 1 delivers the most benefit.

Next steps

This PACR represents the third and final step of the consultation process in relation to the application of the Regulatory Investment Test for Transmission (RIT-T) process undertaken by TransGrid. It follows a Project Specification Consultation Report (PSCR) released in May 2019. No submissions were received in response to the PSCR.

The second step, production of a Project Assessment Draft Report (PADR), was not required as the investment in relation to the preferred option is exempt from this part of the RIT-T process under NER clause 5.16.4(z1). Production of a PADR is not required[7] due to:

- the estimated capital cost of the proposed preferred option being less than $43 million;
- the PSCR stated:
  - the proposed preferred option (including reasons for the proposed preferred option)
  - RIT-T is exempt from producing a PADR
  - the proposed preferred option and any other credible option will not have material market benefits[8] except for voluntary load curtailment and involuntary load shedding
- RIT-T proponent considers that there were no PSCR submissions identifying additional credible options that could deliver a material market benefit; and
- PACR must address any issues raised in relation to the proposed preferred option during the PSCR consultation.

Parties wishing to raise a dispute notice with the AER may do so prior to 3 July 2020 (30 days after publication of this PACR). Any dispute notices raised during this period[9] will be addressed by the AER within 40 to 120 days, after which the formal RIT-T process will conclude.

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

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

8 As per clause 5.16.1(c)(6)

9 Additional days have been included to cover public holidays.

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1. Introduction

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining reliable secondary systems at Haymarket substation. 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 Haymarket 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 PACR[10] is to:

- Describe the identified need
- Describe and assess credible options to meet the identified need
- Describe the assessment approach used
- Provide details of the proposed preferred option to meet the identified need.

1.2 Next steps

This PACR represents the third and final step of the consultation process in relation to the application of the Regulatory Investment Test for Transmission (RIT-T) process undertaken by TransGrid. It follows a Project Specification Consultation Report (PSCR) released in May 2019. No submissions were received in response to the PSCR.

The second step, production of a Project Assessment Draft Report (PADR), was not required as the investment in relation to the preferred option is exempt from this part of the RIT-T process under NER clause 5.16.4(z1).

Production of a PADR is not required[11] due to:

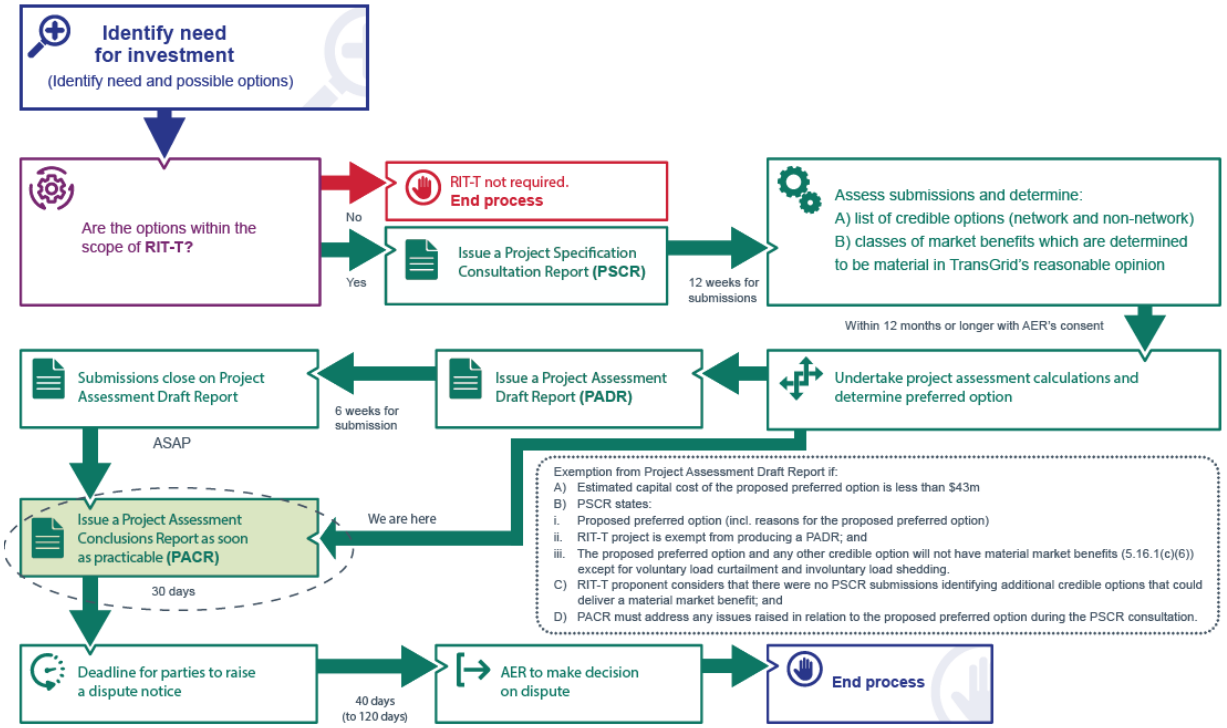
- the estimated capital cost of the proposed preferred option being less than $43 million;
- the PSCR stated:
  - the proposed preferred option (including reasons for the proposed preferred option)
  - RIT-T is exempt from producing a PADR
  - the proposed preferred option and any other credible option will not have material market benefits[12] except for voluntary load curtailment and involuntary load shedding
- RIT-T proponent considers that there were no PSCR submissions identifying additional credible options that could deliver a material market benefit; and
- PACR must address any issues raised in relation to the proposed preferred option during the PSCR consultation.

