WESTERN VICTORIA RENEWABLE INTEGRATION

PROJECT SPECIFICATION CONSULTATION REPORT

Published: **April 2017**

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

AEMO has prepared this document to provide information about potential network limitations in Western Victoria and potential options to address these limitations, as at the date of publication.

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EXECUTIVE SUMMARY

The Regulatory Investment Test for Transmission (RIT-T) is an economic cost-benefit test used to assess and rank different electricity transmission investment options that address an identified need. Its purpose is to identify the investment option that maximises the present value of net economic benefit to all those who produce, consume and transport electricity in the market.

AEMO's 2016 Victorian Annual Planning Report (VAPR) and 2016 National Transmission Network Development Plan (NTNDP) identified a high level of interest in renewable generation connection in the Western Victoria area, further accentuated by the proposed Victorian Renewable Energy Target (VRET).

If the projected volume of new generation connects into the grid, individual generators (both new and existing) may be constrained or disconnected, mainly due to thermal and system strength limitations of the transmission system in Western Victoria. Network limitations outside of Western Victoria (including interconnector capability) may also constrain the output of these new generators.

AEMO is undertaking a RIT-T to assess the technical and economic viability of increasing transmission network capability in Western Victoria, to identify the preferred augmentation option and its optimal timing.

This Project Specification Consultation Report (PSCR) is the first stage of the RIT-T process and includes the following:

- A description of the identified need for investment.
- A description of the network options being considered to overcome this.
- The technical characteristics and performance requirements that a non-network option would need to deliver to overcome the forecast network loading issues.
- Specific categories of market benefit and their applicability to this RIT-T.

Identified need for investment

The identified need is to increase the capability of the Western Victoria power system, to reduce constraints on projected new generation in that region.

AEMO projects that over 3,000 megawatt (MW) of new renewable generation may be constructed in Western Victoria as a result of the Victorian Government's VRET target. New generators connecting to this part of the Victorian electricity network are expected to be heavily constrained by emerging thermal limitations[1] on the 220 kilovolt (kV) transmission system, with up to half of their energy output curtailed (depending on proximity to constraints). New generators proposing to connect to the 500 kV transmission network will not be constrained by limitations in Western Victoria, but may be constrained by other limitations in the Victoria transmission network.

Thermal limitations in the transmission network may result in a lost generation opportunity for Western Victoria generation of over 1,600 gigawatt hours (GWh) per year. Inefficient generation dispatch could result in higher prices for electricity for consumers. Preliminary market modelling, assuming connection of over 3,000 MW of new renewable generation, shows that removing thermal limitations in Western Victoria, either through network augmentation, non-network services, or a mix of both, could result in a gross market benefit of $300–500 million over 30 years, from reducing the cost of generation alone. The next stage of this RIT-T will further quantify the benefits of augmentation across different scenarios, and with more accurate assumptions.

[1] Power flow on a transmission element cannot exceed its design rating (either continuous or short-term) under normal conditions or following a credible contingency, to prevent equipment damage.

System strength is an important factor contributing to power system stability under all reasonably possible operating conditions, and can materially impact the way a power system operates. System strength in Western Victoria is low due to the electrical distance (i.e. network impedance) between local terminal stations in Western Victoria and connected synchronous plant. This limits the amount of non-synchronous generation (like new wind and solar generation) that may be connected to the existing Western Victoria network. Without network investments to improve system strength, the 3,000 megawatt (MW) of new renewable generation may still be constrained or disconnected, even after investments to improve network thermal capacity have been carried out.

The National Electricity Rules (NER) are unclear about who is responsible for maintaining system strength, but the Australian Energy Market Commission (AEMC) has proposed changes to the NER through the System Security Market Frameworks Review that will impose this responsibility on Transmission Network Service Providers (TNSPs). Network investments to improve system strength will facilitate the connection of non-synchronous generation in Western Victoria, and AEMO will consider any outcomes of the AEMC's review in the next stage of this RIT-T.

Investment options

AEMO is considering minor network augmentations, major network augmentations, and non-network options to address the identified need. The outcome that maximises net market benefits needs to factor in the combined costs of developing new generation where abundant resources are located, and additional infrastructure to transmit the generated electricity.

Next steps

The second stage of the RIT-T process, full options analysis and publication of the Project Assessment Draft Report (PADR), will be published within 12 months from 14 July 2017.

The recommended option may be a combination of network and non-network options, since minor network augmentations and non-network solutions are unlikely to fully address the identified need, while network augmentation can address the identified need but may not be implemented in time, or have sufficient market benefits.

Submissions

AEMO welcomes written submissions on this PSCR, particularly in relation to the credible network and non-network options presented, and issues addressed in this report.

Submissions should be emailed to Planning@aemo.com.au and are due on or before 14 July 2017.

Submissions will be published on the AEMO website. If you do not want your submission to be publicly available, please clearly stipulate this at the time of lodgement.

