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Improving Voltage Control in Southern New South Wales

RIT-T Project Specification Consultation Report

Region: Southern New South Wales

Date of issue: 15 November 2024

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Executive summary

We are applying the Regulatory Investment Test for Transmission (RIT-T) to options focused on ensuring voltage in southern New South Wales (NSW) is managed appropriately and in the most efficient manner. This Project Specification Consultation Report (PSCR) represents the first step in the application of the RIT-T.

Voltage is the electric potential between two points that gives rise to the flow of electricity. Network service providers undertake voltage control to ensure that voltage is kept within technical limits, thereby safeguarding the security and reliability of the power system. Voltage is controlled by managing the production and absorption of reactive power (residual power flowing forwards and backwards between connection points, which is juxtaposed by active power which services a load).[1] AEMO's Electricity Statement of Opportunities (ESOO) 2024 report shows that Minimum Demand in NSW will continue to decline over the next couple of years. This value is expected to be less than 1000 MW (Summer and Shoulder) in the FY 2029/30 under the 50% Probability of Exceedance (POE) Central Scenario[2]. The reduction in minimum demand is already causing high voltage issues, especially at some switchyards where the maximum voltage rating is lower than 1.1 p.u. These switchyards are listed in the table below:

Table E-1 Substations with a maximum voltage limitation of less than 1.1 pu

Switchyard	Maximum Voltage Limit (kV)	Comments
Bendeela 330	346	Power station transformer limitation
Kangaroo Valley 330	346	Power station transformer limitation
Lower Tumut 330	355	Limit by generator unit transformer
Upper Tumut 330	346	Limit by generator unit transformer

The NSW southwest subsystem is also experiencing high voltage issues at times of low demand due to a reduction in Wagga area load. This can be primarily attributed to the Norske Skog paper mill ceasing operations (about a 100 MW load decrease). Accordingly, there are over-voltage issues at Balranald substations at times of overnight light load conditions, in particular in the event of the contingent trips in that region.

Identified need: maintaining voltage control in southern NSW to comply with NER requirements

The identified need for this RIT-T is to maintain voltage levels in southern NSW by managing the risk of excess voltage levels due to declining minimum demand. There is an increasing likelihood of non-compliance with NER and NSW reliability standards without investments to address this need.

We are required to maintain compliance with Schedule 5.1.4 of the NER and the NSW Electricity Reliability and Performance Standards 2017. Consequently, we consider this 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.

[1] power-system-stability-guideline.pdf (aemo.com.au)
[2] 2024-electricity-statement-of-opportunities.pdf (aemo.com.au)

Two credible network options have been identified

We have identified two credible network options that would meet the identified need from a technical, commercial, and project delivery perspective.[3] These options are summarised in Table E-2 below.

Table E-2 Summary of credible options

Option	Description	Estimated capex ($2024/25 +/- 25%)	Operating costs ($2024/25, $ per year)
Option 1	Install 1 x 50 MVAr Shunt Reactor at Kangaroo Valley 330 kV switching station and Install 1 x 20 MVAr Shunt Reactor at Balranald 220 kV station	$13.4m	$134,000
Option 2	Install 2 x 50 MVAr Shunt Reactors at Capital Wind Farm 330 kV and install 1 x 20 MVAr Shunt Reactor at Balranald 220 kV station	$23.1m	$231,000

Non-network options may also be able to form credible options for this RIT-T

We consider that non-network options may be able to assist with meeting the identified need, specifically non-network technologies that are able to provide reactive support. At this stage we consider that possible solutions may include, but are not limited to:

- battery energy storage systems (BESS), and
- generators in the region who can provide reactive power support.

However, we note that the cost of the network options may act to effectively bound the cost available for any non-network options to be considered commercially feasible.

We encourage parties to make written submissions regarding the potential of non-network options to satisfy, or contribute to satisfying, the identified need for this RIT-T.

Option 1 delivers highest net economic benefits and will meet relevant regulatory obligations

Implementing Option 1 by 2028/29 will not only satisfy relevant regulatory obligations set out in the NER and NSW reliability standards, it will also maintain voltage control in southern NSW for the long term.

Option 1 delivers the highest (least negative) net economic benefits in all scenarios, meeting the identified need at a lower cost than Option 2. Accordingly, Option 1 has been identified as the preferred Option.

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

Draft Conclusion

The optimal commercially and technically feasible option presented in this PSCR – Option 1 (install a new shunt reactor at Kangaroo Valley and Balranald) – is the preferred option to meet the identified need and improve voltage control in southern NSW. Moving forward with this option is the most prudent and economically efficient solution to ensure NER requirements and NSW reliability standards are met in the long term.

The estimated capital expenditure associated with this option is $13.4 million (+/- 25 per cent). Routine operating and maintenance costs relating to planned activities are approximately $134,000 per year.

Option 1 is not found to have a positive net market benefit under the weighted scenario. However, since this RIT-T is a reliability corrective action, the top-ranked option is permitted to have a negative market benefit.

We have also conducted sensitivity analysis to assess the robustness of the economic assessment to key assumptions (changes in capital costs and discount rates). This sensitivity analysis confirmed that Option 1 being the preferred option is a robust outcome.

The works will be undertaken between 2024/25 and 2027/28. Planning, design, development and procurement (including the completion of the RIT-T) will occur between 2024/25 and 2025/26, while project delivery and construction will occur in 2026/27. All works are expected to be completed by 2027/28, with final commissioning of the solution expected in 2027/28 to best meet the need of improving voltage control.

Exemption from preparing a Project Assessment Draft Report

Subject to the identification of additional credible options during the consultation period, publication of a Project Assessment Draft Report (PADR) is not required for this RIT-T as we consider that the conditions in clause 5.16.4(z1) of the NER exempting RIT-T proponents from providing a PADR have been met.

Specifically, production of a PADR is not required because:

- the estimated capital cost of the preferred option is less than $54 million[4];
- we have identified in this PSCR our proposed preferred option, together with the reasons for the preferred option; and
- the proposed preferred option and any other credible options in respect of the identified need do not have any material market benefits (with the exception of market benefits arising from changes in involuntary load shedding).