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

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

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

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



Parties wishing to raise a dispute notice with the AER may do so prior to 3 July 2020 (30 days after publication of this PACR). Any dispute notices raised during this period[14] will be addressed by the AER within 40 to 120 days, after which the formal RIT-T process will conclude.

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

[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

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

2. The identified need

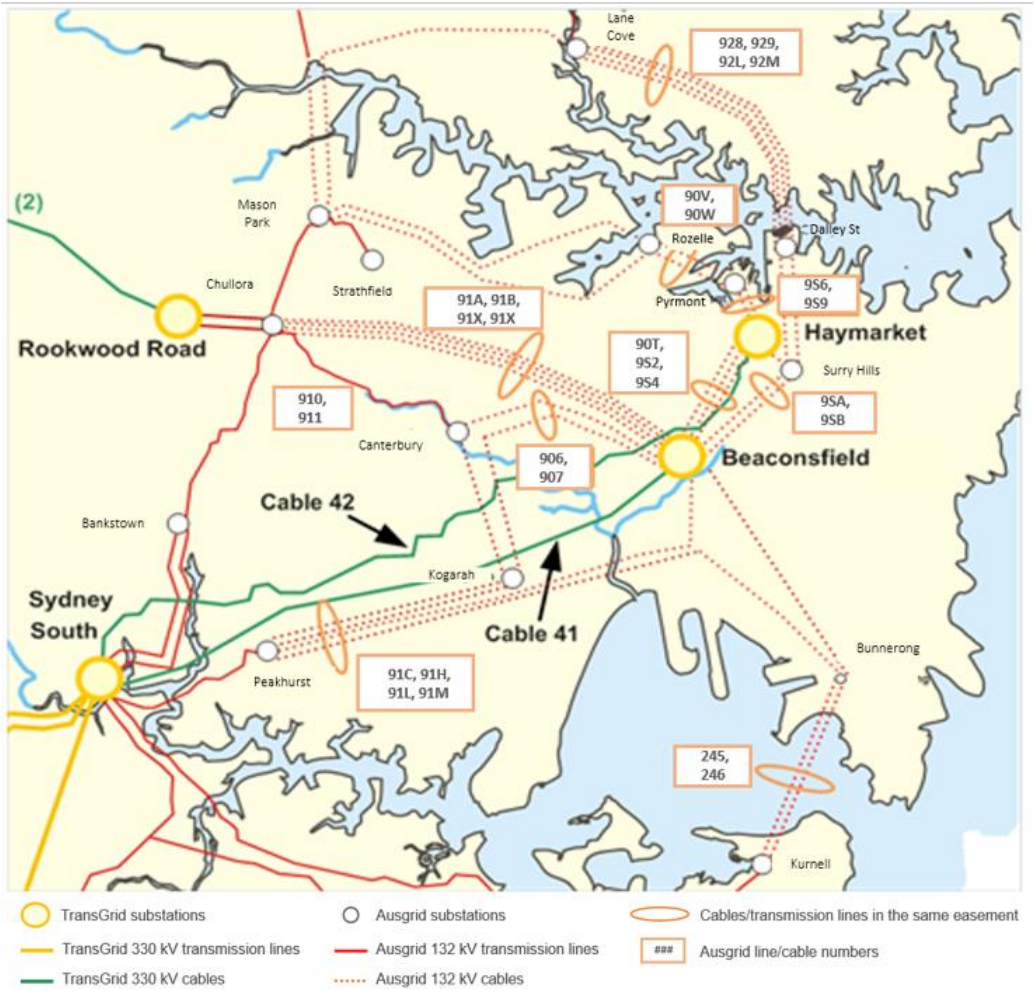
This section outlines the identified need for this RIT-T, as well as the assumptions and data underpinning it. It first sets out background information related to the transmission network supplying the Inner Sydney area, including Sydney Central CBD and existing electricity supply arrangements.

