Voltage Control in North West Victoria

Project Assessment Conclusions Report

Regulatory Investment Test - Transmission

October 2022

mission zero

AusNet services

Important notice

Purpose

AusNet Services has prepared this document to provide information about potential limitations in the Victoria transmission network and options that could address these limitations.

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Executive summary

AusNet Services undertook this Regulatory Investment Test for Transmission (RIT-T) to evaluate options to maintain reliable transmission network services at Horsham Terminal Station (HOTS).

The Project Specification Consultation Report (PSCR), which represents the first step in the RIT-T process was published in June 2020 and the succeeding Project Assessment Draft Report (PADR) was published in April 2021. Publication of this Project Assessment Conclusions Report (PACR) represents the third and final step in the RIT-T process in accordance with clause 5.16 of the National Electricity Rules (NER) and section 4.2 of the RIT-T Application Guidelines.

The Static Var Compensator (SVC) at HOTS is owned and operated by AusNet Services. It was commissioned in 1986 to provide dynamic voltage and reactive power control services in North West Victoria. The SVC is reaching the end of its service life and the RIT-T analysis shows that it is no longer economical to continue to provide transmission network services with the existing dynamic voltage and reactive power control assets at HOTS as the asset failure risk has increased to a level where investment to replace the selected assets presents a more economical option.

The preferred option to address the asset failure risk at HOTS is to replace the existing SVC with a modern SVC or flexible alternating current transmission system (FACTS) such as a STATCOM of similar size as the HOTS SVC by 2024/25 at an estimated cost of $41.8 million. Alternative technologies or solutions that deliver a similar service at the same or lower cost and that meet the RIT-T identified need will also be considered by AusNet if they become available prior to this project becoming a committed project at the time of approval of the project business case.

Identified need

The SVC at HOTS has been providing dynamic voltage and reactive power control services for about 36 years and is reaching the end of its service life. AusNet Services will not be able to meet its obligation to provide voltage and reactive power control services as outlined in the Network Agreement between AEMO and AusNet Services should the HOTS SVC fail. It would also reduce the ability to maintain voltages in North West Victoria within the limits specified under clauses S5.1a.4 and S5.1a.5 of the NER (see extract in section 2.4.1) and clauses 110.2.2(a) and 110.2.3(a)[1] of the Victorian Electricity System Code. Emergency asset replacement will also be required to minimise major impacts to the power system and the wholesale electricity market following a failure of the HOTS SVC.

Therefore, the 'identified need' this RIT-T intends to address is to continue to provide voltage and reactive power control services at HOTS such that voltages in the North West transmission network can be maintained within the limits specified in the NER and Victorian Electricity System Code; and mitigate risk of increased costs associated with emergency asset replacement.

The present value of the baseline risk cost to maintain the HOTS SVC in service is more than $75 million. The biggest components of the baseline risk are the market impact (generation and electricity consumers) and reactive asset replacement cost of a failure of the HOTS SVC. AusNet Services must ensure continued compliance with the NER and Victorian Electricity System Code and identified the need for investment as part of its obligation for '*reliability corrective action*'[2]. AusNet Services is therefore proposing investment in asset replacement options that will allow

[1] "A transmitter must use best endeavours to maintain the normal voltage level at each point of supply with a nominal voltage at or above 100 kV within a range of plus or minus 10% of the voltage level nominated by VENCorp from time to time to the relevant transmitter and the relevant Participants which are supplied at that point of supply." Office of the Regulator-General, Victoria, '*Electricity System Code*'.

[2] 'NER 5.10.2 defines reliability corrective action as a network business' investment in its network to meet 'the service standards linked to the technical requirements of schedule 5.1 or in applicable regulatory instruments and which may consist of network options or non-network options'.' - Australian Energy Regulator, *"Application guidelines Regulatory investment test for transmission"*.

continued delivery of safe and reliable transmission network services.

Credible options

AusNet Services identified several investments that may deliver more economical and reliable solutions to address the identified need, compared with the base case (business as usual) where the existing assets are kept in service and emergency asset replacement is required when the SVC fails. The credible network options considered in this RIT-T are:

- Option 1 – Replacement with modern SVC or FACTS; and
- Option 2 – Replacement with a synchronous condenser, and
- Option 3 – Notional non-network option

Since the PADR, there have been updates to the capital cost assumptions for the two network options. The cost for Option 1 is estimated at $41.8 million and $56.9 million for Option 2.

Responses to the Project Assessment Draft Report

The non-network proposal for this RIT-T have been made in confidence and AusNet Services is thus not allowed to publish any part of the non-network proposal. Instead a notional non-network option is modelled to assess the economic merits of a non-network option.

Assessment approach

AusNet Services employed the following two-step approach to evaluate the options considered in this RIT-T:

- Power system analysis to evaluate AusNet Services' ability to comply with power system operation regulatory obligations
- Economic modelling to identify the preferred option with due consideration of the asset failure risk cost, which includes impact on the wholesale market, safety, environment, collateral damage and emergency asset replacement.

The economic benefits of the options were assessed against a base case (business as usual) where no proactive capital investment is made, and the existing maintenance regime continues to be implemented.

The analysis includes three Integrated System Plan (ISP) scenarios to explore the range of net economic benefits for each option. Sensitivity analysis that involves variation of failure rate, capital cost, and discount rate assumptions was also used to test the robustness of the investment decision with regards to the selected RIT-T preferred option and economical investment timing.

AusNet Service updated the assumptions used in the economic assessment to align with AEMO's latest Inputs, Assumptions and Scenarios Report (IASR).

RIT-T Conclusion

Option 1 and 2 are both technically feasible in providing the voltage management services needed to comply with the limits specified under clauses S5.1a.4 and S5.1a.5 of the NER and clauses 110.2.2(a) and 110.2.3(a)[3] of the Victorian Electricity System Code. Option 3 is less effective in providing voltage management services.

3 "A transmitter must use best endeavours to maintain the normal voltage level at each point of supply with a nominal voltage at or above 100 kV within a range of plus or minus 10% of the voltage level nominated by VENCorp from time to time to the relevant transmitter and the relevant Participants which are supplied at that point of supply." Office of the Regulator-General, Victoria, '*Electricity System Code*'.

Replacement with a modern SVC or FACTS (Option 1) is the most economic option as it provides the highest present value of net economic benefits for all scenarios and sensitivities investigated as illustrated in Figure 1.