If an additional credible option that could deliver a material market benefit is identified during the consultation period, then we will produce a Project Assessment Draft Report (PADR) that updates the NPV assessment presented in this PSCR.

Submissions and next steps

We welcome written submissions on materials contained in this PSCR. Submissions are due on 20 February 2025.[5]

[4] Varied from $46m to $54m based on the AER Final Determination: Cost threshold review, November 2024.
[5] Consultation period is for 12 weeks. Additional days have been added to cover public holidays.

Submissions should be emailed to our Regulation team via regulatory.consultation@transgrid.com.au.[6] In the subject field, please reference 'Improving Voltage Control in Southern NSW PSCR'.

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

We intend to produce a Project Assessment Conclusions Report (PACR) that addresses all submissions received and presents our draft analysis and conclusion on the preferred option for this RIT-T. Subject to submissions to this PSCR, we anticipate publication of a PACR by mid-2025.

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

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1. Introduction

We have commenced this Regulatory Investment Test for Transmission (RIT-T) to options focused on ensuring voltage in southern New South Wales (NSW) is controlled appropriately and in the most efficient manner. This Project Specification Consultation Report (PSCR) represents the first step in the application of the RIT-T.

1.1. Purpose of this report

The purpose of this PSCR[7] is to:

- set out the reasons why we propose that action be undertaken (the 'identified need');
- present the credible option that we currently consider addresses the identified need;
- explain the basis on which we have concluded that non-network options are not expected to be able to contribute to meeting the identified need for this RIT-T;
- summarise the assumptions proposed to feed into the PADR analysis; and
- allow interested parties to make submissions and provide inputs to the RIT-T assessment.

Overall, this report provides transparency into the planning considerations for investment options addressing the expected increase in fault levels. A key purpose of this PSCR, and the RIT-T more broadly, is to provide interested stakeholders the opportunity to review the analysis and assumptions, provide input to the process, and have certainty and confidence that the preferred option has been robustly identified as optimal.

1.2. Exemption from producing a Project Assessment Draft Report

Subject to the identification of additional credible options during the consultation period, publication of a Project Assessment Draft Report (PADR) is not required for this RIT-T as we consider that the conditions in clause 5.16.4(z1) of the NER exempting RIT-T proponents from providing a PADR have been met.

Specifically, production of a PADR is not required because:

- the estimated capital cost of the preferred option is less than $54 million[8];
- we have identified in this PSCR our proposed preferred option, together with the reasons for the preferred option; and
- the proposed preferred option and any other credible options in respect of the identified need do not have any material market benefits (with the exception of market benefits arising from changes in involuntary load shedding).

If an additional credible option that could deliver a material market benefit is identified during the consultation period, then we will produce a Project Assessment Draft Report (PADR) that updates the NPV assessment presented in this PSCR.

[7] See Appendix A for the NER requirements.
[8] Varied from $43m to $46m based on the AER Final Determination: Cost threshold review, November 2024.

1.3. Submissions and next steps

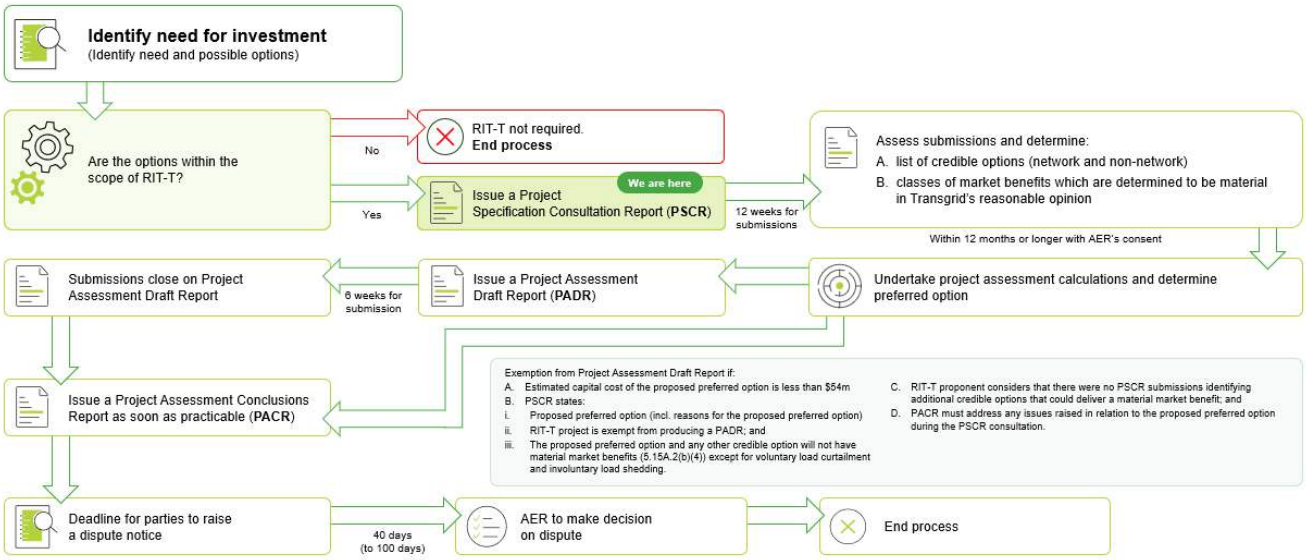
We welcome written submissions on materials contained in this PSCR. Submissions are due on 20 February 2025.[9]

Submissions should be emailed to our Regulation team via regulatory.consultation@transgrid.com.au.[10] In the subject field, please reference 'Improving Voltage Control in Southern NSW PSCR'.

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

Should we consider that no additional credible options were identified during the consultation period, we intend to produce a Project Assessment Conclusions Report (PACR) that addresses all submissions received including any issues in relation to the proposed preferred option raised during the consultation period. Subject to additional credible options being identified, we anticipate publication of a PACR by mid-2025.

Figure 1-1 This PSCR is the first stage of the RIT-T process[11]



[9] Consultation period is for 12 weeks. Additional days have been added to cover public holidays.