2.1 Background to the identified need

TransGrid's Haymarket 330/132 kV substation was commissioned in 2004. Along with other key substations including Rookwood Road and Beaconsfield, Haymarket substation forms part of TransGrid's network that serves the Sydney CBD.

The location of Haymarket substation and supply arrangements to the Inner Sydney area is provided in **Error! Reference source not found.** below[15].

Figure 2-1 Location of Haymarket substation and supply arrangements to the Inner Sydney area



[15] The purpose of the map is to demonstrate the location of Haymarket on the Inner Sydney network. The distribution networks around CBD area supplied by Haymarket substation are not illustrated in this map.

Haymarket substation supplies the Inner Sydney area including Sydney CBD, whereas Beaconsfield substation supplies Sydney's Eastern suburbs. Haymarket substation is supplied by Sydney South substation through underground cable 42 and is also connected to fourteen 132 kV feeders owned by Ausgrid. It also employs three 330/132 kV transformers and one 132 kV reactor.

The secondary systems components were installed from 2003 through to 2015 to further support the safe and reliable operation of the substation. This arrangement is necessary to support the growing need[16] of Australia's biggest commercial district. The load for Haymarket substation is predominantly commercial and residential[17] which was 508 MW in the summer of 2018/19[18]– almost half the load of the biggest smelter in New South Wales.

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.[19] 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.[20] 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.[21]

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 Haymarket substation secondary systems. The issue of spares depletion may present an additional challenge for Haymarket substation as the substation was built as a "design and construct" project that did not conform to TransGrid's standard designs at the time. Consequently, resolving issues once spares are depleted will likely require significant additional efforts particularly where engineering and integration activities involving proprietary systems is required.

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16 TransGrid. "Transmission Annual Planning Report 2019." Sydney: TransGrid, 2019. 81. Accessed 18 February, 2020. 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 14 February, 2019. http://www.aemo.com.au/aemo/apps/visualisations/map.html

18 TransGrid metering data

19 As per Schedule 5.1 of the NER.

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

21 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

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 Haymarket 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 Haymarket 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 Haymarket substation. The issues are outlined in **Error! Reference source not found.** are expected to escalate until the asset is fully inoperable.

Table 2-1 Identified condition of Haymarket substation secondary systems

Asset components	Issues	% of services at site
Energy Meters	> Component technology obsolescence resulting in a lack of spares and no manufacturer support	100% of all market meters on site
Protection Relays	> Increasing numbers of faults across a range of models	96% of all protection relays on site
Remote Monitoring and Control Equipment	> End of serviceable life > Manufacturer support withdrawn	100% of all remote monitoring and control on site

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 **Error! Reference source not found.** for benefits of each option.