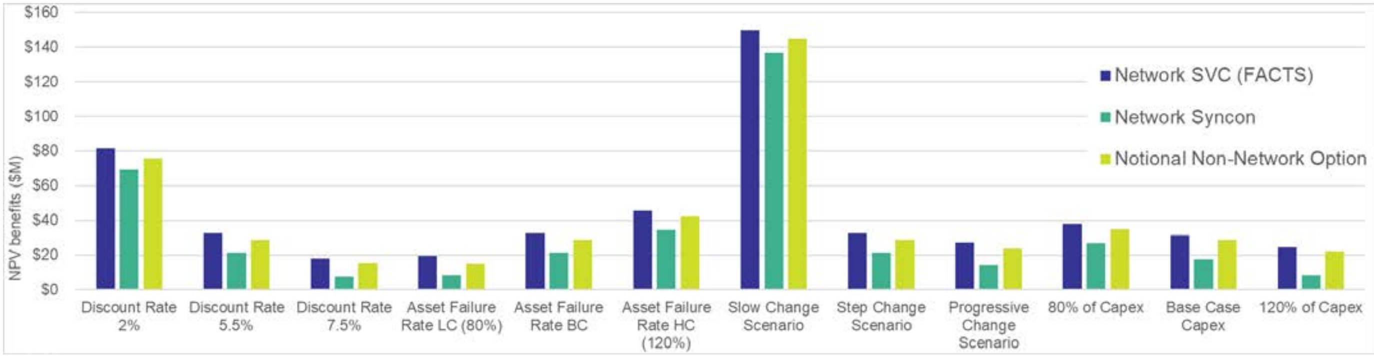

Figure 1 – Preferred option considering different ISP scenarios and sensitivity analysis

Therefore, AusNet Services concludes that Option 1 is the preferred option with an optimal timing of 2025/26.

Next steps

In accordance with clause 5.16B of the NER, within 30 days of the date of publication of this PACR, any party disputing the conclusion made in this PACR should give notice of the dispute in writing setting out the grounds for the dispute (the dispute notice) to the AER. If there are no dispute notices within 30 days of the date of publication of this PACR, AusNet Services expects to implement the preferred option.

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Tables

1. Introduction

AusNet Services initiated this RIT-T to evaluate options to provide voltage and reactive power control in North West Victoria as the SVC at HOTS is reaching the end of its service life and is no longer an economic option to deliver voltage and reactive power control services.

The Project Specification Consultation Report (PSCR), which represents the first step in the RIT-T process was published in June 2020 and the succeeding Project Assessment Draft Report (PADR) was published in April 2021. Publication of this Project Assessment Conclusions Report (PACR) represents the third and final step in the RIT-T process in accordance with clause 5.16 of the National Electricity Rules (NER) and section 4.2 of the RIT-T Application Guidelines.

The SVC at HOTS is owned and operated by AusNet Services. It was commissioned in 1986 to provide dynamic voltage and reactive power control services in North West Victoria. The SVC is reaching the end of its serviceable-life and the RIT-T analysis shows that it is no longer economical to continue to provide transmission network services with the existing dynamic voltage and reactive power control assets at HOTS, as the asset failure risk has increased to a level where investment to replace the selected assets present a more economical option.

2. Identified need

The SVC at HOTS plays an important role to control voltages in the North West Victoria 220 kV transmission network. This section of the PACR describes the condition of the SVC, quantify the risk costs of an asset failure and establish the need for investment in the transmission network.

2.1. Network configuration

North West Victoria transmission network

Horsham is in the Wimmera region of Victoria, situated approximately 300 km from Melbourne near the Grampians National Park. HOTS is located four kilometres east of Horsham. HOTS is connected to a 220 kV single-circuit transmission loop which supplies terminal stations at Ballarat (BATS), Bendigo (BETS), Kerang (KGTS), Wemen (WETS) and Red Cliffs (RCTS) as shown in Figure 2. The North West Victoria 220 kV transmission loop also provides connections to several renewable generators including Waubra, Ararat, Crowlands, Bulgana and Murra Warra Wind Farms and Kiamal Solar Farm.