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[11] Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.

2. The identified need

2.1. Background to the identified need

We are applying the Regulatory Investment Test for Transmission (RIT-T) to options focused on ensuring voltage in southern New South Wales (NSW) is managed appropriately and in the most efficient manner. This Project Specification Consultation Report (PSCR) represents the first step in the application of the RIT-T.

Voltage is the electric potential between two points that gives rise to the flow of electricity. Network service providers undertake voltage control to ensure that voltage is kept within technical limits, thereby safeguarding the security and reliability of the power system. Voltage is controlled by managing the production and absorption of reactive power (residual power flowing forwards and backwards between connection points, which is juxtaposed by active power which services a load).[12]

AEMO's Electricity Statement of Opportunities (ESOO) 2024 report shows that Minimum Demand in NSW will continue to decline over the next couple of years. This value is expected to be less than 1000 MW (Summer and Shoulder) in the FY 2029/30 under the 50% Probability of Exceedance (POE) Central Scenario[13]. The reduction in minimum demand is already causing high voltage issues, especially at some switchyards where the maximum voltage rating is lower than 1.1 p.u. These switchyards are listed in the table below:

Table 2-1 Substations with a maximum voltage limitation of less than 1.1 pu

Switchyard	Maximum Voltage Limit (kV)	Comments
Bendeela 330	346	Power station transformer limitation
Kangaroo Valley 330	346	Power station transformer limitation
Lower Tumut 330	355	Limit by generator unit transformer
Upper Tumut 330	346	Limit by generator unit transformer

The NSW southwest subsystem is also experiencing high voltage issues at times of low demand due to a reduction in Wagga area load. This can be primarily attributed to the Norske Skog paper mill ceasing operations (about a 100 MW load decrease). Accordingly, there are over-voltage issues at Balranald substations at times of overnight light load conditions, in particular in the event of the contingent trips in that region.

2.2. Description of the identified need

Schedule 5.1.4 of the NER requires us to plan and design equipment for voltage control to maintain voltage levels within 10% of normal voltage14. The NER also requires the power system to be operated in a satisfactory operating state, which requires voltages to be maintained within these levels, both in normal

[12] power-system-stability-guideline.pdf (aemo.com.au)
[13] 2024-electricity-statement-of-opportunities.pdf (aemo.com.au)
[14] These levels are specified in Clause S5.1a.4. of the system standards.

operation and following any credible contingency event15. In addition to such requirements, Transgrid will ensure the voltage for some busbars will not go beyond the true limits, which is usually lower than 1.1 p.u. as discussed in the previous Section, under both normal and N-1 network conditions.

Transgrid's study is based on the network minimum demand forecast (collected from distribution network service providers in FY2027/28 and FY2028/29), while taking into account committed generators and network augmentations. The assessment shows that overvoltage will continue to occur at Kangaroo Valley 330 in contingency conditions, particularly if one shunt reactor in the southern region is out of service in the day and/or overnight, when Shoalhaven generators are not generating and there is no reactive power support from most solar farms.

In addition, the NSW southwest subsystem is experiencing high voltage issues at times of low demand due to a reduction in Wagga area load, primarily due to Norske Skog paper mill ceasing operations (about a 100 MW load decrease). There are over-voltage issues at Balranald substation at times of overnight light load conditions, in particular in the event of the contingent trips in that region.

To ensure voltage is managed within voltage limits as prescribed by the NER, Transgrid needs to install shunt reactors at Kangaroo Valley and Balranald.

2.3. Assumptions underpinning the identified need

This RIT-T has been initiated in response to declining minimum demand in the NSW region, particularly in the Southwest NSW region. The demand forecasts underpinning the identified need for this RIT-T reflect the expected continued growth in embedded and distributed generation which will continue to reduce minimum demand in the future.

A number of operating scenarios (day and night times) to assess the impact of the decreasing minimum demand, which usually occurs either in the mid-day when generation from rooftop PVs is high or in the night when the utilisation of electric power is relatively low. In all the studied scenarios, the active and reactive demands are based on the forecast from distribution network service providers (DNSPs) and the total active demand of the whole NSW region is assumed to be under 3000 MW. These studies shows that the voltage at a few busbars, particularly the following ones, will exceed acceptable levels during a credible contingency with and/or without a pre-outage of a reactive plant:

- Kangaroo Valley 330 kV,
- Bendeela 330 kV, and
- Balranald 220 kV

Some of the study results (observations with higher voltage violations) when the over-voltage issues occur are presented in Table 2-2. The over-voltage issues are expected to occur in the day and/or nighttime periods when the demand is low and sufficient reactive power support is unavailable from renewable generators in the region.

[15] These requirements are set out in Clauses 4.2.2(b), 4.2.4 and 4.2.6 of the NER. The requirement for secure operation of the power system in Clause 4.2.4 requires the power system to be in a satisfactory operating state following any credible contingency event, that is, to maintain voltage within 10% of normal voltage following the first credible contingency event.

Table 2-2: Observed over-voltage issues in the study.

Bus Name	Voltage (p.u.)	Voltage Upper Limit (p.u.)	Pre-outage Equipment	Contingency	Time	Year
Bendeela 330 kV	1.0531	1.0485	Yass 330 kV Inductor #2	Line 37 (Kemps Creek 330 kV to Macarthur 330 kV)	Day	2027/28
Kangaroo Valley 330 kV	1.0531	1.0485	Yass 330 kV Inductor #2	Line 37 (Kemps Creek 330 kV to Macarthur 330 kV)		
Balranald 220 kV	1.1237	1.1136	Darlington Point 220 kV Inductor	Line X3 (Balranald 220 kV to Buronga 220 kV)	Night	2027/28
Bendeela 330 kV	1.0604	1.0485	Yass 330 kV Inductor #2	Line 18 (Dapto 330 kV to Kangaroo Valley 330 kV)		
Kangaroo Valley 330 kV	1.0604	1.0485	Yass 330 kV Inductor #2	Line 18 (Dapto 330 kV to Kangaroo Valley 330 kV)		
Bendeela 330 kV	1.0607	1.0485	Yass 330 kV Inductor #2	Line 18 (Dapto 330 kV to Kangaroo Valley 330 kV)	Day	2028/29
Kangaroo Valley 330 kV	1.0606	1.0485	Yass 330 kV Inductor #2	Line 18 (Dapto 330 kV to Kangaroo Valley 330 kV)		
Balranald 220 kV	1.1230	1.1136	Darlington Point 220 kV Inductor	Line X3 (Balranald 220 kV to Buronga 220 kV)	Night	2028/29
Bendeela 330 kV	1.0714	1.0485	Yass 330 kV Inductor #2	Line 18 (Dapto 330 kV to Kangaroo Valley 330 kV)		
Kangaroo Valley 330 kV	1.0714	1.0485	Yass 330 kV Inductor #2	Line 18 (Dapto 330 kV to Kangaroo Valley 330 kV)		