TransGrid considered two technically and commercially feasible options in the PSCR and this PACR:

> **Option 1** – combined on-site replacement of protection and control systems; and
> **Option 2** – independent on-site replacement of protection and control systems

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

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

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

3.1 Base case

The costs and benefits of each option in this PACR were compared against those of a base case[22]. 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. Annual maintenance costs are approximately $7,000 per year. Increases to the regular maintenance regime will not be able to mitigate the risk of failure of the secondary systems at Haymarket 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 ($ 2019/20)

Item	Operating expenditure ($)
Annualised protection maintenance activities	7,000
Total operating cost	**7,000 (+/-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.

[22] As per the RIT-T Application Guidelines, the base case provides a clear reference point for comparing the performance of different credible options. Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018. Accessed 6 May 2020. 22. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

TransGrid calculates the annual safety and operational risk costs associated with the Haymarket substation secondary systems under the base case to be approximately $1.8m.[23]

3.2 Option 1 – Combined on-site replacement of protection and control systems

Option 1 involves an on-site upgrade and renewal (replacement) of the protection and control systems at Haymarket substation to combined systems which eliminates the need for standalone remote monitoring and control units. Efficiencies will be leveraged by reusing the existing building, tunnel boards, and the cabling where practicable.

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.

The work will be undertaken over the four-year period from 2019/20 to 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 $12.1 million +/- 25 per cent. The table below provides a breakdown.

Table 3-2 Capital expenditure breakdown under Option 1 ($m 2019/20)

Item	Capital expenditure ($m)
FY20	0.5
FY21	3.3
FY22	3.9
FY23	4.4
Total capital cost	**12.1 (+/-25%)**

Routine operating and maintenance costs are approximately $7,000 per year. The table below provides a breakdown.

Table 3-3 Operating expenditure breakdown under Option 1 ($ 2019/20)

Item	Operating expenditure ($)
Annualised protection maintenance activities	7,000

[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.

Total operating cost	**7,000 (+/-25%)**

TransGrid calculates the annual safety and operational risk costs associated with the Haymarket 330 kV substation secondary systems under Option 1 to be approximately $729,000.[24]

3.3 Option 2 – Independent on-site replacement of protection and control systems

Option 2 involves on-site replacement of individual protection and control systems at Haymarket substation with modern equivalents utilising the same methodology and philosophy as currently installed. Efficiencies will be leveraged by reusing the existing building, tunnel boards, and the cabling where practicable. However, this option would not provide any additional benefits to consumers in leveraging new design standards with reduced asset quantities to deliver the same functionality.

The work will be undertaken over the four-year period from 2019/20 to 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 $12.7 million. The table below provides a breakdown.

Table 3-4 Capital expenditure breakdown under Option 2 ($m 2019/20)

Item	Capital expenditure ($m)
FY20	0.1
FY21	4.5
FY22	3.8
FY23	4.3
Total capital cost	**12.7 (+/-25%)**

Routine operating and maintenance costs are approximately $7,000 per year. The table below provides a breakdown.

Table 3-5 Operating expenditure breakdown under Option 2 ($ 2019/20)

Item	Operating expenditure ($)
Annualised protection maintenance activities	7,000

[24] 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.

Total operating cost	**7,000 (+/-25%)**

TransGrid calculates the annual safety and operational risk costs associated with the Haymarket 330 kV substation secondary systems under Option 2 to be approximately $771,000.[25]

3.4 Options considered but not progressed

TransGrid determines that there is no other commercially and technically feasible option to meet the identified need.

3.5 No material inter-network impact is expected

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

> *"A material impact on another Transmission Network Service Provider's network, which 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:[27]

- 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
- 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 they do 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.

