electranet

Managing the Risk of 275 kV Current Transformer Failures 2024-2028

Project Assessment Conclusions Report

16 January 2025

EXECUTIVE SUMMARY

This Project Assessment Conclusions Report is the final stage of identifying the preferred option to address an identified need relating to replace 56 current transformers at eight substations to manage the risk that these assets will fail.

This Regulatory Investment Test for Transmission (**RIT-T**) identifies the need to replace 56 sets of current transformers at eight substations as the preferred solution to manage the risk that these assets will fail.

Current transformers are a major component of the electrical protection system that ensure electrical faults are cleared within designated times as specified in the National Electricity Rules (**NER**)[1]. If a current transformer fails, depending on the nature of the failure it can cause unpredictable damage resulting in harm to people, substation failure and involuntary load curtailment for customers.

Based on the recent failures of current transformers, we have commenced replacement of the higher risk current transformers located at Torrens Island Power Station B to manage the risk that these assets will fail.

The Project Specification Consultation Report was released in September 2024 identifying a proposed solution.

The Project Specification Consultation Report (**PSCR**) for this project was published on 27 September 2024. It described the identified need and suggested that there is only one technically and economically feasible option to meet that need, which is to replace at risk current transformers with an estimated capital cost of approximately $30.2 million.

The PSCR assessed two different network options. Option 1, to replace the 56 sets of current transformers by 2026 that are at high risk of failure and Option 2, leaving the current transformers in service and increasing the testing regime with a view to replacing current transformers based on those test results. It concluded that that replacing the current transformers by 2026 is preferred.

The PSCR also explained why non-network options are not expected to have a feasible role. This is due to the specific role that current transformers play in the transmission of electricity and their relatively low replacement cost.

No submissions were received on the PSCR.

This PACR maintains the initial conclusion of replacing the identified current transformers at 8 substations by 2026 is the preferred option[2].

[1] S5.1a.8 of the NER outlines the requirements regarding fault clearance times, including the specific maximum permitted fault clearance times.

[2] The preferred option is defined as the option that maximises net benefits under the RIT-T framework.

The preferred option for addressing the identified need in this assessment is Option 1, which is to replace 56 sets of current transformers at eight substations by 2026.

Most of the expected benefits are derived from the avoided risk, and consequences, of current transformer failure. These are primarily comprised of avoided expected outages.

On a weighted basis (i.e., weighted across the three scenarios investigated), the preferred option is expected to deliver approximately $22.0 million in net market benefits.

Next steps

ElectraNet intends to replace the 56 sets of current transformers by 2026.

Further details in relation to this project can be obtained from consultation@electranet.com.au.

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Glossary

AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
NPV	Net Present Value
NEM	National Electricity Market
NER	National Electricity Rules
PACR	Project Assessment Conclusions Report
PADR	Project Assessment Draft Report
PSCR	Project Specification Consultation Report
PoF	Probability of Failure
RET	Renewable Energy Target
RIT-T	Regulatory Investment Test for Transmission
TNSP	Transmission Network Service Provider
VCR	Value of Customer Reliability

1 Introduction

This Project Assessment Conclusions Report (**PACR**) is the final step in the application of the Regulatory Investment Test for Transmission (**RIT-T**) to addressing the risk of failure of current transformers at eight substations located across the South Australian transmission network.

The Project Specification Consultation Report (**PSCR**) was released on 27 September 2024. It

- described the identified need that we are seeking to address, together with the assumptions used in identifying this need;
- set out the technical characteristics that a non-network option would be required to deliver to address this identified need;
- outlined the only credible option that we consider addresses the identified need;
- discussed specific categories of market benefit that, in the case of this RIT-T assessment, are unlikely to be material;
- presented the results of our economic assessment of the credible option and identifies the preferred option and the reasons for the preferred option; and
- set out our basis for exemption from a Project Assessment Draft Report (PADR).

No submissions were received on the PSCR.

1.1 Why we consider this RIT-T is necessary

The National Electricity Rules (**NER**) require the application of the RIT-T to replacement capital expenditure where there is at least one credible option costing more than $7 million.[3]

Accordingly, we have initiated this RIT-T to consult on proposed expenditure related to replacing the current transformers, noting that none of the exemptions listed in NER clause 5.16.3(a) apply.

The credible option discussed in this PACR has not been foreshadowed in AEMO's Integrated System Plan (**ISP**) as the works involved do not impact on the main transmission flow paths between the NEM regions.

1.2 Next steps

ElectraNet intends to replace the 56 sets of current transformers by 2026.

Further details in relation to this project can be obtained from consultation@electranet.com.au

[3] NER clause 5.15A.1(c) states that the purpose of the regulatory investment test for transmission in respect of its application to both types of projects is to identify the credible option that maximises the present value of net economic benefit (the preferred option). For the avoidance of doubt, a preferred option may, in the relevant circumstances, have a negative net economic benefit (that is, a net economic cost) to the extent the identified need is for reliability corrective action or the provision of inertia network services required under clause 5.20B.4.

2 The identified need for this RIT-T is to ensure safe and reliable supply of electricity in South Australia

This section outlines the identified need and the assumptions underpinning it. It first provides some background on the identified current transformers and their role in the wider transmission of electricity in South Australia.