Further details in relation to this project can be obtained from:

Kiet Lee

Network Planning

AEMO

Phone: (02) 8884 5620

Email: kiet.lee@aemo.com.au

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CHAPTER 1. INTRODUCTION

This Project Specification Consultation Report (PSCR) has been prepared in accordance with the requirements of clause 5.16 of the National Electricity Rules (NER), for a Regulatory Investment Test for Transmission (RIT-T).

In line with these requirements, this PSCR:

- Describes the identified need that AEMO is seeking to address and the assumptions used in identifying the need.
- Describes the technical characteristics that a non-network option would be required to deliver to meet the identified need.
- Describes all credible options that AEMO is aware of that address the identified need.
- Describes the classes of market benefit that are not likely to be material.

The next stage of the RIT-T process is a full option analysis and publication of the Project Assessment Draft Report (PADR), due within 12 months from the end of the consultation period. Refer to Appendix A for a summary of the next steps.

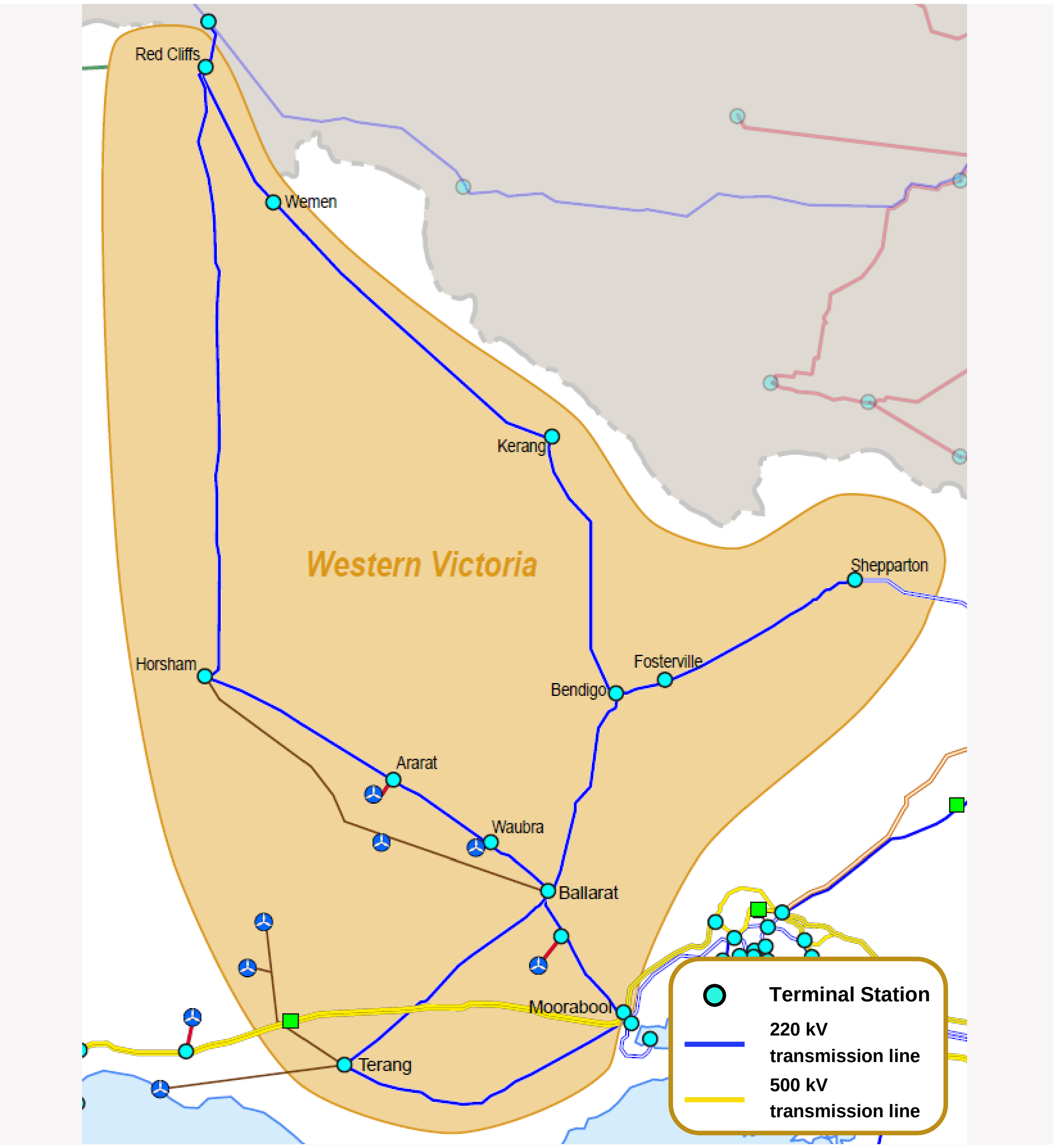
The PADR will include information on the preferred option that returns the higher net market benefits, details on its technical characteristics, estimated construction timetable and commissioning date, and analysis showing that the preferred option satisfies the RIT-T.

CHAPTER 2. NETWORK LIMITATIONS

"Western Victoria", in the context of this RIT-T, is defined as the Central Highlands, Wimmera Southern Mallee, Mallee, Loddon Campaspe, and parts of the Great South Coast.