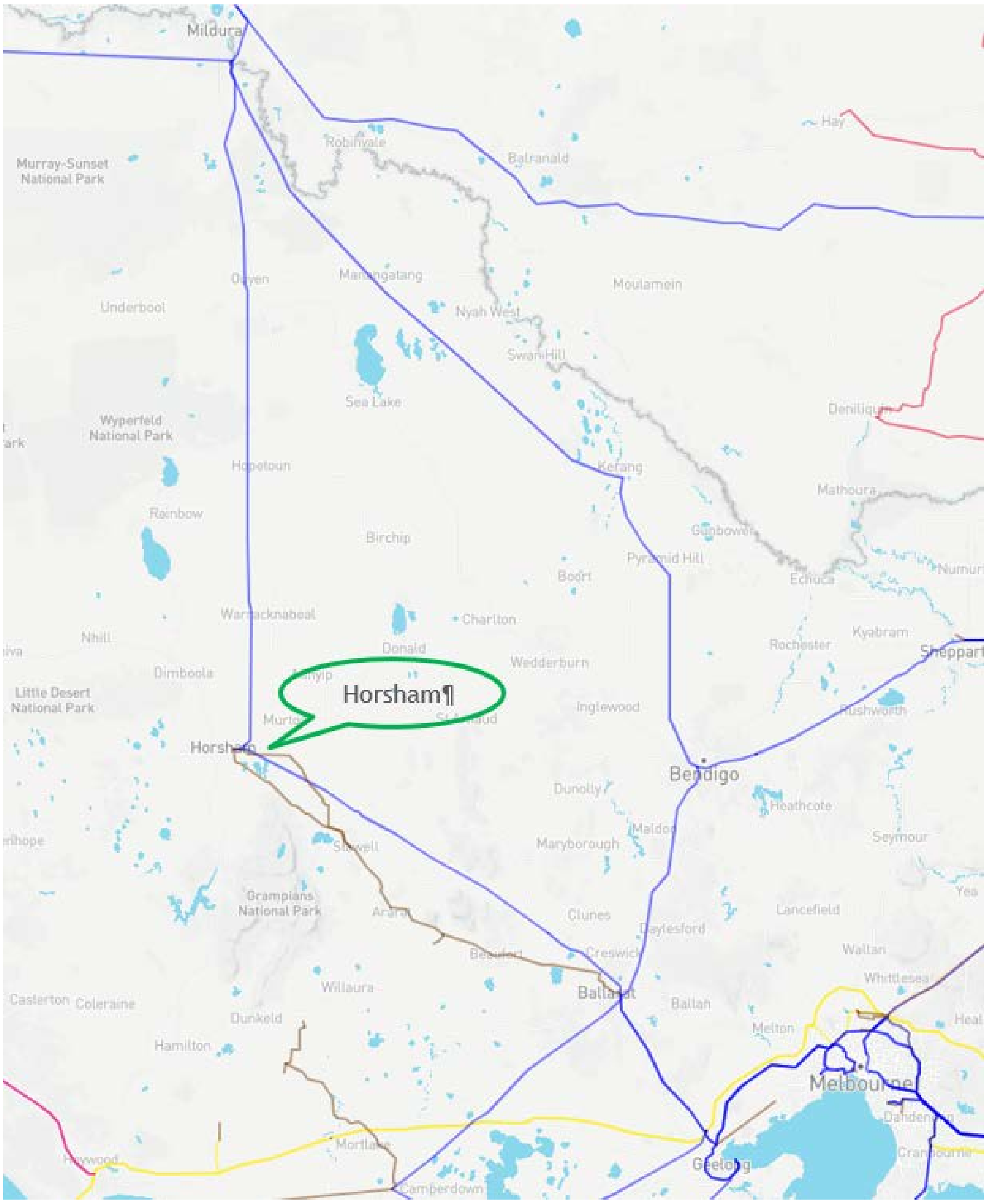

Figure 2 – North West Victoria transmission network

Horsham Terminal Station

HOTS supplies Powercor's 66 kV network via two 220/66 kV transformers. Voltage and reactive power control at HOTS are provided by the following assets at HOTS:

- +50 MVAr to -25 MVAr 220 kV Static Var Compensator (SVC);
- Two 15 MVAr 66 kV shunt reactors; and
- Three 15 MVAr 66 kV shunt capacitors.

The shunt capacitors and reactors provide switchable reactive power control and the SVC provides dynamic voltage control with a connection to the 220 kV busbar at HOTS. Switching of the shunt reactors and capacitors is managed so that the SVC have sufficient dynamic reactive reserves available to respond to network disturbances and contingency events.

Figure 3 below provides a simplified illustration of the voltage and reactive power control assets at HOTS.

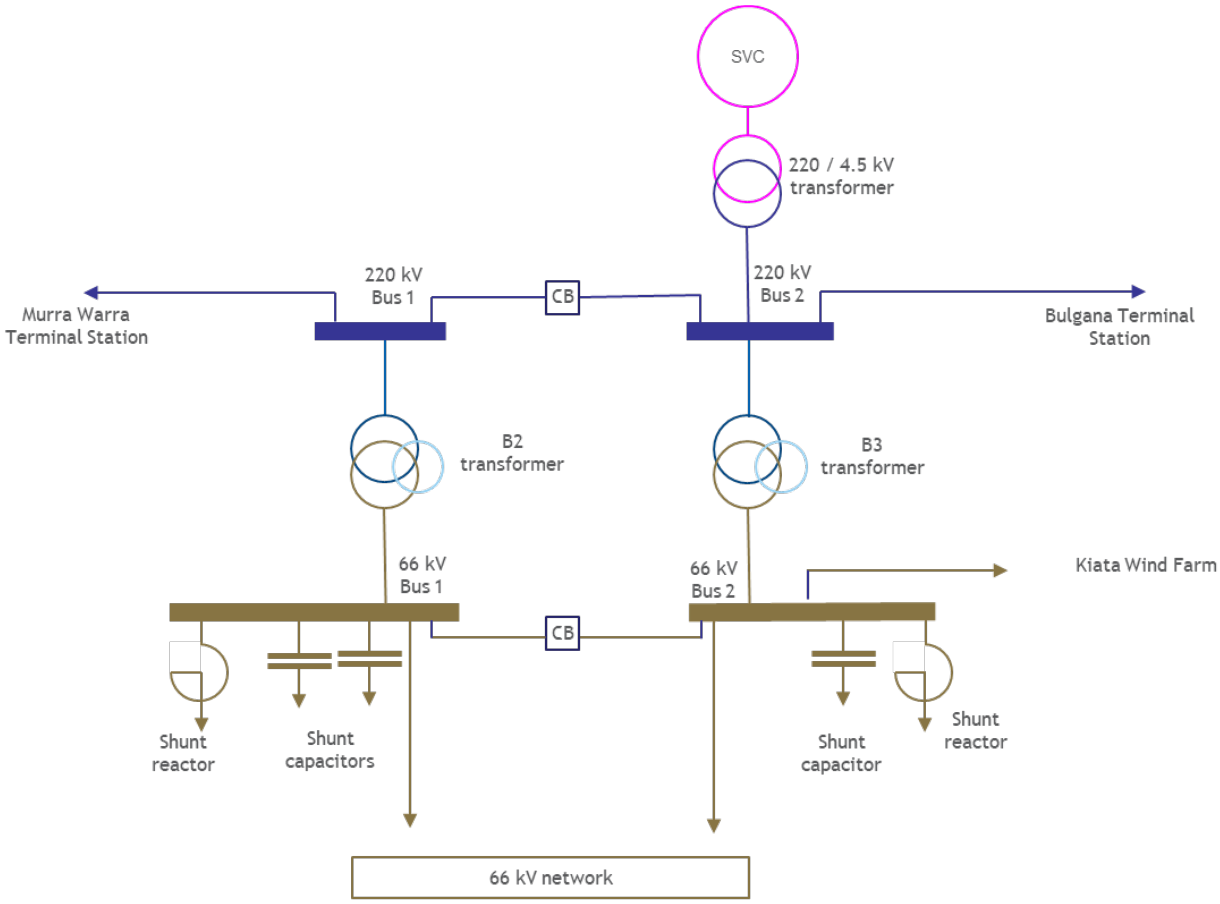

Figure 3 – HOTS single line diagram

2.2. HOTS SVC performance

The SVC and other reactive plants at HOTS have been instrumental in controlling voltages to support demand in North West Victoria. Figure 4 below shows the reactive power generation and consumption of the SVC during calendar year 2020. The reactive power generation and absorption ranges from +23.4 MVAr to -23.8 MVAr during this period.