3.6 Non-network options

In the PSCR, TransGrid noted that non-network solutions will not enable TransGrid to continue meeting its Rules obligation 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. Notwithstanding, as part of this consultation process, interested parties were able to make submissions regarding non-network options that satisfy, or contribute to satisfying, the identified need.

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

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[25] 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.

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

[27] Inter-Regional Planning Committee. *"Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations."* Melbourne: Australian Energy Market Operator, 2004. Appendix 2 and 3. Accessed 6 May 2020. https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf

4. Materiality of market benefits

This section outlines the categories of market benefits prescribed in the National Electricity Rules (NER) and whether they are considered material for this RIT-T.[28]

4.1 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.[29]

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

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

4.2 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 in relation to each credible option: differences in the timing of transmission investment; option value; and changes in involuntary load shedding. TransGrid considers that none of the classes of market benefits listed are material for this RIT-T assessment for the reasons in Table 4-1.

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

Market benefits	Reason
Changes in involuntary load shedding	A failure of secondary system element results in an extremely low chance of unserved energy.

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

[29] Australian Energy Regulator. "Application guidelines Regulatory Investment Test for Transmission - December 2018." Melbourne: Australian Energy Regulator, 2018.39.Accessed 6 May 2020. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

Market benefits	Reason
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. 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.[30] 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.

[30] Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018.58-59. Accessed 6 May 2020. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

5. Overview of the assessment approach

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

5.1 Description of the base case

The costs and benefits of each option in this document are compared against the base case. Under this base case, no investment is undertaken and TransGrid 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.

TransGrid notes that this course of action is not expected in practice. However, this approach has been adopted since it is consistent with AER guidance on the base case for RIT-T applications. [31]

5.2 Assessment period and discount rate

An outlook period of 15 year assessment period from commissioning 2022/23, from 2019/20 to 2036/37, was considered in this analysis. This period takes into account the expected asset life of the secondary systems.

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

TransGrid also tested the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 2.85 per cent equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PACR[34], and an upper bound discount rate of 8.95 per cent (a symmetrical adjustment upwards) were used.

5.3 Approach to estimating option costs

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

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

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31 TransGrid notes that the final updated December 2018 AER RIT-T Guidelines state that the base case is where the RIT–T proponent does not implement a credible option to meet the identified need, but rather continues its 'BAU activities'. The AER define 'BAU activities' as ongoing, economically prudent activities that occur in the absence of a credible option being implemented. See: AER, *Regulatory Investment Test for Transmission Application Guidelines,* December 2018. 21

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

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

34 See 2019-24 TasNetworks' 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

5.4 Three different scenarios have been modelled to address uncertainty

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

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

Table 5-1 Summary of scenarios

Variable / Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Discount rate	5.90%	8.95%	2.85%
Costs			
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Benefits			
Reduction in safety 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.

6. Assessment of credible options

This section outlines the assessment TransGrid has undertaken of the credible network options.

The assessment compares the costs and benefits of each credible option to the base case. The benefits of each credible option are represented by reduction in costs or risks compared to the base case.

The following changes have occurred since the PSCR which have not made an impact on the preferred option:

- changes to the discount rate for the high and low benefit scenarios used in the PSCR which was based on earlier discount rates
- all costs have been escalated using inflation to 2019/20 dollars
- minor adjustments to Capex to ensure consistent escalation
- included benefits associated with reductions in risk costs in the NPV analysis.

However, there were no material changes since publication of the PSCR that affect the ranking preference for Option 1.

All costs presented in this PACR have been escalated using inflation and are in 2019/20 dollars.