The electrical transmission network extends from Moorabool Terminal Station, west to Terang Terminal Station, north-east to Ballarat Terminal Station, and to the 220 kV loop extending Ballarat – Horsham – Red Cliffs – Kerang – Bendigo. Generators connecting along the 500 kV path from Moorabool to Tarrone and Mortlake are also included. Figure 1 illustrates the area and surrounding electrical network.

Figure 1 Western Victoria



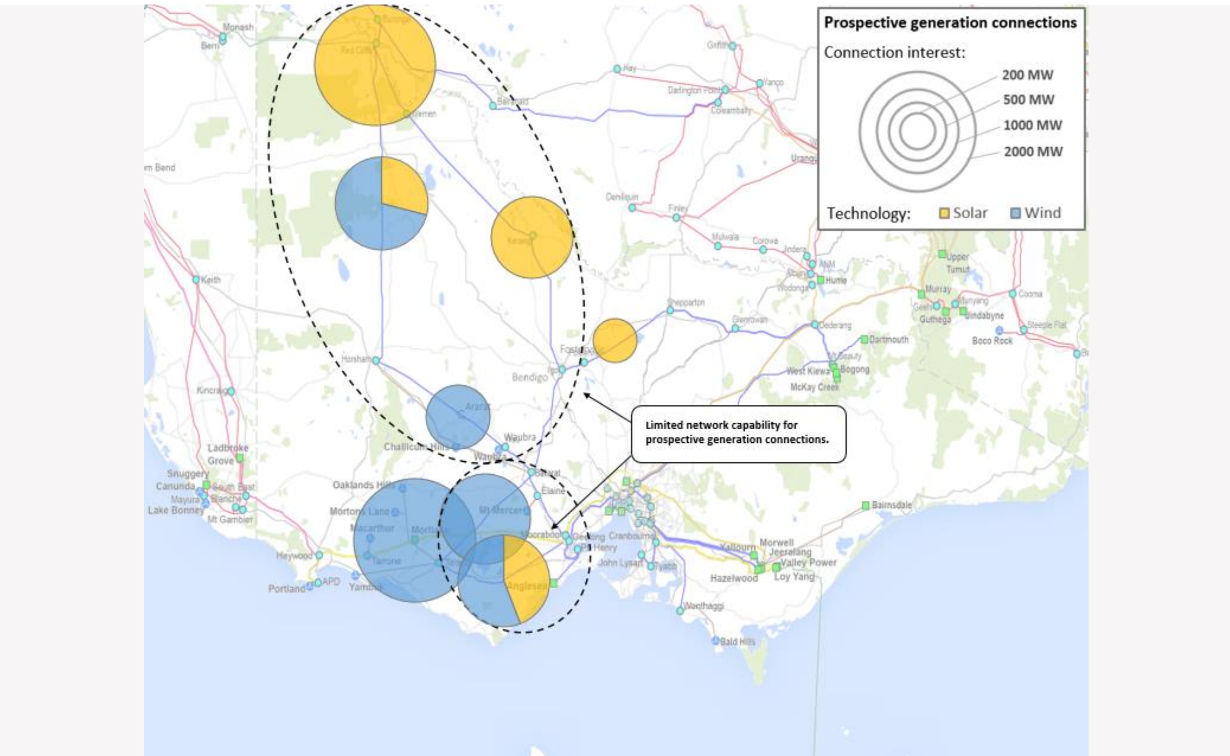
The Western Victoria network supplies approximately 10% of total Victorian demand. Based on current connection point forecasts, average and peak demand in Western Victoria is expected to remain flat, with a decline in minimum demand over the ten-year planning horizon. This area is an attractive location for new renewable generation connections due to the availability of renewable energy resources and the low cost of land. However, the electrical infrastructure in this part of Victoria is insufficient to allow unconstrained access to all of the new renewable generation seeking to connect to it.

The 2016 Victorian Annual Planning Report (VAPR) identified that transmission line augmentation between Ballarat and Waubra Terminal Stations to reduce thermal constraints on new renewable generation connections in the area could return net market benefits. The VAPR stated that AEMO would commence a Regulatory Investment Test for Transmission (RIT-T) in late 2016 to investigate this further.

Earlier, in June 2016, the Victorian Government proposed a Victorian Renewable Energy Target (VRET). This target proposes that 25% of energy generation in Victoria will come from renewable sources by 2020, and 40% by 2025. This is expected to deliver up to 1,500 megawatts (MW) of additional large-scale renewable generation by 2020, and 5,400 MW by 2025, through a reverse auction scheme.[2]

To date, AEMO has received new connection applications and enquiries for over 5,000 MW of new generation capacity in Western Victoria. Of this capacity, 80% is proposing to connect to the 66 kV and 220 kV network, with the remainder connecting to the 500 kV network. Figure 2 shows the approximate location of new connections in Western Victoria, up to March 2017. Due to high interest in renewable generation connection in this area, the exact number of new generation proposals is subject to change.