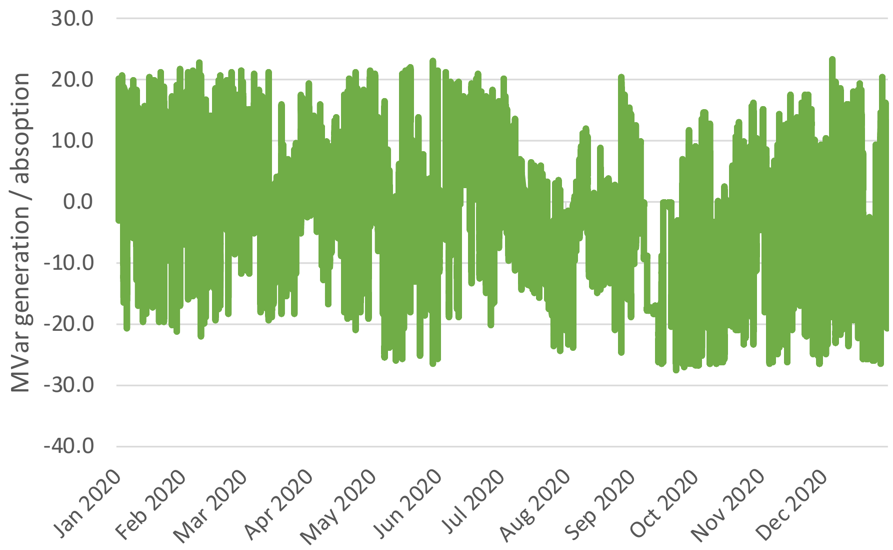

Figure 4 - Typical dynamic reactive power control delivered by the HOTS SVC

AEMO's 2021 Victorian Annual Planning Report (VAPR)[4] includes a network need assessment section that assesses the network need for declared shared network (DSN) assets that are considered for retirement or replacement such as the HOTS SVC. VAPR 2021 concludes that voltages cannot be maintained within prescribed limits and there would be reduced Murraylink export during outage of Western Victoria 220 kV lines should the HOTS SVC be retired without another solution for dynamic voltage control being implemented.[5] AEMO also flags the potential for restrictions on local generation should the HOTS SVC be retired without another proper solution being implemented.

2.3. Asset condition

In 2019, there have been two unplanned outages of the SVC with durations of 55 and 21 hours respectively. The number of forced outages is expected to rise as the SVC components continue to deteriorate with age and continued service.

AusNet Services classifies asset condition using scores that range from C1 (initial service condition) to C5 (extreme deterioration) – as set out in Appendix C of the PSCR.[6]

In September 2019, AusNet Services conducted a comprehensive asset condition assessment of the SVC where all major components were evaluated across a range of criteria including: physical condition; spares availability; estimated rate of deterioration; and manufacturer support.

The assessment found that the SVC has deteriorated and most of the essential SVC components are in poor condition (C4) or very poor condition (C5) as expected of assets that have been in service for an extended period. Furthermore, with manufacturer support no longer available and the scarcity of spare parts the SVC is reaching the end of its serviceable life. No maintenance strategies have been identified that would reduce the failure rates materially or address the lack of manufacturer support.

4 Australian Energy Market Operator, *"Victorian Annual Planning Report"*
5 Australian Energy Market Operator, *"Victorian Annual Planning Report,"* p91
6 AusNet Services, *"Voltage Control in North West Victoria Project Specification Consultation Report Regulatory Investment Test - Transmission"*

2.4. Description of the identified need

Dynamic voltage and reactive control services are an ongoing need as operational demand for electricity in North West Victoria is forecast to continue at or above the current level, and renewable generation continues to grow.

The deteriorating condition of the components of the SVC has increased the likelihood of asset failure with prolonged SVC outages resulting in:

- lack of dynamic reactive support services to respond to network disturbances and contingency events;
- inability to control voltages at HOTS and the surrounding areas in compliance with the NER and Victorian Electricity System Code; and
- risk of increased costs resulting from emergency asset replacements and repairs.

Additionally, since the start of the RIT-T it has been identified that the HOTS SVC is critical to avoid voltage oscillations that could constrain renewable generation should the HOTS SVC not be available for service.

Therefore, the 'identified need' this RIT-T intends to address is to continue to provide voltage and reactive power control services at HOTS such that voltages in the North West transmission network can be maintained within the limits specified in the NER and Victorian Electricity System Code; and mitigate risk of increased costs associated with emergency asset replacement.

AusNet Services must ensure continued compliance with the NER and Victorian Electricity System Code and identified the need for investment as part of its obligation for '*reliability corrective action'*[7] in compliance with clauses S5.1a.4 and S5.1a.5 of the NER and clauses 110.2.2(a) and 110.2.3(a)[8] of the Victorian Electricity System Code.

2.4.1. Assumptions

AusNet Services adopted several assumptions to quantify the risks associated with asset failure. These assumptions are detailed in the following subsections.

Voltage level requirements

Schedule 5.1a of the *National Electricity Rules*[9] (NER) establishes system standards for the safe and reliable operation of the network including limits on changes in voltage levels at connection points during different network conditions. S5.1a.4 of the NER is reproduced below. This requirement is also reflected in Clause 110.2.2(a) of the Victorian Electricity System Code, which requires the same standard for voltage for levels at or above 100 kV.

7 'NER 5.10.2 defines reliability corrective action as a network business' investment in its network to meet 'the service standards linked to the technical requirements of schedule 5.1 or in applicable regulatory instruments and which may consist of network options or non-network options'.' - Australian Energy Regulator, *"Application guidelines Regulatory investment test for transmission"*.
8 "A transmitter must use best endeavours to maintain the normal voltage level at each point of supply with a nominal voltage at or above 100 kV within a range of plus or minus 10% of the voltage level nominated by VENCorp from time to time to the relevant transmitter and the relevant Participants which are supplied at that point of supply." Office of the Regulator-General, Victoria, '*Electricity System Code*'
9 Australian Energy Market Commission, *"National Electricity Rule"*

S5.1a.4 Power frequency voltage

Except as a consequence of a contingency event, the voltage of supply at a connection point should not vary by more than 10 percent above or below its normal voltage, provided that the reactive power flow and the power factor at the connection point is within the corresponding limits set out in the connection agreement. As a consequence of a credible contingency event, the voltage of supply at a connection point should not rise above its normal voltage by more than a given percentage of normal voltage for longer than the corresponding period shown in Figure S5.1a.1 for that percentage. As a consequence of a contingency event, the voltage of supply at a connection point could fall to zero for any period.