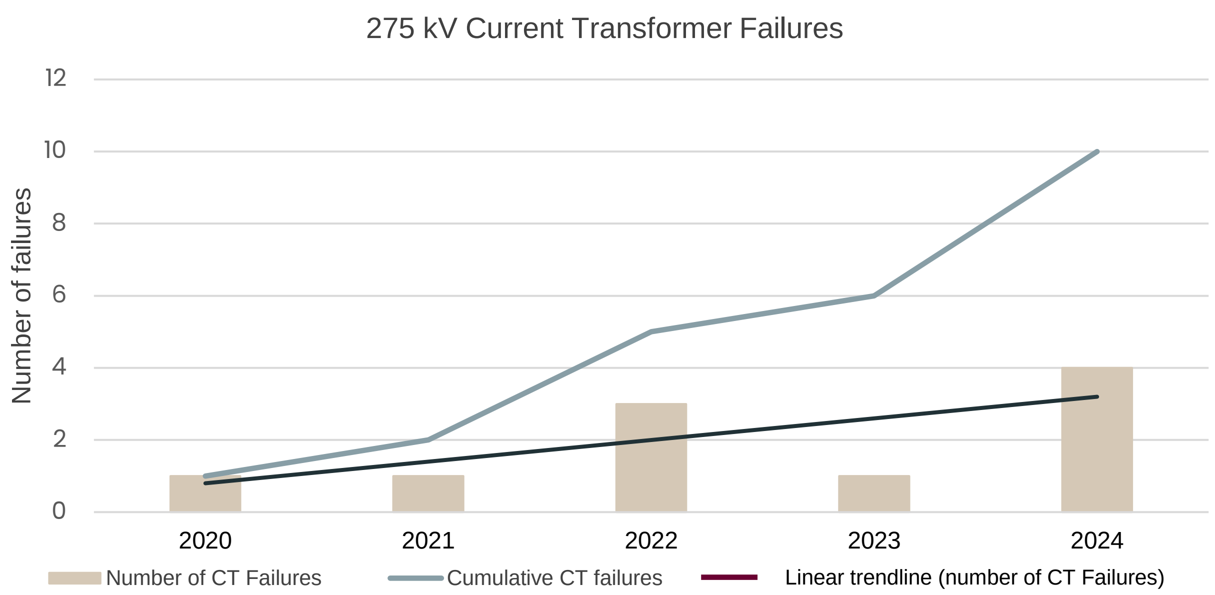
2.1 Background to the identified need

Current transformers are generally used in metering and protection circuits to provide transformation of electric current generally from high current values to lower and safer values. This provides safer conditions for both the operators and end use devices.

Current transformers are a major component of the electrical protection system that ensures faults are cleared within designated times, as stipulated by the NER.[4] Failure of a current transformer can cause unpredictable damage resulting in potential substation failure and consequential involuntary load curtailment for consumers.

Since 2020, we have experienced ten failures of current transformer that were the same make and model and of similar age. The failure rate of the current transformers has been increasing since 2020 as shown in Figure 1 below.

Figure 1 – Current transformer failures since 2020



100% of these failures were explosive in nature, resulting in debris spreading up to diameter of 15 metres. Fortunately, none resulted in injury to network personnel or members of the public. As

4 S5.1a.8 of the NER outlines the requirements regarding fault clearance times, including the specific maximum permitted fault clearance times.

shown in Table 1 some failures resulted in significant fire that damaged adjoining assets and infrastructure. These fires have been contained within the substations to date.

Table 1 – Details of current transformer failures

Incident Failure Number	1	2	3	4	5	6	7	8	9	10
Failure / Gassing date	16/10/2020	12/03/2021	11/02/2022	1/04/2022	30/11/2022	27/10/2023	21/02/2024	25/03/2024	25/03/2024	27/03/2024
Manufactured Date	2006	2006	2005	2005	2005	2006	2006	2006	2005	2006
Expansion head resting place	1.5m	NA	<1.0m	NA	NA	NA	NA	NA	NA	NA
Tank failed	No	Yes	No	Yes	NA	NA	NA	No	Yes	Yes
Other debris	8m	2m	13m	3m	NA	NA	NA	bellows cover at 3m	only oil/soft	terminal box breather 3m
Oil spray / sand	8m	oil fire 6m	11.5	15	NA	NA	NA	11.5m	Local - oil in ducts, sandbags degraded	15m

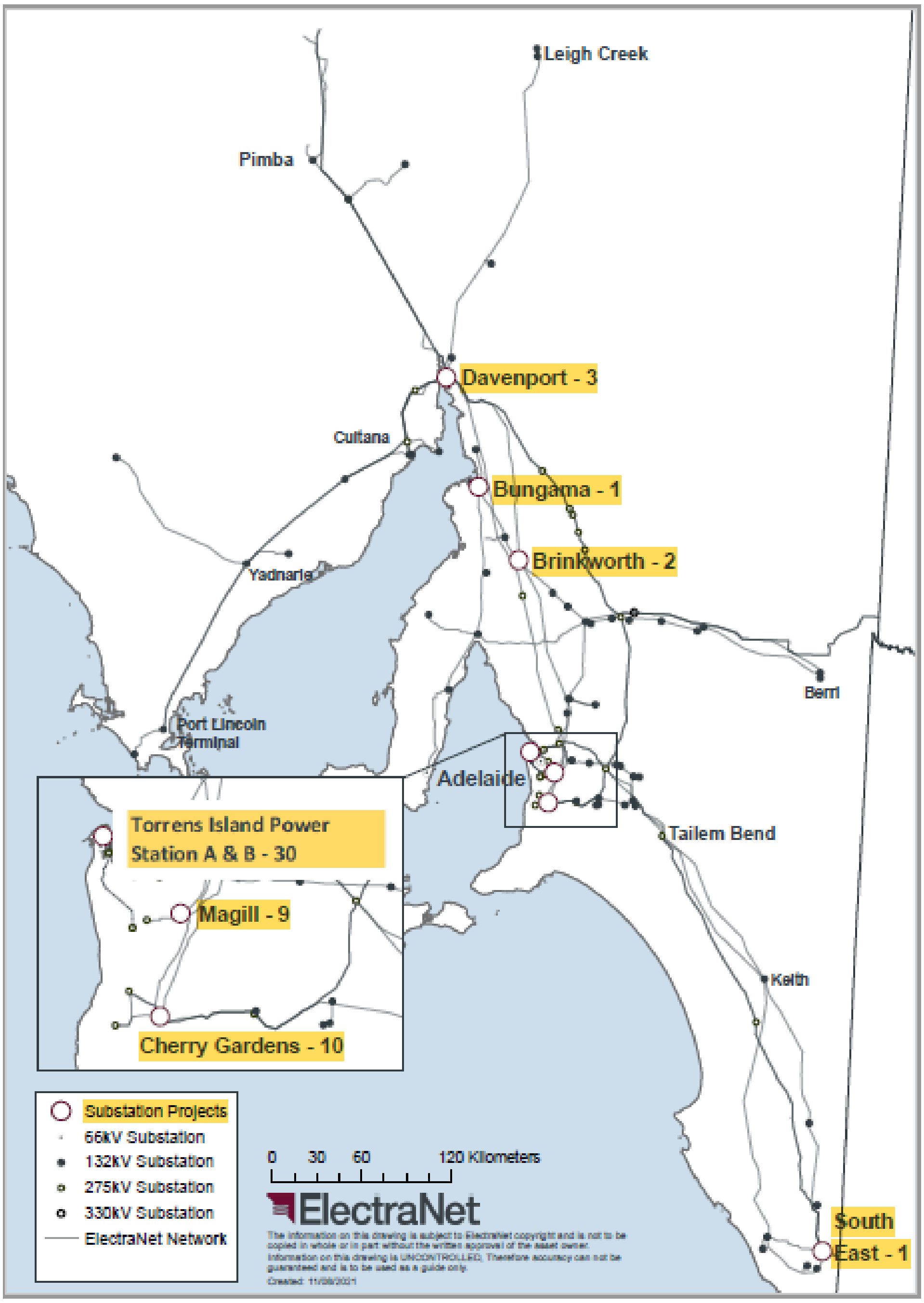
Across our transmission network, we have identified 56 sets of current transformers which, based on their make, model, year of manufacture, location and risk level, require replacement by 2026 to manage the risk of failure.