Figure 2 New connection applications and enquiries in Western Victoria up to March 2017



Since new transmission lines may take between four to seven years to plan, construct and commission, AEMO has decided to proceed with this RIT-T before any new generation is committed, because any

[2] State Government of Victoria. Victoria's Renewable Energy Targets. Available at: http://delwp.vic.gov.au/energy/renewable-energy/victorias-renewable-energy-targets.

additional delay may result in constraining off both new and existing generators, limiting potential market benefits. Scenario studies considering different levels of generation uptake will be carried out in the PADR to manage the risk of uncertainty, and to minimise the risk of stranded assets.

For the PSCR, AEMO has assessed the impact of two different generation expansion scenarios:

- **Base Case** – New generation capacity of over 3,000 MW is installed in Western Victoria by 2025.
- **Sensitivity** – New generation capacity of over 5,000 MW is installed in Western Victoria by 2027.

Refer to Section 5.1 for further details generation expansion assumptions.

2.1 Thermal limitation

During times of peak renewable generation, electrical energy that is not consumed by local Western Victorian load will flow towards the Melbourne load centre from Ballarat Terminal Station and via Moorabool Terminal Station. Power may also be transferred to New South Wales via the Buronga Interconnector, via the Bendigo to Shepparton 220 kV transmission line, and to South Australia via the Murraylink Interconnector. Refer to Figure 1 for a map of the Western Victorian electrical transmission network.

Due to the limited number of flow paths and the thermal capacity of these lines, there is risk of congestion should more generation connect to this network. This would result in constraining off new or existing generation in Western Victoria, and inefficient generation dispatch.

Refer to Chapter 3 for more details on the thermal limitation in Western Victoria.

2.2 System strength limitation

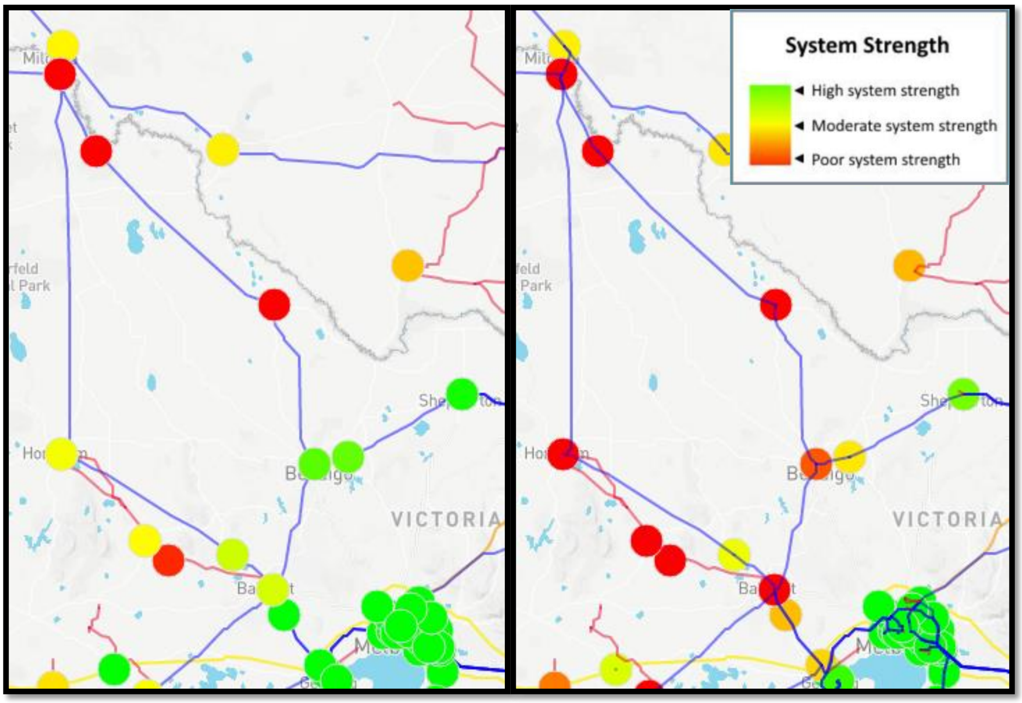
System strength is an important factor contributing to power system stability under all reasonably possible operating conditions, and can materially impact the way a power system operates.

Low system strength in Western Victoria can degrade elements of system performance, or threaten power system security due to factors such as:

- Inability to control voltage during normal system and market operations such as switching of transmission lines or transformers, switching reactive plant (capacitors and reactors), transformer tap changing, and routine variations in load or generation. Synchronous plant may also suffer instability if connected to a weak network.
- Manufacturers' design limits on power electronic converter-interfaced devices such as wind turbines, solar PV systems, and static VAr compensators. Operation of these devices outside their minimum design limits could give rise to generating system instability and consequent disconnection from the grid.
- Protection systems that rely on measurement of current (excluding differential protection), or current and voltage during a network fault to achieve two basic design requirements:
  - Selectivity (that is, to operate only for conditions for which the system has been installed)
  - Sensitivity (that is, to be sufficiently sensitive to faults on the equipment it is protecting).
- Propagation of voltage dips. A voltage dip (also called a voltage sag) is a short-term drop in network voltage following a network fault or switching event. In a weak network area, voltage dips are deeper, more widespread, and can last longer than in a strong network. This would mean that more non-synchronous generators are likely to see the fault and go into fault ride through at a similar time.