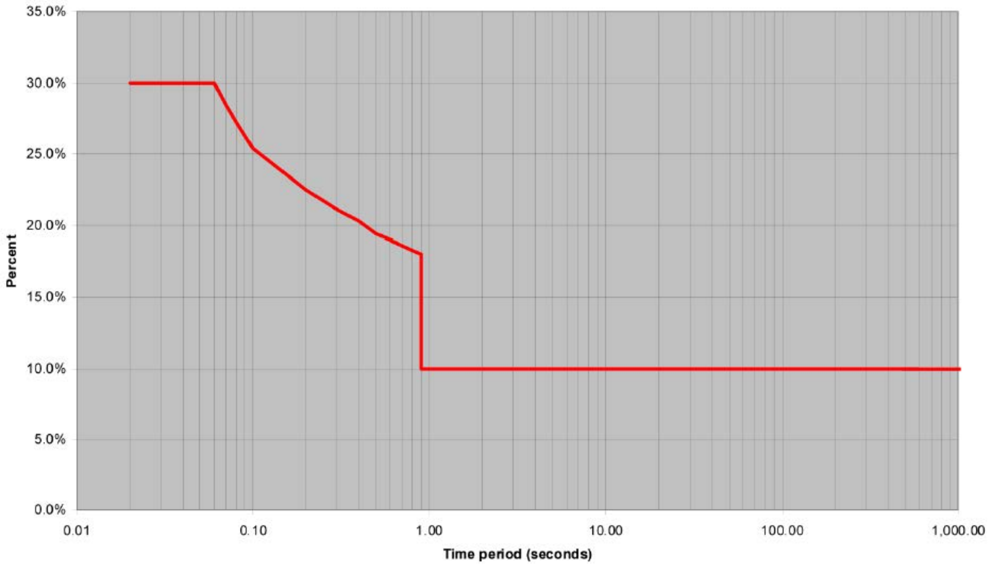

Figure 5 – Figure S5.1a.1 of NER

Market impact costs

AusNet Services calculated the market impact cost, which consist of increased generation cost and expected unserved energy of an asset failure based on the latest Value of Customer Reliability (VCR) and assumptions defied in AEMO's IASR.

Financial risk costs

As there is a lasting need for the services that the HOTS SVC provides, the failure rate weighted cost of replacing failed assets (or undertaking reactive maintenance) is included in the assessment.[10]

Safety risk costs

The Electricity Safety Act 1998[11] requires AusNet Services to design, construct, operate, maintain, and decommission its network to minimize hazards and risks to the safety of any person as far as reasonably practicable or until the costs become disproportionate to the benefits from managing those risks.

[10] The assets are assumed to have survived and their condition-based age increases throughout the analysis period.
[11] Victorian State Government, Victorian Legislation and Parliamentary Documents, *"Energy Safe Act 1998,"* available at http://www.legislation.vic.gov.au/domino/Web_Notes/LDMS/LTObject_Store/ltobjst9.nsf/DDE300B846EED9C7CA257616000A3571/1D9C11F63DEBA5E2CA257E70001687F4/%24FILE/98-25aa071%20authorised.pdf

By implementing this principle for assessing safety risks from explosive asset failures, AusNet Services uses:

- a value of statistical life[12] to estimate the benefits of reducing the risk of death;
- a value of lost time injury[13]; and
- a disproportionality factor[14].

AusNet Services notes this approach, including the use of a disproportionality factor, is consistent with the practice notes[15] provided by the AER.

Environmental risk costs

Environmental risks related to the potential release of transformer oil in the event of asset failure is valued at $30,000 per event.

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[12] Department of the Prime Minister and Cabinet, Australian Government, *"Best Practice Regulation Guidance Note: Value of statistical life,"* available at https://www.pmc.gov.au/resource-centre/regulation/best-practice-regulation-guidance-note-value-statistical-life

[13] Safe Work Australia, "The Cost of Work-related Injury and Illness for Australian Employers, Workers and the Community: 2012-13," available at https://www.safeworkaustralia.gov.au/system/files/documents/1702/cost-of-work-related-injury-and-disease-2012-13.docx.pdf

[14] Health and Safety Executive's submission to the1987 Sizewell B Inquiry suggesting that a factor of up to 3 (i.e. costs three times larger than benefits) would apply for risks to workers; for low risks to members of the public a factor of 2, for high risks a factor of 10. The Sizewell B Inquiry was public inquiry conducted between January 1983 and March 1985 into a proposal to construct a nuclear power station in the UK.

[15] Australian Energy Regulator, *"Industry practice application note for asset replacement planning"*

3. Credible network options

AusNet Services considered both network and non-network options to address the identified need but did not find any suitable non-network solution. The two network options and a notional non-network option are presented below.

3.1. Option 1 – Replace with modern SVC or FACTS

Option 1 involves replacement of all components of the SVC in a single integrated project with a modern SVC or FACTS such as a STATCOM of similar size as the existing SVC. The SVC will require a new transformer to connect to the HOTS 220 kV bus and will be installed in a manner that will minimise the network and market impact during construction with outages limited to the cut-over period.

The estimated capital cost of this option is $41.8 million with operating and maintenance cost estimated at $30 k pa, excluding network losses.

3.2. Option 2 – Replace with a synchronous condenser

Option 2 involves replacing the SVC with a synchronous condenser of similar size than the current SVC. It will replace the current functionality of the SVC and provide additional inertia and system strength benefits.

The estimated capital cost of this option is $56.9 million with operating and maintenance cost estimated at $55 k pa, excluding network losses.

3.3. Option 3 – Notional non-network option

Option 3 assess the economic merits of deferring asset replacement by contracting for dynamic voltage and reactive power control services. It is assumed that the contract will be for about 3 to 4 years and that a more permanent service will then be put in place. Similar capital and operating costs have been assumed as that used for the two network options for the permanent solution.

This option is not considered credible as it does not meet the technical requirements and identified need of the RIT-T and it is thus only used to test whether the network options present economical solutions compared with a notional non-network option.

3.4. Options considered but not progressed

The following options have been assessed but ether do not meet the technical requirements and identified need of this RIT-T or deliver much lower economic benefits compared with Option 1 and 2:

- Retirement of the SVC - Retiring the HOTS SVC will reduce the capability to manage ongoing requirements for voltage and reactive power control as required by clauses S5.1a.4 and S5.1a.5 of the NER and clauses 110.2.2(a) and 110.2.3(a) of the Victorian Electricity System Code. Additionally, market modelling concluded that the market impact will be significant should the HOTS SVC be retired based on the latest constraint equations[16].
- Options to remediate or refurbish the SVC do not materially reduce the failure rates as technology obsolescence continues to be a limiting factor, hence refurbishment option is not progressed further.
- Options utilising static capacitors and reactors are not considered credible as they do not

[16] Australian Energy Market Operator, *"Victorian Transfer Limit Advice – Outages", March 2022*

provide the necessary dynamic support to respond to network disturbances and contingency events. Therefore, this option is not technically feasible.