Figure 2 below shows the set of current transformers at Bungama substation that are planned to be replaced.

Figure 2 – Current transformers at Bungama substation.

The current transformers in scope have been assessed as high or medium risk and are located at eight substations (refer Figure 3) that are within bushfire zones and where we have experienced similar failures or in locations where we have experienced multiple failures.

Figure 3 – Location and number of the current transformers identified for replacement.



If the current transformers in scope of this RIT-T are not replaced by 2026, it is expected that a number of these assets will fail at an increasing rate going forward. This type of failure may cause unpredictable damage, potentially resulting in potential substation failure and involuntary load shedding on parts of the network. Also, if the replacement program is not implemented there will be an increased cost to replace the assets upon failure in a reactive fashion.

We have implemented interim safety measures to mitigate the risk of injury to network personnel or members of the public should one of these current transformers fail catastrophically and are planning to replace the identified current transformers with current transformers that have a significant higher rating to mitigate the risk of similar failures.

2.2 Description of the identified need for this RIT-T

As set out in the PSCR, the identified need for this project is to efficiently manage the risk of failure of individual current transformers across eight substations which have been identified at risk of failure, based on failure of similar of current transformers that were of same make and model and of similar age.

We have assessed the risk, and timing for the ultimate replacement of current transformers in accordance with ElectraNet's asset management policies and processes. There is an increased likelihood that several of these assets will fail in coming years given the recent failures and the results of our risk assessments. This was particularly acute at the Torrens Island Power Station B substation where we have already commenced the replacement of the higher risk current transformers

In its Industry Practice Note for asset replacement planning, the Australian Energy Regulator says that Network Service Providers should apply the As Low as Reasonably Practicable (ALARP) approach to safety matters.[5] This is consistent with the *Work Health and Safety Act 2012* (SA), which requires us to ensure, so far as is reasonably practicable, the health and safety of workers at our various sites and of the public generally. It is also consistent with our Safety, Reliability and Maintenance Technical Management Plan and with its legislative obligations and the requirements of the Electricity Transmission Code to observe good electricity industry practice for the maintenance and operation of the transmission network.

Further, the replacement program will also ensure compliance with a range of obligations under the NER and jurisdictional instruments (which is not expected to be the case under the base case). Specifically, Option 1 maintains compliance with:

- system standards and specifically the relevant fault clearance times;
- network reliability (S5.1.2):

1. *when planning and operating the network we must consider a credible contingency event where the disconnection of any single generating unit or transmission line occurs and assume that the fault will be cleared in primary protection time;*
2. *ensuring that for all lines above 66kV the line's protection system is always available, other than for short period (not greater than eight hours) whilst maintenance is carried out;*

- protection systems and the fault clearance times applicable (including the fault clearance times mentioned in maintaining system security).

[5] Australian Energy Regulator, "Industry practice application note Asset replacement planning", p.51, available from www.aer.gov.au, retrieved 2 April 2024.

Electricity (General) Regulations (the Regulations) 2012, section 52. Earthing and electrical protection systems.

1. *Earthing and electrical protection systems must be designed, installed, operated and maintained to safely manage abnormal electricity network conditions likely to significantly increase the risk of personal injury or significant property damage.*
2. *Schedule 4 applies in relation to earthing and electrical protection systems installed after 1 July 1997."*[6]

These obligations have been taken in to account in quantifying the benefits of this project which is classified as a 'market benefits' RIT-T. It is being progressed to deliver positive net benefits to customers by managing the risk of asset failure.

A full cost benefit assessment has been undertaken, comparing the risk cost reduction benefits of asset replacement options with the cost of those options.

[6] Electricity (General) Regulations 2012 (SA) s 51 & 52

3 Credible options to address the identified need

In the PSCR, we investigated two different network options. Option 1, to replace the 56 sets of current transformers by 2026 that are at high risk of failure and Option 2, leaving the current transformers in service and increasing the testing regime with a view to replacing current transformers based on those test results.

We concluded in the PSCR that Option 1, replacing the current transformers by 2026 was the preferred option, this decision has not changed. This assessment is presented in section 4.

Option 1 is technically and economically feasible and able to be implemented in sufficient time to meet the identified need[7].

3.1 Option 1 – Planned replacement of current transformer by 2026

Option 1 involves replacing the 56 sets of current transformers at eight substations by 2026 that have been identified at high risk of failure.

ElectraNet has prepared an estimate of the cost of implementing this option which is $30.2 million. This is a Class 4 estimate prepared in accordance with the Australian Association of Cost Engineer's 'class 4' estimate categorisation. As such it was produced through a desktop review based on a scope prepared by ElectraNet's asset engineering team. It has an estimating range of -30% to +50%.

Under this option there is no incremental change in routine maintenance when the current transformers are replaced compared to the base case.

The estimated construction time is approximately 2 years. We estimate that all the current transformers could be replaced and commissioned by 2026 under this option.

3.2 Option 2 – Increase testing and selected replacement of current transformer

Option 2 involves leaving the current transformers in service and increasing the testing regime with a view to replacing current transformers based on those test results. Under this option we expect that we would identify and replace two or three current transformers per year. We predict that another one or two current transformers will fail catastrophically each year requiring emergency replacement. It is expected to take approximately 10 years to replace all the identified current transformers under this option.

ElectraNet has prepared an estimate of the cost of implementing this option which is $30.2 million plus increase in routine maintenance of $275,000 per year until all identified current transformers are replaced compared to the base case.