Figure 3 below is extracted from AEMO's 2016 NTNDP, and shows how system strength in Western Victoria may decline from 2017 to 2036, after new renewable generation is connected.

Figure 3 System strength assessment in 2016–17 (left) and 2035–36 (right)



System strength is usually measured by available fault current or the short circuit ratio at a given location. Higher fault current levels are found in a stronger power system, while lower fault current levels are representative of a weaker power system. Fault currents vary around the grid, with fault currents being higher in areas close to synchronous plant.

System strength in Western Victoria is low due to the electrical distance (i.e. network impedance) between local terminal stations in Western Victoria and connected synchronous plant. This limits the amount of non-synchronous generation that may be connected to the existing Western Victoria network.

Without any additional investment, new wind or solar generation may be constrained off, or may have to build additional plant at their own cost, to ensure that local system strength is adequate for correct operation of their plant.

The NER is unclear on who has responsibility for system strength, but the Australian Energy Market Commission (AEMC) is considering changes to the NER that will impose such responsibility on transmission network service providers (TNSPs) as part of its System Security Market Frameworks Review.[3] AEMO has made a submission to this review. [4] Network investments to improve system strength will allow connection of more non-synchronous generation in Western Victoria, and AEMO will consider any outcomes of the AEMC’s review in the next stage of this RIT-T.

2.3 Other limitations

2.3.1 Voltage support limitation

The 2016 VAPR identified a risk of high voltages exceeding limits at some 500 kV busses when the 500 kV transmission lines are lightly loaded. High voltages exceeding limits have the potential to damage transmission, generation and customer equipment, and must be avoided. The VAPR also identified the risk of inadequate reactive power support in North West Victoria during periods of high demand.

Several options for improving the identified thermal and system strength limitations may also increase voltage support to Western Victoria. The PADR will consider the need to maintain adequate voltage support in the options assessment.

2.3.2 Limitations outside of Western Victoria

The 2016 NTNDP identified that new renewable generation in Western Victoria may be constrained by limitations outside of Western Victoria, on the 220 kV transmission path from Moorabool to Geelong to Keilor to Thomastown, as well as the Thomastown – Ringwood transmission line. Existing limitations on the Victoria to New South Wales interconnector may limit generation export from Western Victoria to New South Wales.

The removal of these limitations will not be considered in this RIT-T, because the thermal constraints in Western Victoria are more severe, and will need to be addressed first. Network limitations outside of Western Victoria (including interconnector capability) may constrain the output of the proposed new generators in Western Victoria, and may be considered in a separate RIT-T.

[3] Available at: http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review.
[4] Available at: http://www.aemc.gov.au/getattachment/94177d01-4833-413e-b012-99ba52113452/AEMO.aspx.

CHAPTER 3. IDENTIFIED NEED

3.1 Description of the identified need

The identified need is to increase the thermal capability of the Western Victoria power system to reduce constraints on anticipated new connected generation.

The system strength limitations that are expected to develop in Western Victoria as a result of increased connection of asynchronous generation will need to be addressed to allow the stable operation of new generators, and to prevent compromising the operation of existing generators. Network investments to address thermal limitations may not remove system strength limitations in Western Victoria, and this could still result in generators being constrained or disconnected. The roles and responsibilities of the TNSPs and Generators for managing system strength are being considered by the AEMC as part of its System Security Frameworks Review. AEMO will consider any outcomes of this review in the next stage of this RIT-T.

3.2 Thermal limitation

Preliminary studies show that the most congested 220 kV transmission path is between Ballarat – Horsham – Red Cliffs – Kerang. If constraints on the Ballarat to Horsham 220 kV transmission line are removed, the Ballarat to Moorabool 220 kV transmission line will become constrained. Generation flow towards New South Wales will constrain the Bendigo to Shepparton 220 kV transmission line. While the generators connected to the 500 kV transmission network will experience less thermal constraints, any outage of a 500 kV line between Sydenham to Moorabool to Mortlake or Tarrone may result in a large market impact.

The following table shows a high-level assessment of the maximum amount of generation that can be connected at points on the Western Victorian system, and still be provided network access for about 95% of the time. As can be seen, the amount of interest at each connection point far exceeds the maximum value. Proponents interested in connecting to these areas are advised to conduct their own due diligence to better understand connection opportunities and risks.