6.1 Estimated gross benefits

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

The benefits included in this assessment are:

- reduction in safety risks
- reduction in operational risks[35]

Table 6-1 Estimated 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
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	9.9	5.8	16.1	10.4
Option 2	9.5	5.6	15.5	10.0

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

6.2 Estimated costs

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

Table 6-2 Estimated costs of 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	10.8	12.8	8.6	10.7
Option 2	11.4	13.5	9.0	11.3

6.3 Estimated net economic benefits

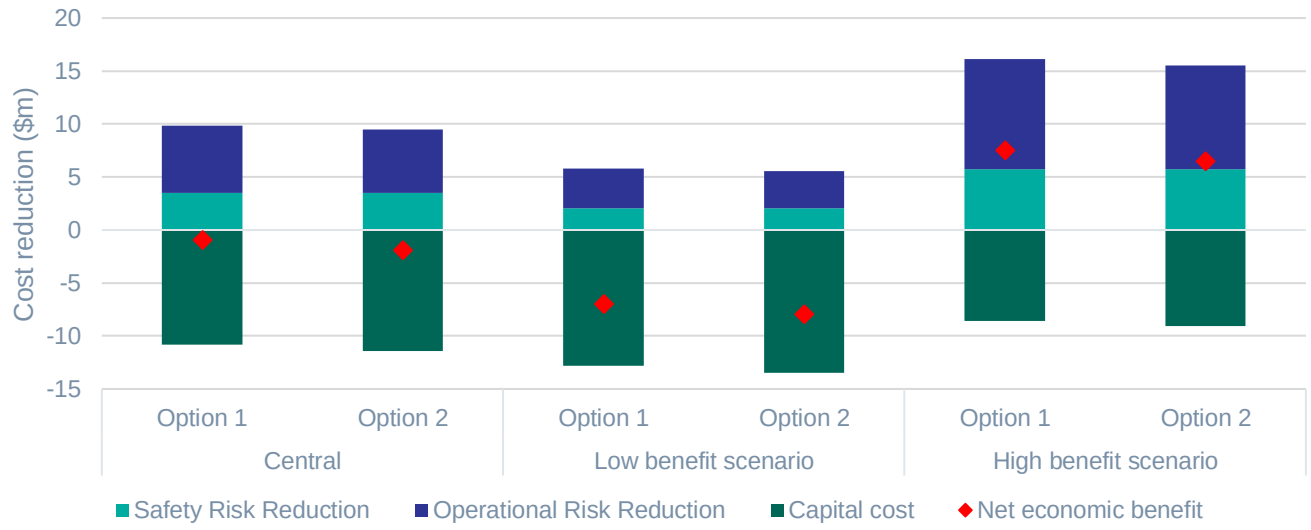
The net economic benefits are the differences between the estimated gross benefits less the estimated costs. The table below summarises the present value of the net economic benefits for each credible option across the three scenarios and the weighted net economic benefits.

Table 6-3 and Figure 6-1 show that Option 1 has the highest net economic benefit or least cost while also maintaining compliance with regulatory and safety obligations.

Table 6-3 Estimated net economic benefits relative to the base case, present value ($m 2019/20)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value	Ranking
Scenario weighting	*50%*	*25%*	*25%*		
Option 1	-1.0	-7.0	7.5	-0.3	1
Option 2	-1.9	-7.9	6.5	-1.3	2

Figure 6-1 Net economic benefits, present value ($m 2019/20)



6.4 Meeting relevant regulatory obligations

Implementation of Option 1 will enable TransGrid to meet regulatory obligations set out under Schedule 5.1 and clauses 4.11.1 and 4.6.1(b)[36] 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 Haymarket substation secondary systems are met.

Implementation of Option 1 is the most efficient option to ensure reliability of the secondary systems at Haymarket substation and mitigate its risks of prolonged failure.

6.5 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. 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.

6.5.1 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 2.85 per cent as well as a higher rate of 8.95 per cent