This is a Class 4 estimate prepared in accordance with the Australian Association of Cost Engineer's 'class 4' estimate categorisation. As such it was produced through a desktop review

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7 In accordance with those identified in section **Error! Reference source not found.**.

based on a scope prepared by ElectraNet's asset engineering team. It has an estimating range of -30% to +50%.

3.3 There is not expected to be a material inter-network impact

We have considered whether the credible option will have a material inter-regional impact.[8].

By reference to AEMO's screening test for an inter-network impact[9], a material inter-regional impact arises if the option:

- involves a series capacitor or modification near an existing series capacitor;
- is expected to result in a change in power transfer capability between South Australia and neighbouring transmission networks; or
- is expected to increase fault levels at any substation in another TNSP's network.

None of these criteria are satisfied for the project discussed here. Therefore, ElectraNet does not consider there are any associated material inter-network impacts.

[8] In accordance with NER clause 5.16.4(b)(6)(ii).

[9] AEMO's suggested screening test for a material inter-network impact is set out in Appendix 3 of the Inter-Regional Planning Committee's Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations, Version 1.3, October 2004.

4 Assessment of credible options

This section outlines the assessment we have undertaken of the credible network options. The assessment compares these options against a 'do nothing' base case option.

For clarity, this section re-presents the underlying assessment in the PSCR. There were no material changes since the PSCR that would affect the finding that Option 1 is preferred.

4.1 Description of reasonable scenarios

A RIT-T analysis is required to incorporate several different reasonable scenarios, which are used to estimate expected net market benefits. The number and choice of reasonable scenarios must be appropriate to the credible options under consideration.

We have developed three scenarios for this RIT-T assessment:

- a 'central' scenario reflecting our base set of key assumptions;
- a 'low benefits' scenario – reflecting a more extreme pessimistic set of assumptions, which represents a lower bound on potential market benefits that could be realised; and
- a 'high benefits' scenario – reflecting a more extreme optimistic set of assumptions, which represents an upper bound on potential market benefits that could be realised.

Table 2 summarises the key assumptions making up each scenario.

Given that the low and high benefits scenarios are more unlikely to occur the scenarios have been weighted accordingly; 33% - low benefits scenario, 33% - central benefits scenario, and 33% - high benefits scenario.[10]

Table 2 - Summary of the three scenarios

Key variable/parameter	Low benefits scenario	Central scenario	High benefits scenario
Capital costs	130 per cent of base case estimate	Base case estimate	70 per cent of base case estimate
Commercial discount rate[11]	3.0%	7.0%	10.5%
Impact of asset failure	70 per cent of base case estimates	Base case estimates	130 per cent of base case estimates
Avoided substation damage due to explosive failure	70 per cent of base case estimates	Base case estimates	130 per cent of base case estimates
Reduced personal injuries from an explosive failure	70 per cent of base case estimates	Base case estimates	130 per cent of base case estimates
Cost of the increased oil testing (Opex)	70 per cent of base case estimates	Base case estimates	130 per cent of base case estimates

10 In accordance with paragraph 4(a) of the RIT-T.

11 Expressed on a real, pre-tax basis

Cost of involuntary load shedding	70 per cent of base case estimates	Base case estimates	130 per cent of base case estimates

4.2 Gross benefits for each credible option

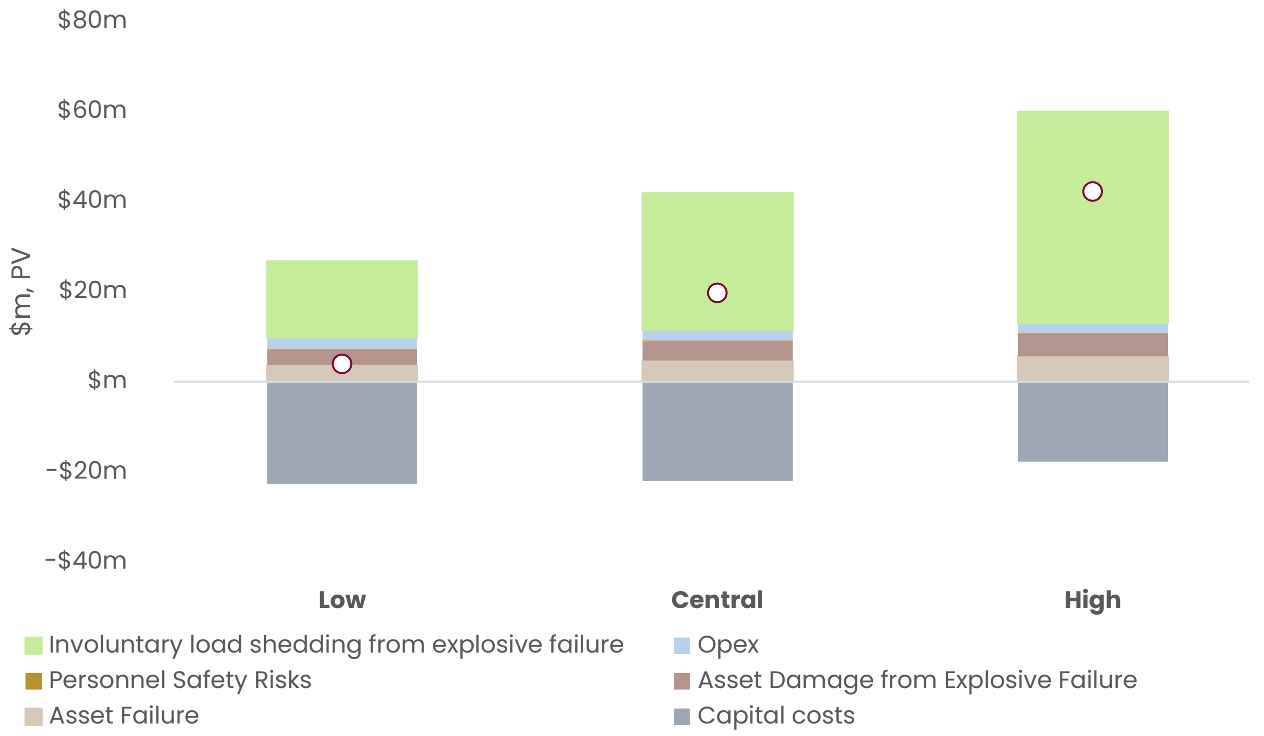
The Table 4 below summarises the gross benefit estimated for the preferred option, Option 1, replacement of the identified current transformers by 2026 and Option 2, increasing the testing of our fleet of current transformers, and the replacement the selected current transformers based on the test results, compared to the 'do nothing' base case in present value terms. The gross market benefit has been calculated for each of the three scenarios outlined in Table 2.