Table 1 Potential 220 kV transmission line limitation and potential new generation

Potential 220 kV transmission line limitation	Maximum new capacity with mostly unconstrained network access, with no additional network investment*, MW	New generation connection enquiries and applications received for the 220 kV and 66kV network, MW	Connection Points contributing to limitation
Horsham to Red Cliffs	150	700	Between Horsham to Red Cliffs
Ballarat to Horsham	0**	300	Between Waubra to Horsham. This constraint will also be made worse by generation connections between Horsham to Red Cliffs, above.
Bendigo to Kerang	250	500	Around Kerang. This constraint will also be made worse by generators connected between Kerang to Red Cliffs, below.
Kerang to Wemen to Red Cliffs	250	1100	Between Wemen to Red Cliffs. This constraint will also be made worse by generators connected around Kerang, above.
Terang to Moorabool	350	700	Between Terang to Moorabool

* Capacity shown assumes that not all connected generators in Western Victoria are operating simultaneously. The allowable generation capacity at each individual location may decrease if other nearby generators are also operating.
** Over 400 MW of wind generation is connected to this transmission line.

AEMO is currently in discussion with new generator proponents about these transmission network limitations, highlighting the risk of being constrained. AEMO has also published information for new generators that intend to connect to the Ballarat to Waubra to Horsham to Red Cliffs transmission path.[5] However, AEMO does not:

1. Offer advice on the commercial viability of a generator connection.
2. Reject connection applications based on limited network access.
3. Provide firm access for new or existing generation.

The extent and nature of transmission line congestion varies greatly with location and the capacity of new generation in the area, and will remain uncertain until new generation projects become committed.

[5] AEMO. *New generator connections to the Victorian transmission system, in particular the 220 kV lines between BATS-WBTS-HOTS and HOTS-RCTS*, November 2015. Available at: http://www.aemo.com.au/-/media/Files/PDF/Q-and-A-WESTERN-VICTORIA-AEMO-template.pdf.

CHAPTER 4. POTENTIAL MARKET BENEFITS

Classes of benefits expected to be material to this RIT-T are summarised in the next table.

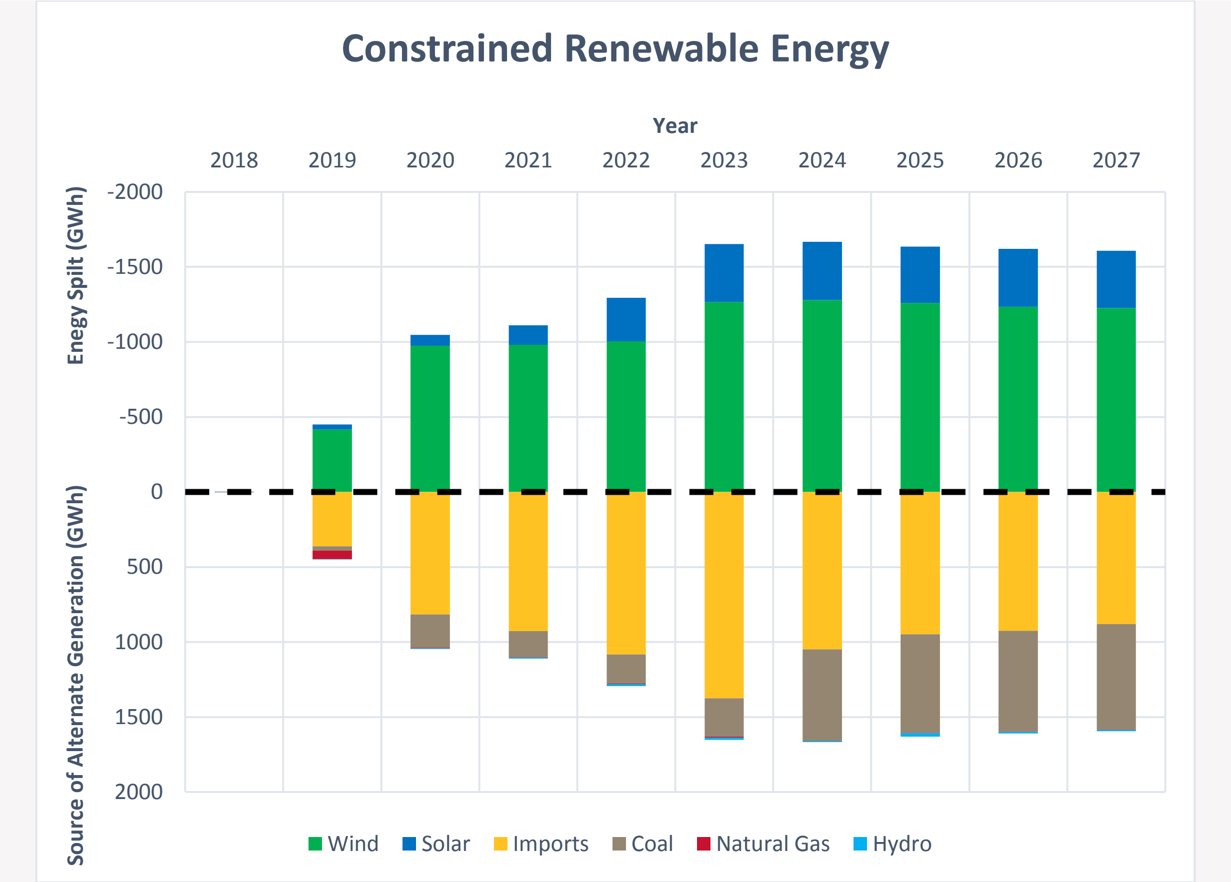
Table 2 Material classes of market benefit