> lower (or higher) assumed safety

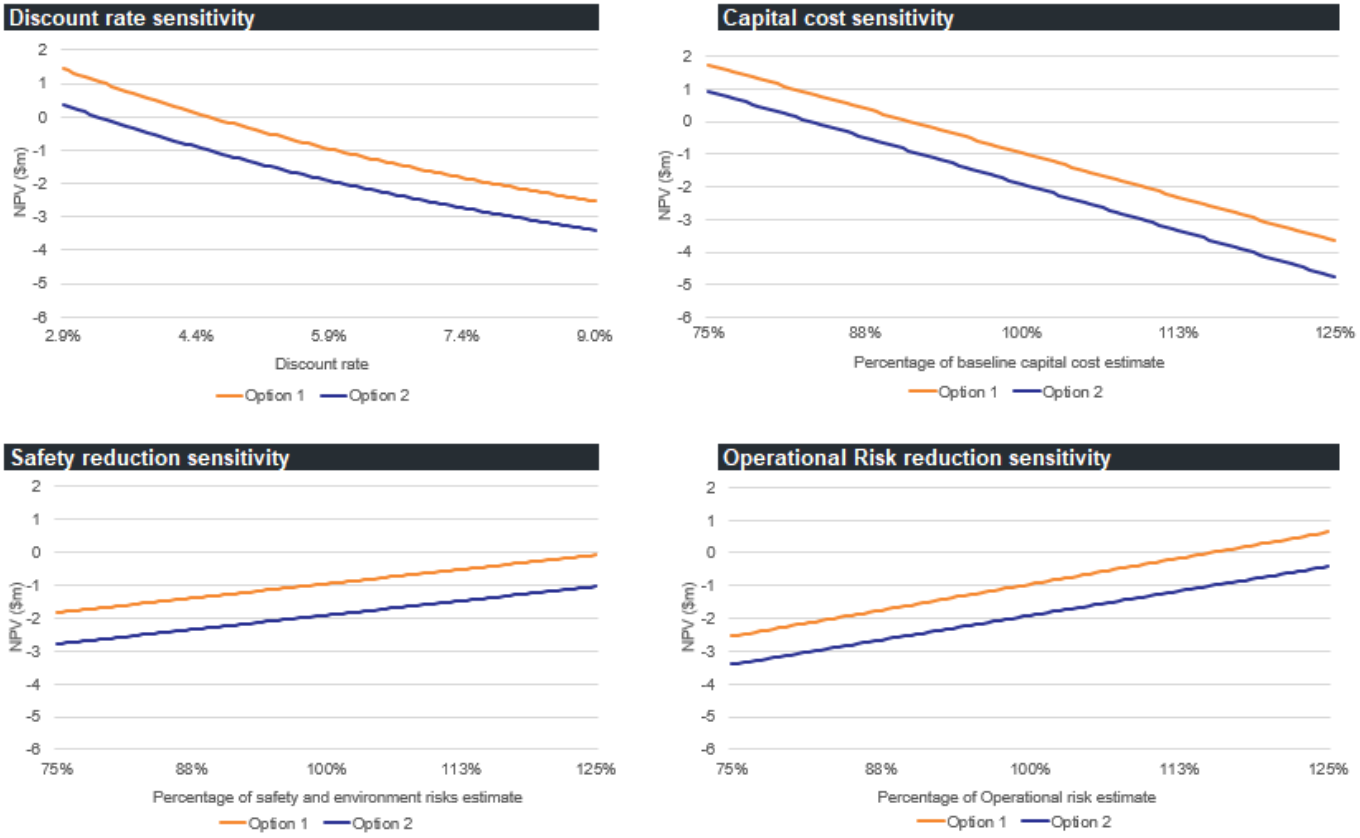
> lower (or higher) assumed operational benefit

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.

[36] 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.

Figure 6-2 Sensitivities



7. Final conclusion on the preferred option

The optimal commercially and technically feasible option presented in the PSCR – Option 1 (combined on-site replacement of protection and control systems) – remains the preferred option to meet the identified need. Option 1 can be implemented in sufficient time to meet the identified need by 2022/23, and is therefore the preferred option presented in this PACR.

Option 1 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),[37] and Schedule 5.1 of the NER. Consequently, it will ensure the performance standards applicable to Haymarket substation secondary systems are met.

Option 1 involves an on-site upgrade and renewal (replacement) of the protection and control systems at Haymarket substation to combined systems which eliminates the need for standalone remote monitoring and control units. Efficiencies will be leveraged by reusing the existing building, tunnel boards, and the cabling where practicable.