Table 3 - Estimated gross market benefit for each option, PV $m

Option	Low benefits scenario	Central scenario	High benefits scenario
Option 1 – Planned replacement of current transformers by 2026	26.7	41.8	59.9
Option 2 – Increase testing and selected replacement of current transformers.	11.6	17.0	22.9

Figure 4 below provides a breakdown of benefits. It shows that the benefits are derived from the avoided risk of current transformer failure and the reduced time taken to resolve such failures.

Figure 4 - Breakdown of present value gross economic benefits of the preferred option



4.3 Estimated costs for each credible option

Table 4 summarises the capital costs of the preferred Option 1 and Option 2, relative to the base case, in present value terms for the different scenarios as described in Table 2.

Table 4 - Estimated capital cost for each option, PV $m

Option	Low benefits scenario	Central scenario	High benefits scenario
Option 1 – Planned replacement of current transformers by 2026	-22.7	-22.1	-17.7
Option 2 – Increase testing and selected replacement of current transformers.	-16.4	-14.8	-11.4

Net present value assessment outcomes

Table 5 summarises the net market benefit for Option 1 and Option 2 across the three scenarios, as well as on a weighted basis. The net market benefit is the gross benefit (as outlined in section 4.1) minus the cost (as outlined in section 4.23), all expressed in present value terms.

The table demonstrates that both options provide a strong expected net economic benefit on a probability-weighted basis in all scenarios as compared to the base case of 'do nothing' option.

Table 5 - Estimated net market benefit for each option, NPV $m

Option	Low benefits scenario	Central scenario	High benefits scenario	Weighted
Option 1 – Planned replacement of current transformers by 2026	3.9	19.8	42.2	22.0
Option 2 – Increase testing and selected replacement of current transformers.	-4.8	2.2	11.6	3.0

We have been conservative in our approach by not including the additional benefits of this option discussed in section 3.3.

4.4 Sensitivity testing

We have undertaken a thorough sensitivity testing exercise to understand the robustness of the RIT-T assessment to underlying assumptions about key variables.

In particular, we have tested the two options against the sensitivity of the total net market benefit to variations in the key factors underlying the assessment, such as for example the sensitivity of the project to increases in capital costs (all sensitivities tested are presented in Figure 5).

As mentioned in section **Error! Reference source not found.**, we have not considered the option of delaying the project as we normally do, due to the risk of catastrophic failure of the current transformers in scope and our requirement detailed in Section **Error! Reference source not found.**, to manage the network risk ALARP and to comply with ElectraNet's obligations to manage the safety risk to personnel and the public.

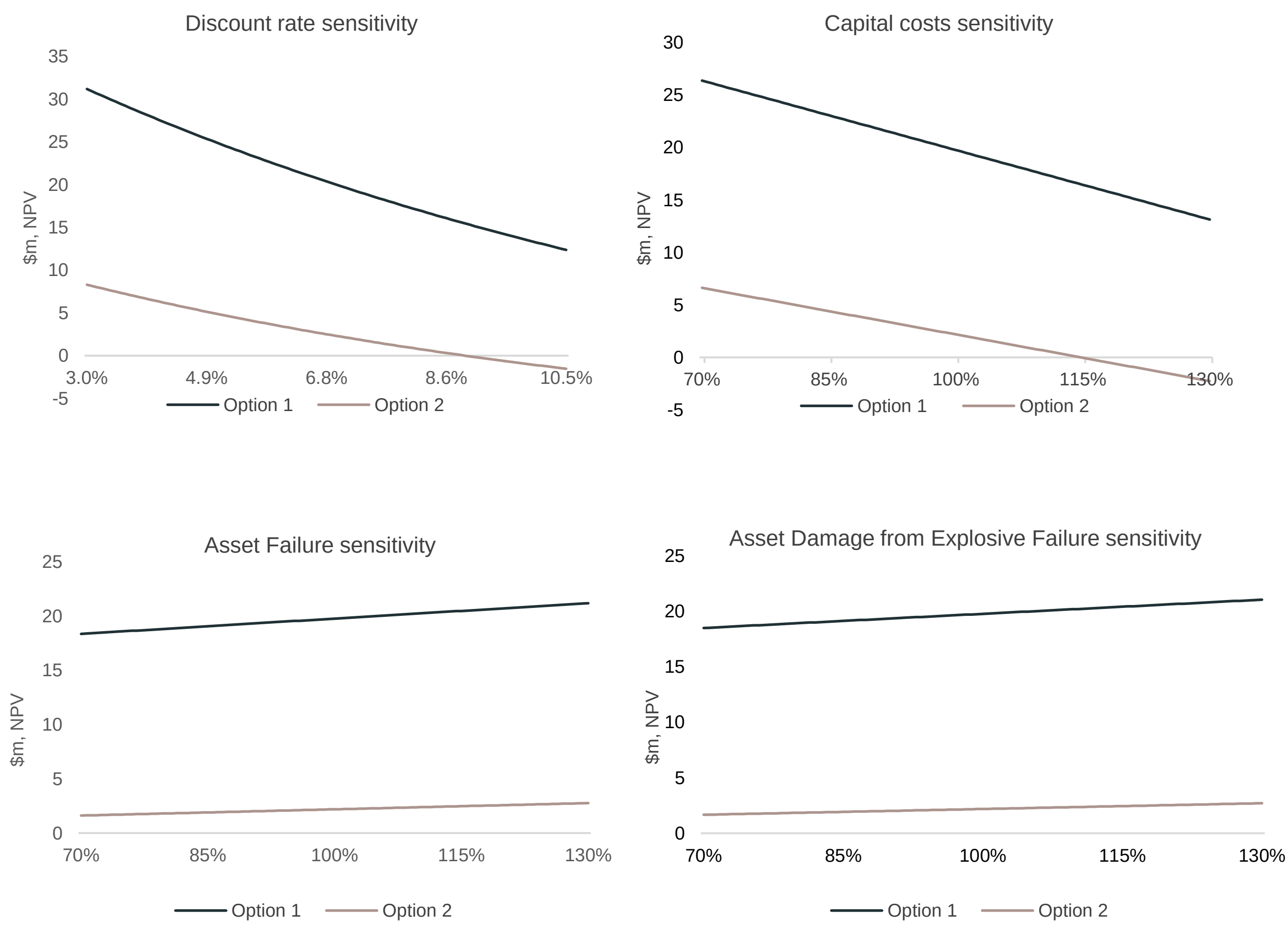
4.4.1 Sensitivity of the overall net market benefit

We have also reviewed the consequences for the preferred option of 'getting it wrong' if the key underlying input assumptions are not accurate.