Benefit	Network limitation
Changes in fuel consumption arising through different patterns of generation dispatch	Thermal limitations in Western Victoria are expected to constrain renewable energy generation, leading to inefficient generation dispatch.
Changes in network losses	Thermal limitations in Western Victoria will constrain local generation, resulting in Victoria relying more heavily on interstate imports, and resulting in higher transmission losses.
Negative of any penalty for not meeting the renewable energy target	There is no direct penalty associated with not meeting the VRET target. If constraints on renewable generation in Western Victoria results in missing the VRET target, new renewable generators may be built to cover the shortfall. The benefit of removing limitations is to avoid the need for additional renewable generators built to cover the VRET target shortfall.
Changes in cost to parties other than the TNSP, due to: • Differences in the timing of the installation of new plant. • Differences in capital costs of different plant. • Differences in the operational and maintenance costs of different plant.	If a credible option can lead to a delay in the commissioning of new plant, this is considered a positive market benefit. Investment decisions in Western Victoria could result in the VRET target being met with a smaller number of new generators. The potential deferral of new generators and new synchronous condensers may be considered in the PADR stage.
Any additional option value (meaning any option value that has not already been included in other classes of market benefits) gained or foregone from implementing the credible option with respect to the likely future investment needs of the market	Uncertainties in generation expansion in Western Victoria could mean that there is value in retaining some flexibility to respond to new information as or when it emerges.

4.1 Changes in fuel consumption and network losses

Preliminary studies for the Base Case scenario estimate that more than 1,600 GWh of wind and solar energy per year is restricted by the thermal capability of the Western Victorian network. Should there be no action to alleviate these limitations, the constrained generation would primarily be replaced by imports from other regions and generation outside Western Victoria, as shown in the following graph.

Figure 4 Constrained renewable energy due to Western Victoria constraints, and alternate generation sources



Wind and solar generation is assumed to have no Short Run Marginal Cost[6] (SRMC), and sourcing generation from thermal or hydro generators will increase the overall cost of generation in Victoria. Generation located far from a load centre will increase network losses.

Preliminary studies show that the negative impact of constrained generation has a Net Present Value (NPV) of $300–500 million over a 30-year period, based on SRMC savings alone.

Market modelling to quantify this benefit is carried out using SRMC bidding, which represents a perfect competition scenario. However, there is a risk that future generation withdrawals or shortage of fuel sources may increase market volatility and lead to high price spikes. This risk is not quantified in the PSCR studies, but will be considered in the PADR stage.

4.2 Negative of any penalty for not meeting the renewable energy target

The Victorian Government has proposed a reverse auction scheme in implementing the VRET, with the aim of achieving renewable energy targets of 25% by 2020 and 40% by 2025. This means that certain amounts of renewable capacity will be auctioned off at certain time periods.

AEMO's modelling showed that based on the Sensitivity scenario, with over 5,000 MW of new renewable generation connection to Western Victoria, the 40% renewable energy target could be met even if the expected network congestion occurs.

[6] Includes a generator's variable operating costs, fuel cost, and any Renewable Energy Target requirements.

This is because network congestion will mainly impact generators connected to the 220 kV transmission network path between Ballarat – Horsham – Red Cliffs – Kerang, which have over half their energy output curtailed.

Generators connected to other parts of the network will have relatively unconstrained output. The VRET also allows the generation contribution from rooftop PV and existing hydro generators to be counted towards its 40% target. These generators are not affected by the limitations in Western Victoria.

If over 3,000 MW of new generation is developed in Western Victoria as projected by the 2016 NTNDP, thermal limitations in the transmission network may result in missing the 2025 VRET target by around 3%.

Refer to Section 5.1 for generation expansion assumptions.

4.3 Changes in cost to parties other than the transmission network service provider

The expected new wind and solar generator connections in Western Victoria may require new synchronous condensers or similar plant, to increase local system strength and maintain system security. AEMO aims to support the VRET target with the least amount of new plant built in Victoria, to minimise overall electricity costs.

Given the scale of new generation anticipated as a result of the VRET, a large centrally-controlled synchronous condenser could provide a range of system benefits (such as inertia and improved system resilience) that cannot be provided by a series of smaller synchronous condensers installed at each new connection.

AEMO will consider a coordinated approach to improving system strength in Western Victoria, to minimise the amount of new plant required to enable new renewable generator connections. The cost of any investments to improve system strength will be included in the PADR's cost benefit analysis; however investment will only be committed subject to the outcome of the AEMC's Review on System Security Market Frameworks, the actual cost of procuring the preferred option (as opposed to the estimates on which the RIT-T is based), and as new generators become committed.

4.4 Option value benefit

Option value benefits refer to the value in retaining flexibility when implementing investment options. Network and non-network solutions that can be incrementally rolled out may provide option value benefits to the NEM. A flexible approach can also be used to manage uncertainty in the size, location and timing of new generator connections.