3. Potential credible options

We consider credible options in this RIT-T assessment as those that would meet the identified need from a technical, commercial, and project delivery perspective.[16] This will include any credible options that are put forward by proponents in response to this PSCR.

Table 3-1 summarises each of the credible options we currently consider can meet the identified need.

Table 3-1: Summary of the credible options

Option	Description	Estimated capex ($2024/25 +/- 25%)	Operating costs ($2024/25, $ per year)
Option 1	Install 1 x 50 MVAr Shunt Reactor at Kangaroo Valley 330 kV switching station and Install 1 x 20 MVAr Shunt Reactor at Balranald 220 kV station	$13.4m	$134,000
Option 2	Install 2 x 50 MVAr Shunt Reactors at Capital Wind Farm 330 kV and install 1 x 20 MVAr Shunt Reactor at Balranald 220 kV station	$23.1m	$231,000

In addition, we consider that non-network solutions may be able to form credible options for this RIT-T. Section 0 provides details on the technical characteristics that non-network options would need to address the identified need of this RIT-T.

None of the credible options listed above are expected to have a material inter-regional impact.

3.1. Base case

Consistent with the RIT-T requirements, the assessment undertaken in this PSCR compares the costs and benefits of each option to a base case 'do nothing' option. The base case is the (hypothetical) projected case if no action is taken, ie:[17]

> "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'. 'BAU activities' are ongoing, economically prudent activities that occur in absence of a credible option being implemented"

Under the base case, i.e. not facilitating network developments to address the need, overvoltage issues at Kangaroo Valley and Balranald are likely to worsen because of decreasing minimum demand. Recent operational experience suggested that the reduction in minimum demand is worse than expected in the

[16] As per clause 5.15.2(a) of the NER.
[17] AER, *Regulatory Investment Test for Transmission Application Guidelines,* October 2023, p.22.

forecasts and can happen during most of the weekends in the shoulder period. This option is not acceptable since there is a risk of non-compliance as per NER voltage control requirements with reduction in demand.

While this is not a situation we plan to encounter, and this RIT-T has been initiated specifically to avoid it, the assessment is required to use this base case as a common point of reference when estimating the net benefits of each credible option.

3.2. Option 1 – Install one 50 MVAr shunt reactor at Kangaroo Valley and one 20 MVAr shunt reactor at Balranald

The table below presents the scope of works required for the installation of one 50 MVAr Shunt Reactor at Kangaroo Valley 330 kV Switching Station and one 20 MVAr shunt reactor at Balranald 220 kV station

Table 3-2 Option 1 scope of works

Kangaroo Valley	Balranald
• Construct a new 330 kV reactor foundation to the East of Bay 1G • Remove and relocate existing drainage pipes • Establish a new oil containment/separation facility to the West of Bay 1G • Construct a hard stand area South of the reactor foundation to enable skating of the reactor • Modifications to the existing roadways in the South-East corner of the switchyard • Establish a new 330 kV gantry to the North of the reactor foundation • Installation of a new 330 kV reactor switchbay and associated conduits including: > 1 x 330 kV disconnector with associated earth switch > 1 x 330 kV circuit breaker with point on wave functionality > 1 x 330 kV current transformers • Earthing of all structures • Construct 3 firewalls 8m high on the North, East and West side of the foundation • Installation of one (1) x 362 kV 50 MVAr shunt reactor and associated bushings, pipework and surge arrestors • Install underslung 330 kV insulators to the North of the enclosure • Installation of the Southern firewall (8m high)	• Construction of a new 220kV reactor foundation (Refer to concept GA in Appendix A) to connect to the X5 line switchbay. This requires: > Establishment of new oil containment/separation facilities and associated pipework for the new reactor bund • Installation of a new 220kV Reactor switchbay and associated conduits. The switchbay includes: > 1 x 220kV Disconnector with associated Earth Switch > 1 x 220kV Live Tank Circuit Breaker with POW functionality > 1 x 220kV Surge Arrestors (for 3 phases) > 1 x 220kV bus support post insulators (for 3 phases) > 3 x 220kV post insulators (single phase) • Installation of 220kV 20 MVAr Shunt Reactor and associated bushings and surge arrestors • Installation of a new reactor combined control/protection panels and associated cabling • Modifications to the existing Substation Automation System to include the new reactor and associated switchbay • Relocation of existing No.1 transformer bay low voltage AC/DC box and associated cables to be outside of the new reactor fire zone

Kangaroo Valley	Balranald
• Installation of a new combined control/protection reactor panel and associated cabling. • Modifications to the existing substation automation system to include the new reactor.	

The scope of works is expected to be carried out between 2024/25 and 2027/28 with commissioning occurring in 2028/29. All works would be completed in accordance with the relevant standards with minimal modification to the wider transmission assets.

The estimated capital expenditure associated with this option is $13.4 million, which is comprised of:

- $1.6 million in labour costs;
- $6.4 million materials costs; and
- $5.4 million in expenses (which includes expenses in relation to contractors, design consultants etc).

The table below shows the expected expenditure profile of this option.

Table 3-3 Annual breakdown of Option 1's expected capital cost ($m, 2024/25)

	2024/25	2025/26	2026/27	2027/28
Capital expenditure	0.4	1	11	1

Routine operating and maintenance cost are estimated at approximately $134,000/annum.