The charts in Figure 5 below illustrate the estimated net market benefits for each option if the three separate key assumptions in the central scenario are varied individually. Importantly, for all sensitivity tests shown below, the estimated net market benefit of Option 1 of replacing the current transformers by 2026 is found to be strongly positive and higher than Option 2, increasing the testing of our fleet of current transformers, and the replacement the selected current transformers based on the test results, compared to the 'do nothing' base case in present value terms.

We do not consider that any of these threshold values can be reasonably expected and, thus, considers that the expected net market benefits have been demonstrated to be robust to a range of alternate input assumptions.

Figure 5 - Sensitivity testing of the NPV of net market benefits



For details about the economic modelling and process we followed, please refer to the following appendices:

- Appendix A defines the terms used in the economic assessment,
- Appendix B provides the process that we followed,
- Appendix C the assumptions underpinning the identified need,
- Appendix D the materiality of market benefits, and
- Appendix E the modelling methodologies used for the assessment of the options.

This information was included in the PSCR.

5 Conclusion on the preferred option

The preferred option that has been identified in this assessment for addressing the identified need is Option 1, i.e., replacing the identified current transformer by 2026. This is estimated to have a capital cost of $30.2 million.

Option 1 is the preferred option 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.

We consider that the analysis undertaken and the identification of Option 1 as the preferred option satisfies the RIT-T.

The Compliance Checklist in Appendix F demonstrates that the PACR complies with section 5.16.4(v) of the NER.

ElectraNet is intending to replace the 56 sets of current transformers by 2026.

Appendix A Definitions

This appendix defines the terms used in the economic assessment.

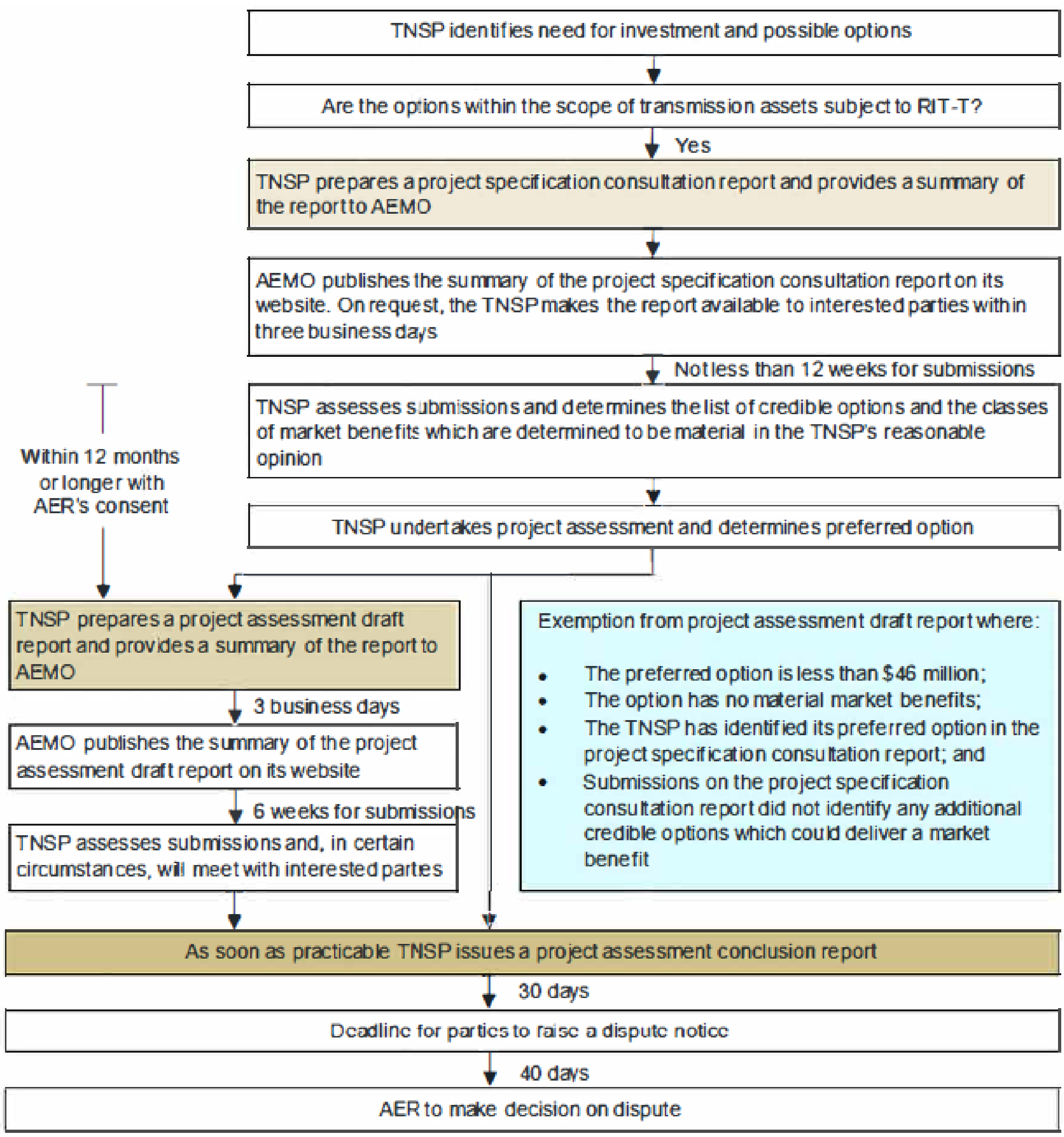
Definitions	
AEMO	Australian Energy Market Operator
Base case	A situation in which no option is implemented by, or on behalf of the transmission network service provider.
Commercially feasible	An option is commercially feasible if a reasonable and objective operator, acting rationally in accordance with the requirements of the RIT-T, would be prepared to develop or provide the option in isolation of any substitute options. This is taken to be synonymous with 'economically feasible'.
Costs	Costs are the present value of the direct costs of a credible option.
Credible option	A credible option is an option (or group of options) that: a) address the identified need; b) is (or are) commercially and technically feasible; and c) can be implemented in sufficient time to meet the identified need.
Economically feasible	An option is likely to be economically feasible where its estimated costs are comparable to other credible options which address the identified need. One important exception to this Rules guidance applies where it is expected that a credible option or options are likely to deliver materially higher market benefits. In these circumstances the option may be "economically feasible" despite the higher expected cost. This is taken to be synonymous with 'commercially feasible'.
Identified need	The reason why the Transmission Network Service Provider proposes that a particular investment be undertaken in respect of its transmission network.