- A new synchronous condenser of the same size as the HOTS SVC at Red Cliffs Terminal Station (RCTS) – although this option would maximise the potential benefit considering the system strength gap declared by AEMO at Red Cliffs in 2019, the distance between RCTS and HOTS make this option or other solutions remote from HOTS less effective at managing voltages at HOTS when considering credible network contingencies such as an outage of the RCTS-HOTS 220 kV line. Alternative locations do not deliver the same capability to control voltages at HOTS compared with a solution implemented at HOTS. Solution remote from HOTS is also not as effective in meeting the RIT-T identified need, AusNet Services' regulatory compliance obligations and meeting the contracted services defined in the AEMO / AusNet Services Network Agreement.
- A new synchronous condenser of the same size as the HOTS SVC at Wemen Terminal Station (WETS) – similar to the option proposed at Red Cliffs Terminal Station, a synchronous condenser at Wemen Terminal Station cannot replace the service provided by the HOTS SVC when considering the need for voltage control at HOTS and North West Victoria for which AusNet Services are contracted under the Network Agreement between AEMO and AusNet Services and considering AusNet Services' regulatory obligations in terms of voltage control. Additionally, a new synchronous condenser at WETS would duplicate the voltage management solution in that part of North West Victoria loop as there is already a SVC at Kerang Terminal Station (KGTS), which is not far from WETS.
- Deferred asset replacement by contracting for dynamic voltage and reactive power control services – this notional option does not fully meet the identified need as the location of the service is some distance from HOTS and the effectiveness of reactive power and voltage control diminishes the greater the distance between the source and desired location for power and voltage control. This notional option also delivers lower net economic benefits for all scenarios included in the RIT-T and is modelled as Option 3 for economic comparison with the network options.

3.5. Material inter-regional network impact

The proposed asset replacement at HOTS will not change the transmission network configuration and none of the network options considered are likely to have a material inter-regional network impact. A 'material inter- regional network impact' is defined in the NER as:

> *"A material impact on another Transmission Network Service Provider's network, which 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."*

4. Non-network option

The non-network proposal for this RIT-T have been made in confidence and AusNet Services is thus not allowed to publish any part of the non-network proposal. Instead a notional non-network option is modelled to assess the economic merits of a non-network option.

The non-network option was evaluated from an economical and technical perspective and it has been determined that the non-network option does not deliver a better economically or technical solution compared with the network options.

5. Responses to PADR

AusNet Services received the following responses to the PADR which are summarised in Table 1.

Topic	Discussion	Response
Critical fault clearing time for faults noting that faults on the lower voltage network can have longer clearing times	All options considered have to be designed such that they meet this technical requirement	Cost estimates for each option provides for this technical requirement and will be included once the project design starts
Flywheel	Is the cost of an additional flywheel included in the capital cost assumption	The assessment considered synchronous condensers with and without flywheels together with the cost if a flywheel is included
Synchronous condenser power consumption	What are the assumptions for synchronous condenser power losses	The market model uses assumptions consistent with AEMO's IASR and standard models for synchronous condensers when analysing the different options

Table 1 – Responses to the PADR

6. Assessment approach

AusNet Services employed the following two-step approach to evaluate the options considered in this RIT-T:

- Power system analysis to evaluate AusNet Services' ability to comply with power system operation regulatory obligations
- Economic modelling to identify the preferred option with due consideration of the asset failure risk cost, which includes impact on the wholesale market, safety, environment, collateral damage and emergency asset replacement.

The economic benefits of the options were assessed against a base case (business as usual) where no proactive capital investment is made, and the existing maintenance regime continues to be implemented.

The analysis includes three of the latest ISP scenarios to explore the range of net economic benefits for each option. Sensitivity analysis that involves variation of failure rate, capital cost, and discount rate assumptions was also used to test the robustness of the investment decision with regards to the selected RIT-T preferred option and economical investment timing.

AusNet Services updated the assumptions used in the economic assessment to align with AEMO's latest IASR.

6.1. Technical assessment

AusNet Services undertook a technical assessment of the two identified credible options:

- Option 1 – Replace with modern SVC or FACTS
- Option 2 – Replace with a synchronous condenser

The technical assessment was conducted by performing steady state studies using PSSE (i.e. load flow and fault level analysis) Operations and Planning Data Management System (OPDMS) snapshots.

6.1.1. Voltage management

Operation of the 220 kV transmission network in North West Victoria has evolved significantly since the HOTS SVC was installed around 36 years ago. The Murraylink interconnector was commissioned in 2002 and there has been significant new renewable generation investment in recent years.

Murraylink and the generator connections all provide some level of voltage and reactive power control. AEMO's VAPR notes that there is ongoing collaboration between AEMO and generators to ensure that any available reactive support can be made available when needed. AusNet Services has undertaken a high-level screening study, using OPDMS snapshots from the past 12 months, to assess the ongoing need for voltage and reactive power control service provided by the HOTS SVC. Given that the two proposed network options (SVC or FACTS, and synchronous condenser) are both rated for +50/-25 MVAR, it is assumed they will provide equivalent reactive support, albeit with different dynamic response. As such the results of this study apply equally to both Option 1 and Option 2.

6.1.2. System strength

The system strength in North West Victoria is low, impacting the stability and dynamics of control systems used by inverter-based resources.[17] AEMO declared a fault level shortfall at Red Cliffs in

17 Australian Energy Market Operator "System Strength in the NEM Explained" March 2020

2019[18] and has engaged non-market service providers to fill the identified gap in the short term.

6.1.3. Market impact

A review of AEMO's limit advice reports[19] identified the limit equations, including the voltage oscillation equations that need to be considered for this RIT-T. These equations were used in the market model to quantify the market impact of an unplanned outage of the HOTS SVC and hence the market benefits that investment in the network will deliver.

6.2. Economic assessment

Consistent with the RIT-T application guidelines and Industry practice application note for asset replacement planning[20], AusNet Services undertook a cost-benefit analysis to evaluate and rank the net economic benefits of the credible options over a 30-year period.

All options considered have been assessed against a base case (business as usual) where no proactive capital investment to reduce the increasing baseline risks is made.

Optimal timing of an investment option is the year when the annual benefits from implementing the option become greater than the annualised investment costs.

6.2.1. Input assumptions, scenarios and sensitivity analysis

The robustness of the investment decision is tested using the range of input assumptions and scenarios described in Table 2. This analysis involves variation of assumptions around the most likely values as per the IASR and AusNet Service's best estimate of project cost and asset failure rates.

Parameter	Lower Bound	Most likely assumption or scenario	Upper Bound / Alternative Scenario
Market Scenario	Slow Change	Step Change	Progressive Change
Asset failure rate	AusNet Services assessment – 20%	AusNet Services assessment	AusNet Services assessment + 20%
Project Capital Cost	Estimated cost - 20%	Estimate cost	Estimated cost + 20%
Discount rate[21]	2.0% - the WACC rate of a network business	5.5% - the latest commercial discount rate	7.5% - Upper Bound

Table 2 - Input assumptions and scenarios

18 Australian Energy Marker Operator, *'Notice of Victorian Fault Level shortfall at Red Cliffs,'* available at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2019/Notice_of_Victorian_Fault_Level_Shortfall_at_Red_Cliffs.pdf

19 Australian Energy Market Operator, "*Victorian Transfer Limit Advice – System Normal* and "*Victorian Transfer Limit Advice – Outages* available at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/congestion-information-resource/limits-advice.