We estimate that it will take 37 months from this RIT-T commencement to complete Option 1 with commissioning possible in 2027/28

3.3. Option 2 Install two 50 MVAr shunt reactors at Capital Wind Farm and one 20 MVAr shunt reactor at Balranald

The Table below presents the scope of works required for the installation of two 50 MVAr Shunt Reactors at Capital Wind Farm and one 20 MVAr shunt reactor at Balranald 220 kV station

Table 3-4 Option 2 scope of works

Capital Wind Farm	Balranald
• Extend the existing switchyard bench by 60m x 95m • Install 215m of perimeter fence to enclose the new bench extension • Remove the Western fence on the existing site	• Construction of a new 220kV reactor foundation (Refer to concept GA in Appendix A) to connect to the X5 line switchbay. This requires: > Establishment of new oil containment/separation facilities and associated pipework for the new reactor bund

Capital Wind Farm	Balranald
• Installation of a new section of earth grid on the new bench area (60m x 95m = 5700m2) • Extend existing roadways by 215m to allow access for low loaders • Construct two (2) new reactor foundations to the West with dimensions 22 x 12m and 600mm bundwalls on 3 sides • Construct firewalls (12m long x 6m high) on each foundation on the side away from the roadways • Establish a new oil containment system and associated pipes from the reactor bunds • Establish two 330 kV gantries to the West of the Substation and 30m strung bus • Extend the existing 330 kV 'A' Bus to connect, using droppers (approx. 15m), to the new Bus Section 'A' • Establish two 330 kV gantries to the West of the Substation and 30m strung bus • Extend the existing 330 kV 'B' Bus to connect, using droppers (approx. 15m), to the new Bus Section 'B' • Remove existing buswork from Bay 1G to Bay 1B, and install the following equipment in its place: > 2 x 330 kV Disconnectors with associated Earth Switches > 1 x 330 kV live tank circuit breaker > 1 x 330 kV current transformer • All associated conduits • Construct two sections of low busbar (approx. 35m each) and connect via droppers to strung bus above • Installation of two (2) new 330 kV reactor switchbay and associated trenches and conduits including: > 2 x 330 kV disconnector with associated Earth Switch (one set switchbay) > 2 x 330 kV circuit breaker with POW functionality (one set switchbay) > 2 x 330 kV current transformer (one set switchbay) > 2 x 330 kV surge arrestors (one set per switchbay)	• Installation of a new 220kV Reactor switchbay and associated conduits. The switchbay includes: > 1 x 220kV Disconnector with associated Earth Switch > 1 x 220kV Live Tank Circuit Breaker with POW functionality > 1 x 220kV Surge Arrestors (for 3 phases) > 1 x 220kV bus support post insulators (for 3 phases) > 3 x 220kV post insulators (single phase) • Installation of 220kV 20 MVAr Shunt Reactor and associated bushings and surge arrestors • Installation of a new reactor combined control/protection panels and associated cabling • Modifications to the existing Substation Automation System to include the new reactor and associated switchbay • Relocation of existing No.1 transformer bay LV AC/DC box and associated cables to be outside of the new reactor fire zone

Capital Wind Farm	Balranald
• Earthing of all structures • Installation of two (2) x 362 kV 50 MVAr shunt reactor and associated bushings, pipework and surge arrestors • Installation of a third firewall (12m long x 6m high) on the foundation adjacent to the existing roadway • Installation of two (2) new combined control/protection reactor panel and associated cabling • Modifications to the existing substation automation system to include the new reactors.	

The scope of works is expected to be carried out between 2024/25 and 2027/28 with commissioning occurring in 2028/29. All works would be completed in accordance with the relevant standards with minimal modification to the wider transmission assets.

The estimated capital expenditure associated with this option is $23.1 million, which is comprised of:

- $2.8 million in labour costs;
- $11.8 million materials costs; and
- $8.5 million in expenses (which includes expenses in relation to contractors, design consultants etc).

The table below shows the expected expenditure profile of this option.

Table 3-5 Annual breakdown of Option 2's expected capital cost, ($m, 2024/25)

	2024/25	2025/26	2026/27	2027/28
Capital expenditure	0.7	1.5	14.3	6.6

Routine operating and maintenance cost are estimated at approximately $231,000/annum.

We estimate that it will take 42 months from this RIT-T commencement to complete Option 1 with commissioning possible in 2027/28.

3.4. Options considered but not progressed

We considered three other options that were not progressed as they were considered not technically or economically feasible. These options are outlined in the table below.

Table 3-6 Options considered but not progressed

Option	Reason for not progressing
Option C Replace Kangaroo Valley No. 3 and No.4 generator transformers and Bendeela No. 1 generator transformer	The cost to replace 3 generator transformers will be more than 50% higher than the cost of Option A.1 or B, and so is not considered commercially viable.
Option D 11 kV supply from Kangaroo Valley town	11 kV supply from Kangaroo Valley town will allow disconnecting Kangaroo Valley substation from 330 kV transmission network in the event of over-voltages following a transmission line trip (i.e. open line 3W from Capital to Kangaroo Valley in the event of a trip of Kangaroo Valley – Dapto Line 18 resulting in over-voltages at Kangaroo Valley substation). However, the high voltage issue at Kangaroo Valley is expected to exist under system normal conditions from 2024. Hence, an additional 11 kV line from Kangaroo Valley town to supply auxiliaries during transmission outages would not resolve the issue, and so is not technically feasible.
Option E Install shunt reactors at Wagga Wagga substation	The installation of shunt reactors at Wagga Wagga instead of Balranald will require a larger size of reactors due to the added distance from the local area experiencing the voltage issues. This will incur a higher cost than Option A.2, and thus is not considered commercially viable.
Switching out lines at times of voltage control issues	Voltage control issues are expected to happen more regularly. Using this option will cause system security issues and maintenance requirements in the long term. This option will cause an additional burden for the control room and pose an additional risk to loads and generating stations. This option will also cause additional generator constraints. This option is only acceptable as a short-term operational emergency measure.