Definitions	
Market benefit	Market benefit must be: a) the present value of the benefits of a credible option calculated by: i) comparing, for each relevant reasonable scenario: a) the state of the world with the credible option in place to b) the state of the world in the base case, And ii) weighting the benefits derived in sub-paragraph (i) by the probability of each relevant reasonable scenario occurring. b) a benefit to those who consume, produce and transport electricity in the market, that is, the change in producer plus consumer surplus.
Net market benefit	Net market benefit equals the market benefit less costs.
Preferred option	The preferred option is the credible option that maximises the net economic benefit to all those who produce, consume and transport electricity in the market compared to all other credible options. Where the identified need is for reliability corrective action, a preferred option may have a negative net economic benefit (that is, a net economic cost).
Reasonable Scenario	Reasonable scenario means a set of variables or parameters that are not expected to change across each of the credible options or the base case.
Technically feasible	An option is technically feasible if there is a high likelihood that it will, if developed, provide the services that the RIT-T proponent has claimed it could provide for the purposes of the RIT-T assessment.

Appendix B Process for implementing the RIT-T

For the purposes of applying the RIT-T, the NER establishes a typically three stage process, i.e.: (1) the PSCR; (2) the PADR; and (3) the PACR. This process is summarised in the figure below (in gold), as well as the criteria for PADR exemption that this RIT-T is seeking to apply (in blue).

Figure 6 - The RIT-T assessment and consultation process



Appendix C Assumptions underpinning the identified need

This appendix summarises the key assumptions from the risk cost modelling and other key assumptions that underpin the identified need for this RIT-T. Appendix E provides further detail on the general modelling approaches applied, including additional details on the risk cost modelling framework.

For the purposes of this assessment, the risk cost model of current transformer failures focuses on the following failure modes being:

- electrical – when there is a loss of electrical connection integrity in primary and secondary components;
- electrical explosive – when the loss of electrical connection integrity in primary components results in an explosive failure;
- insulation – an internal and external dielectric failure, insulation leakage or accuracy out of tolerance;
- insulation explosive – an explosive internal and external dielectric failure or explosive insulation leakage failure;
- other – where the asset loses mechanical integrity; and
- other explosive – which is any other major failure where the asset loses mechanical integrity resulting in explosive failure.

Each failure mode has different characteristics and consequential likelihoods of occurring, as detailed in the sections below.

C.1 The probability of failure

The probability of failure is based on investigation of the recent current transformer failures, the result of our risk assessment of the remaining fleet of the current transformers and is calculated at 2.5 current transformers per year.

C.2 The consequences of failure

The consequences of failure of a current transformer include:

- potential for unplanned outages resulting in unavailability of parts of the network, possible supply interruption, possible network constraint and subsequent market impact;
- increased costs to replace these assets upon failure;
- in the event of a catastrophic failure;
    - risk to safety of personnel and the public;
    - risk of damage to adjoining infrastructure from debris and fire within the substation; and
    - risk of fire spreading to surrounding areas.

C.3 The likelihood and cost of instrument transformer failure

Our risk cost model considers each of the adverse effects that could occur from a current transformer failure separately. Specifically, it defines a set of assumptions for the adverse effects, which allows the 'likelihood of consequence' (**LoC**) and 'cost of consequence' (**CoC**) to be estimated for current transformer failures.

Depending on its nature, a current transformer failure might cause an outage. The likelihood is assumed to be between 1 and 100 per cent. This likelihood depends on several considerations including whether the substation is part of the meshed network and the distance between the location of the current transformer to other assets critical to supplying energy.

It is also assumed in specific instances that if there is a failure of certain current transformers that support the interconnector there is a possibility of a wide scale outage. However, the LoC for this to occur is only when the interconnector is importing above the relevant limits (i.e. very unlikely).

Outage cost is calculated using the Australian Energy Regulator's (**AER**) estimated Value of Customer Reliability (**VCR**) which reflects the value different customer types place on reliable electricity supply. All loads are based on a representative load trace taken from 2019-20 escalated to 2023 dollars based on the Consumer Price Index for that year.

We note that, should a current transformer fail, there may also be wider outages than the load groups we have considered and/or planned outages for operational and capital work may have to be postponed. These additional adverse effects have not been captured in our risk cost modelling since doing so would require a significant modelling exercise and it is not considered material in the context of the RIT-T assessment (i.e. in identifying the preferred option) but are expected to further increase the net market benefits associated with Option 1.

The failure of a current transformer may in some cases cause material damage to other assets within the substation that will then require replacement or significant corrective work, resulting in additional costs and operational impacts. These costs have been estimated using historical information and experience by the relevant internal teams at ElectraNet as discussed in section 3.1.

Depending on the nature of the failure, there is a material risk of personal injury if someone is at a substation when a current transformer fails. The substations where the current transformers are proposed to be replaced have been risk assessed on the basis of the likelihood of personal injury as a result of a current transformer failure.

We have used the Value of Statistical Life[12], escalated to today's dollars and multiplied by a relevant disproportionate factor, in order to quantify these avoided consequences. It has also been assumed that any such events will incur additional costs such as a legal, compensation and investigation costs (which have been estimated using Safe Work Australia reports).[13]

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[12] Australian Government, Department of Prime Minister and Cabinet, Office of Impact Analysis (OIA) October 2023. Value of statistical life, pp 1. https://oia.pmc.gov.au/resources/guidance-assessing-impacts/value-statistical-life#value-of-statistical-life .