20 Australian Energy Regulator, *"Industry practice application note for asset replacement planning,"*

21 Discount rates as recommended in the AEMO Inputs Assumptions and Scenarios Report (IASR) 2021

6.2.2. Material classes of market benefits

NER clause 5.16.1(c)(4) formally sets out the classes of market benefits that must be considered in a RIT-T. AusNet Services estimates that the classes of market benefits that are likely to be material include changes in involuntary load shedding, and changes in fuel cost arising through different patterns of generation dispatch.

6.2.3. Other classes of benefits

Although not formally classified as classes of market benefits under the NER, AusNet Services expects material reduction in: safety risks from potential explosive failure of deteriorated assets, environmental risks from possible oil spillage or release of greenhouse gasses, collateral damage risks to adjacent plant, and the risk of increased costs resulting from the need for emergency asset replacements and reactive repairs by implementing any of the options considered in this RIT-T.

6.2.4. Classes of market benefits that are not material

AusNet Services determined that the following classes of market benefits are unlikely to be material for any of the options considered in this RIT-T:

- Changes in costs for parties, other than the RIT-T proponent – there is no other known investment, either generation or transmission, that will be affected by any option considered.
- Changes in ancillary services costs – the options are not expected to impact on the demand for and supply of ancillary services.
- Competition benefits – there is no competing generation affected by the limitations and risks being addressed by the options considered for this RIT-T.
- Option value – as the need for and timing of the investment options are driven by asset deterioration, there is no need to incorporate flexibility in response to uncertainty around any other factor.

7. Result of options assessment

This section presents the results of the economic cost benefit analysis and the economic timing of the preferred option.

All options will deliver a reduction in market impact risk, safety risk, environmental risk, collateral risk and risk cost of emergency replacement in the event of asset failure.

Presented in Figure 6, the total risk cost reduction outweighs the investment cost for all modelled options for all scenarios and sensitivities where input variables are varied one at a time. All options deliver net market benefits for all three ISP scenarios, i.e. Slow Change, Step Change and Progressive Change.

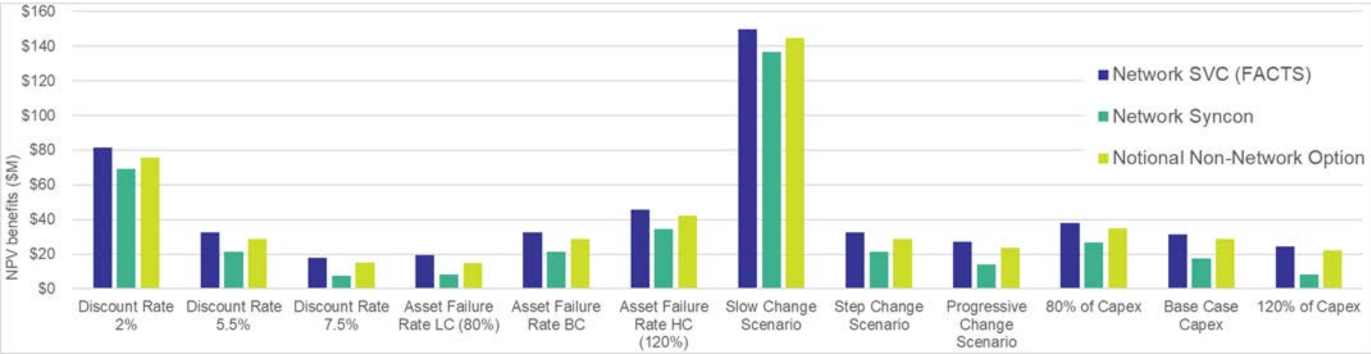

Figure 6 – Option Selection

7.1. Preferred Option

Option 1 (Replace with modern SVC or FACTS) has the highest net economic benefit for all the scenarios and sensitivities considered and is therefore the preferred option. Scenario weighting will not make a difference to the preferred option as Option 1 has the highest net benefits for all three scenarios (Slow Change, Step Change and Progressive Change).

7.1. Optimal timing of the preferred option

This section describes the optimal timing of the preferred option for different assumptions of key variables and ISP scenarios. Figure 7 shows that the optimal timing of the preferred option (Option 1) is 2024/25 and that the investment is needed within the 2022 to 2027 regulatory control period.