In addition, we considered all other voltage control and NSCAS related projects included in the portfolio to optimise the scope, including the project N2393: Maintain Voltage in South Western Subsystem, however, found that there is no opportunity to further optimise. This is due to the local nature of the voltage issues identified to be addressed in this need.

3.5. No material inter-network impact is expected

We have considered whether the option outlined above is expected to have material inter-regional impact.[18] 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:[19]

[18] As per clause 5.16.4(b)(6)(ii) of the NER.
[19] Inter-Regional Planning Committee. *"Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations."* Melbourne: Australian Energy Market Operator, 2004. Appendix 2 and 3. Accessed 14 May 2020. https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf

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

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

4. Non-network options

This Section describes the technical characteristics that a non-network option would need to address the identified need. At this stage we consider that possible solutions could include but are not limited to:

- battery energy storage systems (BESS); and
- generators in the region that provide reactive power support.

However, we note that the cost of the network options may act to effectively bound the cost available for any non-network options to be considered commercially feasible. We are interested in hearing from proponents on their individual solutions and costs.

The following table outlines the size, location, and nature of the required non-network options, determined based on the power system studies carried out by Transgrid for a period of 10 years. Further, the size of the reactive power requirement has been estimated for the worst-case scenario which is the day time minimum demand forecast for the critical contingency when nearby generation is out of service or not providing sufficient reactive support.

Table 4-1 Summary of the technical characteristics

From Financial Year	Size - (absorbing)	Location	Time of the day
2028	Up to 50 MVAr	Kangaroo Valley 330 kV	Day and night time
2028	Up to 20 MVAr	Balranald 220 kV	Day and night time

We encourage parties to make written submissions regarding the potential of non-network options to satisfy, or contribute to satisfying, the identified need for this RIT-T.

5. Materiality of market benefits

This Section outlines the categories of market benefits prescribed in the National Electricity Rules (NER) and whether they are considered material for this RIT-T.[20]

5.1. Wholesale electricity market benefits are not material

The AER has recognised that if the credible options considered will not have an impact on the wholesale electricity market, then a number of classes of market benefits will not be material in the RIT-T assessment, and so do not need to be estimated.[21]

The credible option considered in this RIT-T will not address network constraints between competing generating centres and is therefore not expected to result in any change in dispatch outcomes and wholesale market prices. We therefore consider 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; and
- competition benefits.

5.2. No other classes of market benefits are considered material

In addition to the classes of market benefits discussed above, NER clause 5.15A.2(b)(4) requires that we consider the following classes of market benefits arising from each credible option. We consider that none of the classes of market benefits listed will be material for this RIT-T assessment for the reasons in Table 5-1.

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

Market benefits	Reason
Changes in involuntary load curtailment	Load and transmission capacity will not change so there is no expected impact on unserved energy.
Difference in the timing of unrelated expenditure	The investment will not affect investment in other parts of the network.
Option value	We note the AER's view is 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.[22] Neither option is flexible enough to respond to changes or uncertainty for this RIT-T.

[20] As per NER clause 5.15A.2(b)(4) See Appendix A for requirements applicable to this document.
[21] Australian Energy Regulator, *Regulatory investment test for transmission Application guidelines*, October 2023, Melbourne: Australian Energy Regulator. https://www.aer.gov.au/system/files/2023-10/AER%20-%20RIT-T%20guidelines%20-%20final%20amendments%20%28clean%29%20-%206%20October%202023_0.pdf
[22] AER, *Regulatory Investment Test for Transmission – Application Guidelines*, October 2023, p. 57.

Market benefits	Reason
Changes in Australian greenhouse gas emissions	Neither option in this RIT-T is expected to affect the dispatch of generation in the wholesale market. No other material source of a change in Australian emissions has been identified. Accordingly, this benefit and has not been estimated.

6. Overview of the assessment approach

This Section outlines the approach that we are proposing to apply in assessing the net benefits associated with the credible options.

6.1. Assessment period and discount rate

A 20-year assessment period from 2024/25 to 2043/44 has been adopted for this RIT-T analysis. This period takes into account the size, complexity and expected asset life of each option.

Where the capital components have asset lives extending beyond the end of the assessment period, the NPV modelling includes a residual value to capture the remaining functional asset life. This ensures that the capital cost of the long-lived assets over the assessment period is appropriately captured, and that costs and benefits are assessed over a consistent period, irrespective of option type, technology or serviceable asset life. The terminal values are calculated as the undepreciated value of capital costs at the end of the analysis period.

A real, pre-tax discount rate of 7.00 per cent has been adopted as the central assumption for the NPV analysis, consistent with AEMO's latest Input Assumptions and Scenarios Report (IASR).[23] The RIT-T requires that sensitivity testing be conducted on the discount rate and that the regulated weighted average cost of capital (WACC) be used as the lower bound. We have therefore tested the sensitivity of the results to a lower bound discount rate of 3.63 per cent.[24] We have also adopted an upper bound discount rate of 10.5 per cent (i.e., the upper bound in the latest IASR).[25]

6.2. Approach to estimating option costs

We have estimated the capital costs based on the scope of works necessary together with costing experience from previous projects of a similar nature.

All costs estimated by Transgrid's project development team use the estimating tool 'MTWO'. The MTWO cost estimating database reflects actual outturn costs built up over more than 10 years from:

- period order agreement rates and market pricing for plant and materials;
- labour quantities from recently completed project; and
- construction tender and contract rates from recent projects.

The MTWO estimating database is reviewed annually to reflect the latest outturn costs and confirm that estimates are within their stated accuracy range and represent the most likely expected cost of delivery (P50 costs[26]). As part of the annual review, Transgrid benchmarks the outcomes against independent estimates provided by various engineering consultancies.[27]

Transgrid does not generally apply the Association for the Advancement of Cost Engineering (AACE) international cost estimate classification system to classify cost estimates. Doing so for this RIT-T would

[23] AEMO, *2023 Inputs, Assumptions and Scenarios Report*, Final report, July 2023, p 123.
[24] This is equal to WACC (pre-tax, real) in the latest final decision for a transmission business in the NEM (TasNetworks) as of the date of this analysis, see: https://www.aer.gov.au/industry/registers/determinations/tasnetworks-determination-2024-29/final-decision.
[25] AEMO, *2023 Inputs, Assumptions and Scenarios Report*, Final report, July 2023, p 123.
[26] I.e., there is an equal likelihood of over- or under-spending the estimate total.
[27] For further detail on our cost estimating approach refer to Section 7 of our Augmentation Expenditure Overview Paper submitted with our 2023-28 Revenue Proposal.

involve significant additional costs, which would not provide a corresponding increase in benefits compared with the use of MWTO estimates and so this has not been undertaken.