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

The estimated capital cost of this option is approximately $12.1 million. Routine and operating maintenance costs are approximately $7,000 per year.

Option 1 is the preferred option in accordance with NER clause 5.16.1(b) because it is the credible option that maximises the net present value of the net economic benefit to all those who produce, consume and transport electricity in the market. This preferred option, Option 1, was found to have the highest net economic benefit or least cost while also maintaining compliance with regulatory and safety obligations. TransGrid also conducted sensitivity analysis on the net economic benefit to investigate the robustness of the conclusion to key assumptions. TransGrid finds that under all sensitivities, Option 1 delivers the most benefit. The analysis undertaken and the identification of Option 1 as the preferred option satisfies the RIT-T.

[37] 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.

Appendix A – Compliance checklist

This section sets out a checklist which demonstrates the compliance of this PACR with the requirements of the National Electricity Rules version 139.

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

Appendix B – Assumptions underpinning the identified need

This appendix summarises the key assumptions and data from the risk assessment methodology that underpin the identified need for this RIT-T and the assessment undertaken for the Revenue Proposal.[38]

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:

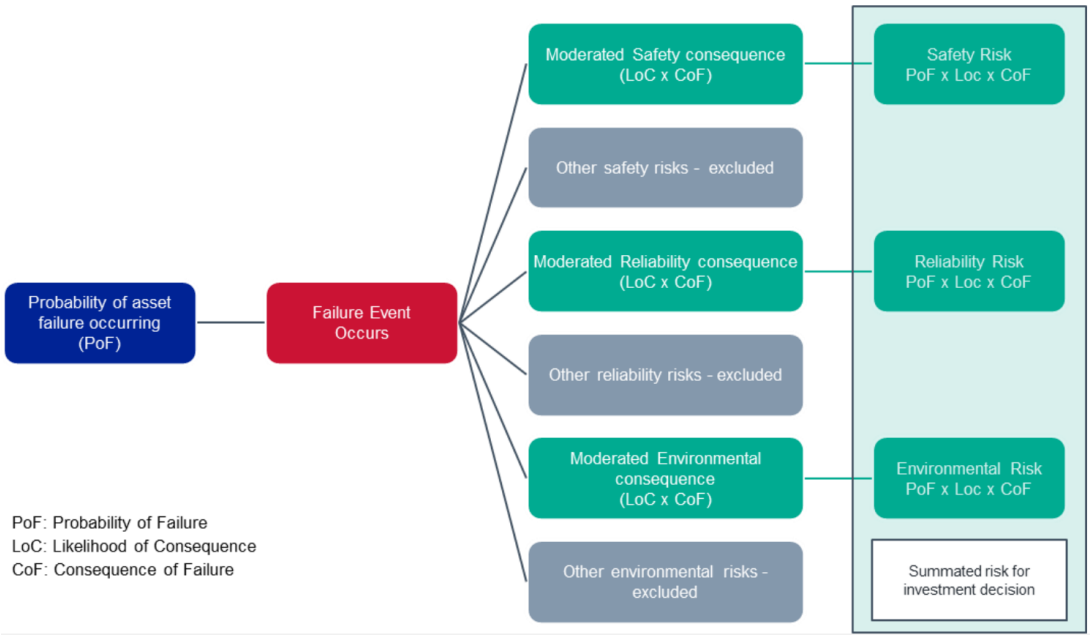
- uses externally verifiable parameters to calculate asset health and failure consequences
- assesses and analyses asset condition to determine remaining life and probability of failure
- applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence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

B.1 Overview 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.

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

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



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

In calculating the PoF, each failure mode that could result in significant impact is considered. For replacement

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

planning, only life-ending failures are used to calculate the risk costs. PoF is calculated for each failure mode based on 'conditional age' (health-adjusted chronological age), failure and defect history, and benchmarking studies. For 'wear out' failures, a Weibull curve may be fitted; while for random failures, a static failure rate may be used.

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