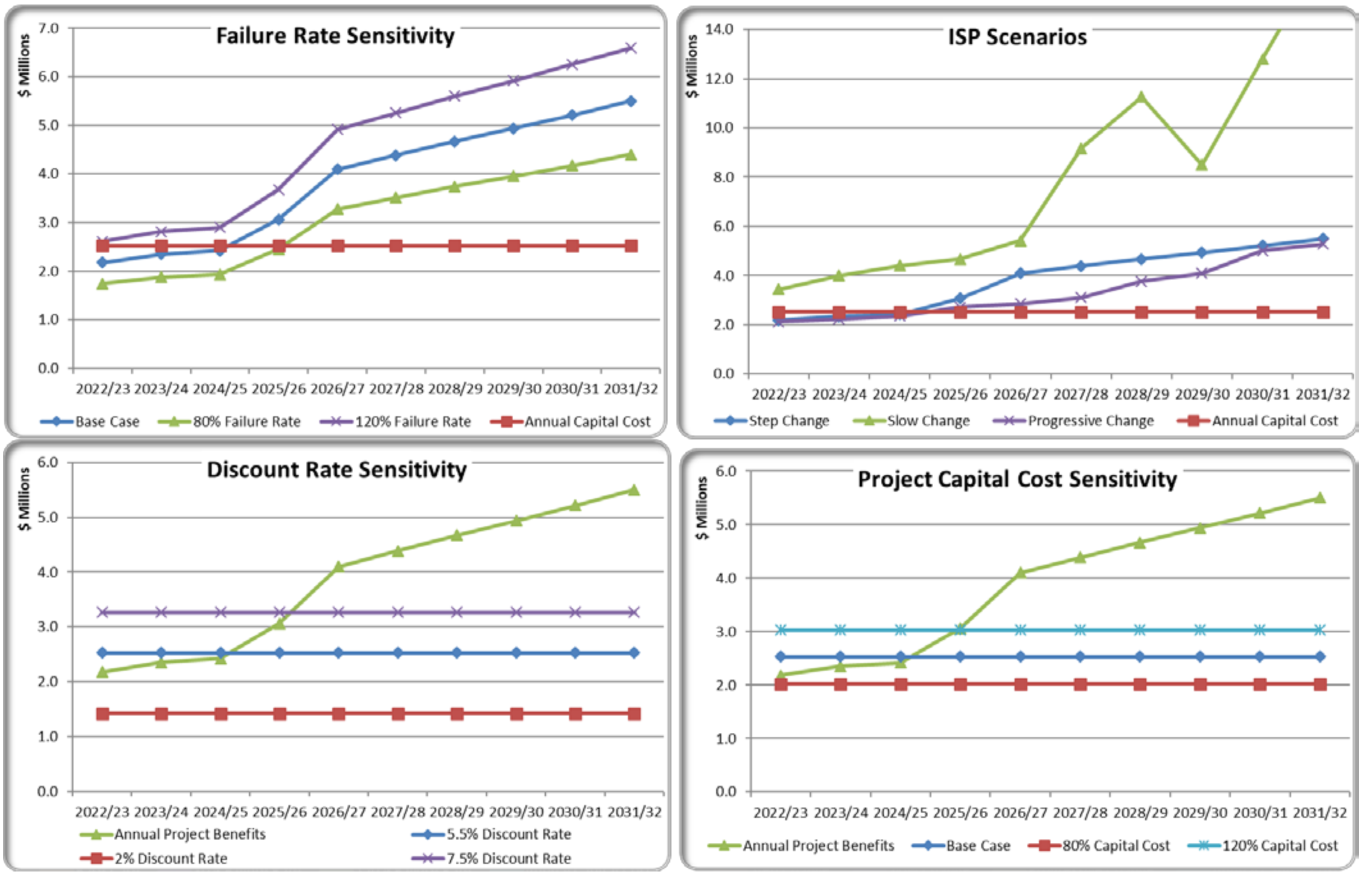

Figure 7 – Optimal investment timing

8. Conclusion of the RIT-T

Amongst the options considered in this RIT-T, Option 1 is the most economical option to maintain reliable transmission network services at HOTS and manage safety, environmental, collateral and emergency replacement risks. Option 1 is therefore the preferred option and involves the following scope of work in a single integrated project:

- Installing a modern SVC or FACTS such as a STATCON of similar size as the existing SVC at HOTS
- Retirement of the old SVC at HOTS

The estimated capital cost of this option is $41.8 million with an estimated operating and maintenance cost of around $30 k pa. The project is economic by 2024/25 and will take about four years to deliver.

Alternative technologies or solutions that deliver a similar service at the same or lower cost and that meet the RIT-T identified need will also be considered by AusNet if they become available prior to this project becoming a committed project at the time of approval of the project business case.

Based on the consultation and RIT-T assessment the preferred option satisfies the regulatory investment test for transmission.

Next steps

In accordance with clause 5.16B of the NER, within 30 days of the date of publication of this PACR, any party disputing the conclusion made in this PACR should give notice of the dispute in writing setting out the grounds for the dispute (the dispute notice) to the AER. If there are no dispute notices within 30 days of the date of publication of this PACR, AusNet Services expect to implement the preferred option.

Appendix A - RIT-T assessment and consultation process

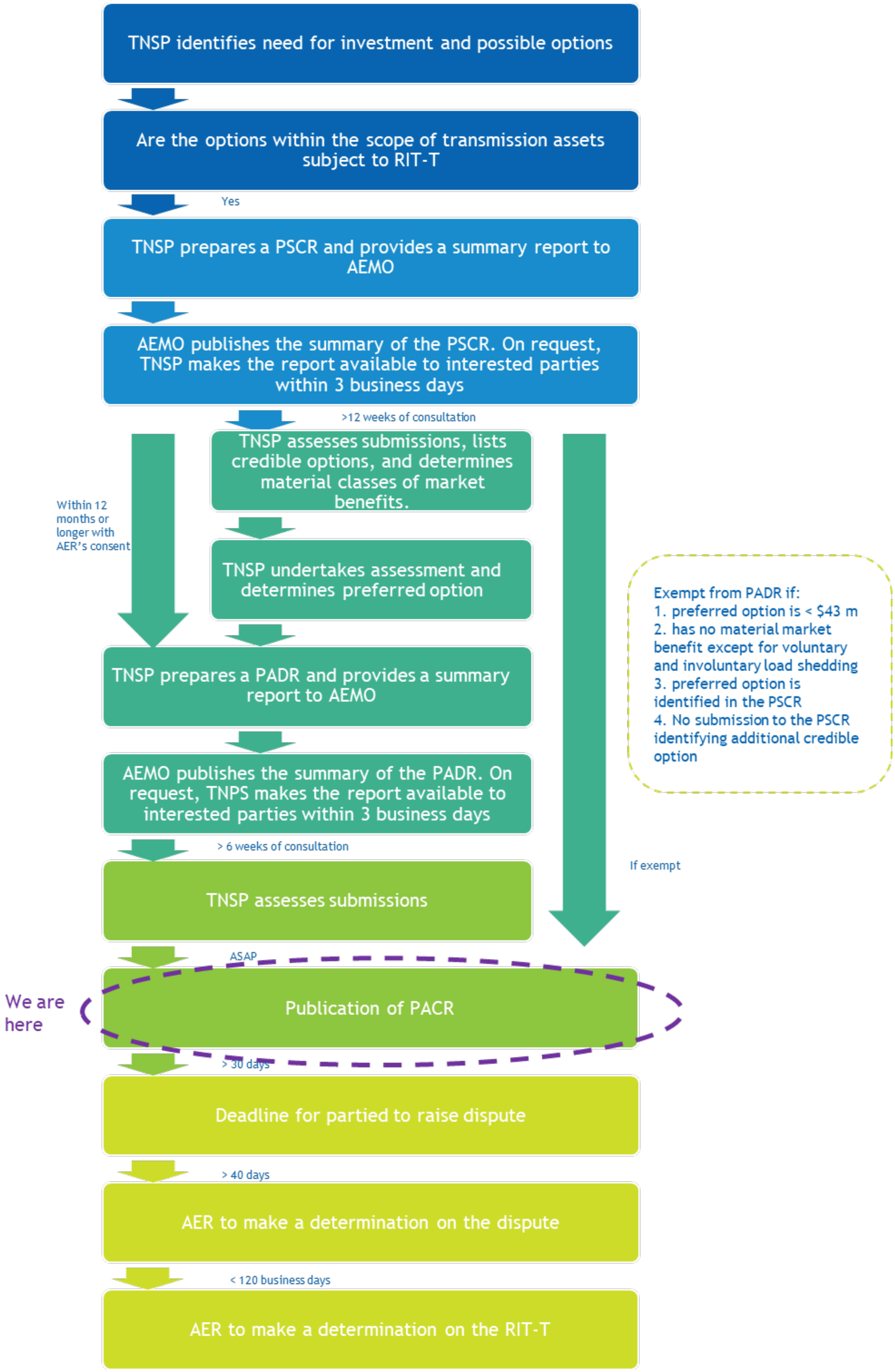

Figure 8 - RIT-T process