We estimate that actual costs will be within +/- 25 per cent of the central capital cost estimate. While we have not explicitly applied the AACE cost estimate classification system, we note that an accuracy of +/- 25 per cent for cost estimates is consistent with industry best practice and aligns with the accuracy range of a 'Class 4' estimate, as defined in the AACE classification system.

No specific contingency allowance has been included in the cost estimates.

Work is planned within existing Transgrid substations. No specific allowance for additional access has been allowed as part of the estimate. Where civil works is anticipated, normal soil conditions have been assumed.

All cost estimates are prepared in real 2024/25 dollars based on the information and pricing history available at the time that they were estimated. The cost estimates do not include or forecast any real cost escalation for materials.

6.3. The option has been assessed against three scenarios

The RIT-T is focused on identifying the top ranked credible option in terms of expected net economic benefits. However, uncertainty exists in terms of estimating future inputs and variables (termed future 'states of the world').

TO deal with this uncertainty, the NER requires that costs and market benefits for each credible option are estimated under reasonable scenarios and then weighted on the likelihood of each scenario to determine a weighted ('expected') net economic benefit. It is this expected net benefit that is used to rank the credible options and identify the preferred option.

The credible options have been assessed under three scenarios as part of this PSCR assessment. These scenarios differ in terms of the key drivers of the estimated net benefit (i.e. estimated capital cost) and are summarised in Table 6-1 below. Given that wholesale market benefits are not relevant for this RIT-T, the three scenarios implicitly assume the most likely scenario from the 2024 ISP (i.e. the 'Step Change' scenario).

Table 6-1 Scenario summary

Variable	Central scenario	Low capital costs	High capital costs
Discount rate	Base estimate	Base estimate	Base estimate
Network capital costs	Base estimate	Base Estimate – 25%	Base Estimate + 25%
Operating expenditure	Base estimate	Base estimate	Base estimate

6.4. Sensitivity analysis

We have also considered the robustness of the outcome of this RIT-T's cost benefit analysis sensitivity testing.

The range of factors tested as part of the sensitivity analysis in this PSCR are:

- lower and higher assumed capital costs;

- alternate commercial discount rate assumptions.

The above list of sensitivities focuses on the key variables that could impact the identified preferred option. The results of the sensitivity tests are set out in Section 7.4.

7. Assessment of the credible option

This Section outlines the assessment of each credible option compared to the base case.

7.1. Estimated gross cost

The table below summarises the present value of the gross cost estimates for Options 1 and 2 relative to the base case.

Table 7-1 Estimated gross costs for each credible option relative to the base case ($m, PV)

Option/scenario	Central scenario	Low capital costs	High capital costs	Weighted
Option 1	11.68	8.76	14.60	11.68
Option 2	19.80	14.85	24.75	19.80

7.2. Estimated net economic benefits

The net economic benefits are the differences between the estimated gross benefits and the estimated costs. The table below summarises the present value of the net economic benefits for the credible option across the three scenarios. Net economic benefits are negative for both Option 1 and 2 as neither provide benefits.

Table 7-2 Net economic benefits for Option 1 relative to the base case ($m, PV)

Option/scenario	Central scenario	Low capital costs	High capital costs	Weighted
Option 1	-11.68	-8.76	-14.60	-11.68
Option 2	-19.80	-14.85	-24.75	-19.80

Option 1 is found to deliver net economic benefits of -$11.68 million on a weighted basis in present value terms. This is larger than Option 2, which delivers net economic benefits of -$19.80 million on a weighted basis in present value terms. As such, Option 1 has therefore been identified as the preferred option.

7.3. Optimal timing

Option 1 (install a new shunt reactor at Kangaroo Valley and Balranald stations) – is the preferred option to meet the identified need and improve voltage control in southern NSW. While Option 1 does not provide positive net market benefits under the weighted scenario, this outcome is permitted given that this RIT-T is a reliability corrective action.

However, Option 1 has no optimal commissioning year as it only ever provides costs without any market benefits. Yet leaving voltage control issues to deteriorate further in Southern NSW is also not viable. Transgrid is required by the National Electricity Rules (NER) clause S5.1.4 to plan and design the transmission network to control voltage within defined voltage limits as per clause S5.1a.4. In addition, clause 4.2.6 of the NER requires Transgrid to operate the transmission network in a secure operating state, which

requires voltages to be maintained within acceptable range during normal operation and following any credible contingency event[28].

The optimal commissioning year within this PSCR has therefore been identified through consideration of how to best meet Transgrid's voltage obligations within the NER. Given that voltage control issues already exist and will deteriorate further in the future without remediation, it is optimal for Option 1 to be commissioned as early as possible. With works for Option 1 being undertaken between 2024/25 and 2027/28, this commissioning year is 2028/29.