[13] Average Indirect Costs for work-related incidents, Australia in June 2013$, The Cost of Work-related Injury and Illness for Australian Employers, Workers and the Community: 2012-13, Safe Work Australia, p.26

Overall, the costs associated with the negative consequences of a current transformer failure are material assumptions for the economic assessment of the project. We have therefore included a range of sensitivity tests on these as part of the economic assessment.

Appendix D Materiality of market benefits for this RIT-T assessment

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

The bulk of the benefits associated with the preferred option are captured in the expected costs avoided by the option (i.e., the avoided expected costs compared to the base case). These include avoided risk costs as described above.

Of these avoided costs only unserved energy due to involuntary load shedding is considered a market benefit category under the NER.

D.1 Avoided involuntary load shedding is the only relevant market benefit

The only relevant market benefit for this RIT-T relates to changes in involuntary load shedding. The expected unserved energy under the base case, which is avoided under the preferred option, has been estimated as part of our risk cost modelling.

D.2 Market benefits relating to the wholesale market are not material

The AER has recognised that a number of classes of market benefits will not be material in a RIT-T assessment if the credible options considered will not have an impact on the wholesale market. In this case the impacts do not need to be estimated.14

The preferred option would not affect network constraints between competing generating centres so it would not change dispatch outcomes or wholesale market prices.

Therefore, we consider the following classes of market benefits to be immaterial 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 for ElectraNet (since there will be no deferral of generation investment);
- changes in ancillary services costs;
- competition benefits; and
- Renewable Energy Target (**RET**) penalties.

[14] AER, *Regulatory Investment Test for Transmission Application Guidelines*, August 2020, p. 29.

D.3 Other classes of market benefits are not expected to be material

In addition to the classes of market benefits listed above, NER clause 5.15A.2(b)(4) requires us 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 network losses.

We consider that none of these are material for this RIT-T assessment for the reasons set out in Table 6.

Table 6 - Reasons why non-wholesale market benefit categories are considered immaterial.

Market benefit category	Reason(s) why it is considered immaterial
Differences in the timing of transmission investment	The preferred option does not affect the timing of other unrelated transmission investments (i.e., transmission investments based on a need that falls outside the scope of that described in section 2). Consequently, the market benefits associated with differences in the timing of unrelated transmission investment are not material to the RIT-T assessment.
Option value	The AER has stated that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available in the future is likely to change and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[15] None of these conditions apply to the present assessment. The AER has also stated the 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. Changes in future demand levels are not relevant for this RIT-T since the need for and timing of the required investment is being driven by asset condition rather than future demand growth. As a result, it is not relevant to consider different future demand scenarios in undertaking the RIT-T analysis.
Changes in network losses	Given the preferred option maintains the current network capacity at the same location, there are not expected to be any differences in network losses.

[15] AER, *Regulatory Investment Test for Transmission Application Guidelines*, August 2020, p. 52.

Appendix E Description of the modelling methodologies applied

This appendix outlines the methodologies and assumptions we have applied to undertake this RIT-T assessment.

E.1 Overview of the risk cost modelling analysis

We have applied an asset 'risk cost' evaluation framework to quantify the risk cost reduction associated with replacing the identified instrument transformers.

The 'risk cost reduction' has been calculated as the product of:

- Probability of Failure, which is the probability of a failure occurring based on asset failure history information and industry data;
- Likelihood of Consequence, which is the likelihood of an adverse consequence of the failure event based on historical information and statistical factors; and
- Cost of Consequence, which is the estimated cost of the adverse consequence.

These three variables allow the expected risk cost reduction benefit to be quantified and an assessment against the cost of the project to be undertaken. The risk cost reduction benefit is the difference between risk costs incurred under the base case and the preferred option.

The approach we apply to quantifying risk was presented as part of our Revenue Proposal for the 2024-2028 regulatory control period. In its Draft Decision on that proposal, the AER found it to be consistent with good industry practice and to generally reflect reasonable inputs and assumptions.

More detail on the key inputs and assumptions made for individual asset risk cost evaluations can be found in ElectraNet's asset risk cost modelling guideline.

E.2 The discount rate and assessment period

The RIT-T analysis has been undertaken over a 10-year period from 2024 to 2033. This considers the size, complexity and expected life of each option to provide a reasonable indication of its cost.

The asset life of a current transformer is more than 10 years. We have taken a terminal value approach to incorporating capital costs in the assessment, which ensures that the capital cost of each option is appropriately captured in the 10-year assessment period.

We have adopted a real, pre-tax discount rate of 7.0 percent as the central assumption for the analysis presented in this report, consistent with AEMO's most recent Inputs, Assumptions and Scenarios Report. We consider that this is a reasonable contemporary approximation of a 'commercial' discount rate (a different concept to a regulatory WACC), consistent with the RIT-T.

The RIT-T requires that sensitivity testing be conducted on the discount rate and that the discount rate scenarios from AEMO's ISP Inputs Assumptions and Scenarios Report should be applied.

We have therefore tested the sensitivity of the results to changes in this discount rate assumption, and specifically to the adoption of a lower bound discount rate of 3.0 percent, and an upper bound discount rate of 10.5 percent.

Appendix F Compliance Checklist

This appendix sets out a compliance checklist which demonstrates the compliance of this PACR with the requirements of clause 5.16.4(v) of the NER version 222.

Rules clause	Summary of requirements	Relevant section(s) in PACR
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)	N/A
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;	N/A
	(3) a quantification of the costs, including a breakdown of operating and capital expenditure, and classes of material market benefit for each credible option;	3,4, Appendix D & Appendix E
	(4) a detailed description of the methodologies used in quantifying each class of material market benefit and cost;	Appendix D
	(5) reasons why the RIT-T proponent has determined that a class or classes of market benefit are not material;	Appendix D
	(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);	N/A
	(7) the results of a net present value analysis of each credible option and accompanying explanatory statements regarding the results;	4
	(8) the identification of the proposed preferred option;	3

Rules clause	Summary of requirements	Relevant section(s) in PACR
	(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*.	3,4 & 5
	(10) if each of the following apply to the RIT-T project: (i) the estimated capital cost of the proposed preferred option is greater than $100 million (as varied in accordance with a cost threshold determination); and (ii) AEMO is not the sole RIT-T proponent, the RIT reopening triggers applying to the RIT-T project.	N/A

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