7.4. Sensitivity testing

We have undertaken sensitivity testing to understand the robustness of the RIT-T assessment to underlying assumptions about key variables. Specifically, we have investigated the flowing sensitivities:

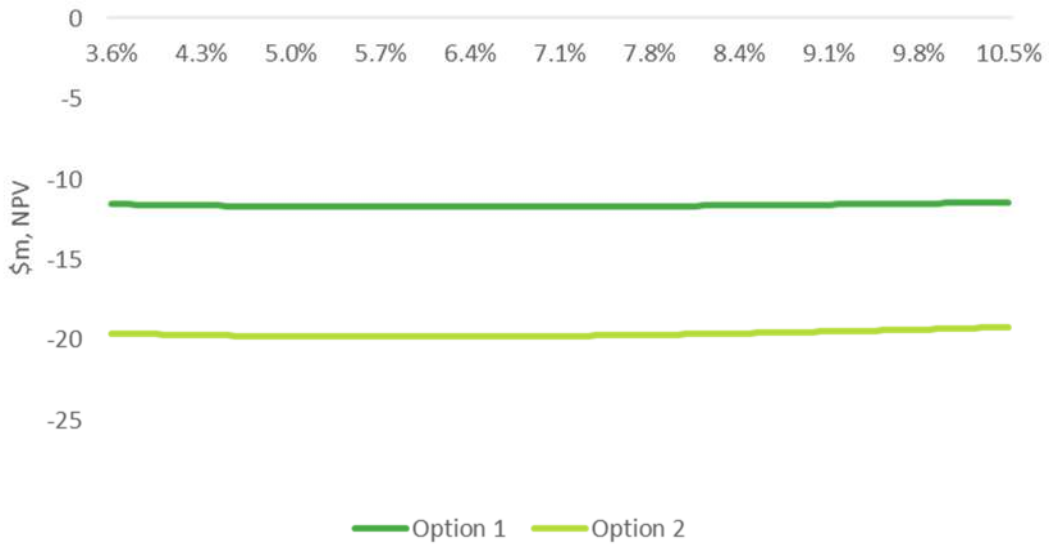
- A 25 per cent increase/decrease in the assumed network capital costs
- A lower discount rate of 3.63 per cent as well as a higher rate of 10.50 per cent.

Results of this sensitivity testing is presented below. As can be seen in the figures presented below, net benefit outcomes are robust to reasonable changes in network capital costs and discount rates.

Figure 7-1 Capital cost sensitivity outcomes ($m, 2024/25)

[28] These requirements are set out in Clauses 4.2.6, 4.2.4 and 4.2.2(b) of the NER. The requirement for secure operation of the power system in Clause 4.2.4 requires the power system to be in a satisfactory operating state following any credible contingency event, that is, to maintain voltage within 10 per cent of normal voltage following the first credible contingency event.

Figure 7-2 Commercial discount rate sensitivity ($m, 2024/25)



We also performed boundary testing to identify the extent to which key variables would need to change for the preferred option (Option 1) to no longer be the preferred option. The following was found:

- No reasonable change in capital costs would result in Option 1 no longer being the preferred Option; and
- No reasonable discount rate costs would result in Option 1 no longer being the preferred Option.

8. Draft conclusion and exemption from producing a PADR

This PSCR has found that Option 1 is the preferred option for this RIT-T. Option 1 involves installing a new shunt reactor at Kangaroo Valley and Balranald stations. The estimated capital expenditure associated with Option 1 is $11.68 million (in 2024/25 dollars).

The works will be undertaken between 2024/25 and 2027/28. Planning, design, development and procurement (including the completion of the RIT-T) will occur between 2024/25 and 2025/26, while project delivery and construction will occur in 2026/27. All works are expected to be completed by 2027/28, with final commissioning of the solution expected in 2027/28 to best meet the need of improving voltage control.

Option 1 is the preferred option in accordance with NER clause 5.15A.2(b)(12) 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. The analysis undertaken and the identification of Option 1 as the preferred option satisfies the RIT-T.

Transgrid considers this conclusion to be robust to changes in capital costs and discount rates as there would need to be unrealistic changes to these key assumptions for the option preference to change (as shown via the sensitivity and boundary testing at the end of Section 7.4). Transgrid will however continue to monitor these key assumptions and will notify the AER if such changes do occur (or appear likely), which would constitute a material change in circumstance.

Appendix A Compliance checklist

This appendix sets out a checklist which demonstrates the compliance of this PACR with the requirements of the National Electricity Rules version 217.

Rules clause	Summary of requirements	Relevant section
5.16.4 (b)	A RIT-T proponent must prepare a report (the project specification consultation report), which must include:	–
	(1) a description of the identified need;	2
	(2) the assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, why the RIT-T proponent considers reliability corrective action is necessary);	2
	(3) the technical characteristics of the identified need that a non-network option would be required to deliver, such as: (i) the size of load reduction of additional supply; (ii) location; and (iii) operating profile;	4
	(4) if applicable, reference to any discussion on the description of the identified need or the credible options in respect of that identified need in the most recent National Transmission Network Development Plan;	NA
	(5) a description of all credible options of which the RIT-T proponent is aware that address the identified need, which may include, without limitation, alterative transmission options, interconnectors, generation, demand side management, market network services or other network options;	3
	(6) for each credible option identified in accordance with subparagraph (5), information about: (i) the technical characteristics of the credible option; (ii) whether the credible option is reasonably likely to have a material inter-network impact; (iii) the classes of market benefits that the RIT-T proponent considers are likely not to be material in accordance with clause 5.15A.2(c)(6), together with reasons of why the RIT-T proponent considers that these classes of market benefit are not likely to be material; (iv) the estimated construction timetable and commissioning date; and (v) to the extent practicable, the total indicative capital and operating and maintenance costs.	3 & 5

5.16.4(z1)	A RIT-T proponent is exempt from [preparing a PADR] (paragraphs (j) to (s)) if: 1. the estimated capital cost of the proposed preferred option is less than $35 million[29] (as varied in accordance with a cost threshold determination); 2. the relevant Network Service Provider has identified in its project specification consultation report: (i) its proposed preferred option; (ii) its reasons for the proposed preferred option; and (iii) that its RIT-T project has the benefit of this exemption; 3. the RIT-T proponent considers, in accordance with clause 5.16.1(c)(6), that the proposed preferred option and any other credible option in respect of the identified need will not have a material market benefit for the classes of market benefit specified in clause 5.16.1(c)(4) except those classes specified in clauses 5.16.1(c)(4)(ii) and (iii), and has stated this in its project specification consultation report; and 4. the RIT-T proponent forms the view that no submissions were received on the project specification consultation report which identified additional credible options that could deliver a material market benefit.	8

[29] Varied to $54m based on the AER Final Determination: Cost threshold review November 2024.