CHAPTER 5. ASSUMPTIONS MADE IN RELATION TO THE IDENTIFIED NEED

The assumptions made in relation to the identified need are detailed in Appendix B. In general, the project inputs are based on the 2016 National Transmission Network Development Plan (NTNDP) methodology and assumptions[7], with some modifications on the generation expansion plan. The planning criteria is based on AEMO's Victorian Electricity Planning Approach[8], which uses an economic cost benefit analysis with a probabilistic approach to determine the benefit.

5.1 Generation expansion

To assess the impact of a large amount of generation connecting to Western Victoria, two scenarios were considered:

- **Base Case** – New generation capacity of over 3,000 MW is installed in Western Victoria by 2025.
- **Sensitivity** – New generation capacity of over 5,000 MW is installed in Western Victoria by 2027.

The Base Case generation expansion plan is consistent with the 2016 NTNDP's 'Neutral' scenario, with no new interconnectors, which reflects AEMO's best estimate for grid demand based on a neutral economic outlook. Approximately 16% of new generation capacity is assumed to be connected to the 500 kV transmission network in Western Victoria. This NTNDP scenario also projected that over 500 MW of peaking generation will be built in Victoria. The new generation capacity may be sourced from either new generators, or generators initially projected to withdraw from the market that have reversed their withdrawal decision.

From the Base Case scenario, a Sensitivity study was conducted with over 5,000 MW of new renewable generation capacity in Western Victoria. This scenario represents all active enquiries received and applications being progressed by AEMO. Generators have been located based on their enquiries and applications. Many generators are proposed to be connected to the same terminal stations, and experience severe localised constraints.

Under both scenarios, the VRET targets of 25% renewable generation by 2020 and 40% renewable generation by 2025 are met if there are no transmission limitations in Western Victoria.

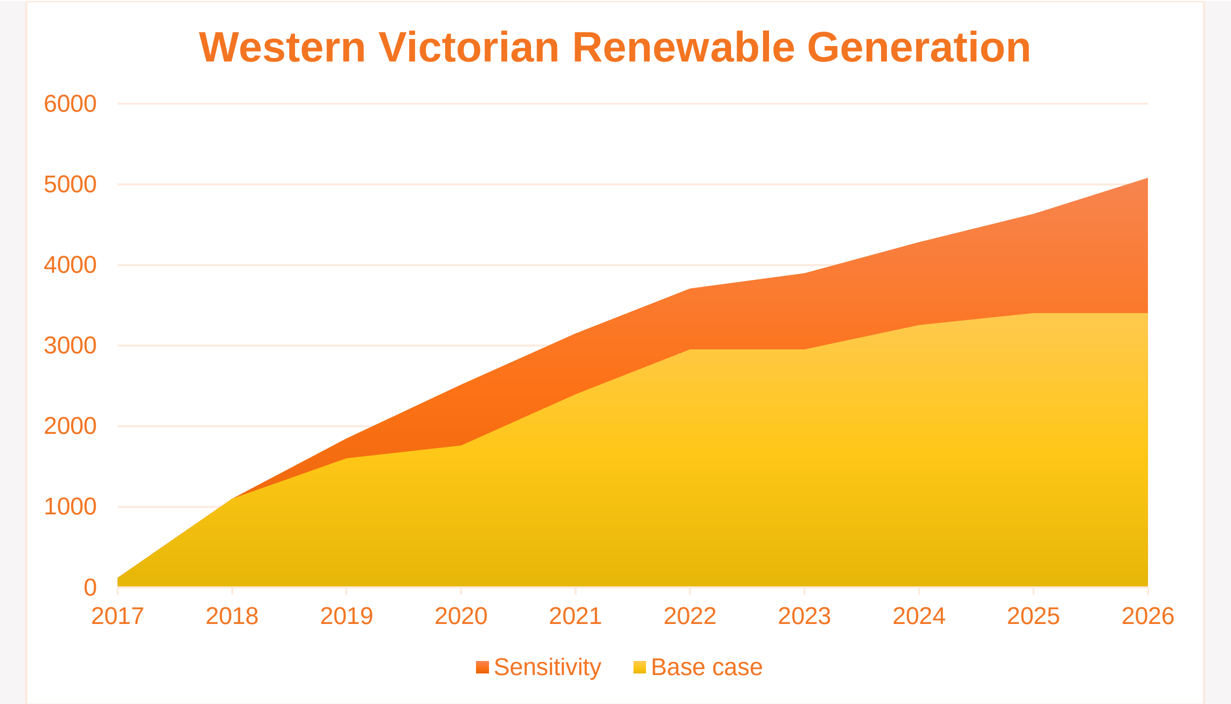
If existing limitations are considered, simulations of the Base Case scenario indicate that the VRET target could have a potential shortfall of around 3% per year. Strategic generator placement outside of Western Victoria, or connecting to the 500 kV network, will reduce the market impact of constraints, minimising the requirement for network investments. While the generators connected to the 500 kV transmission network will not be thermally constrained, any outage of a 500 kV line between Sydenham to Moorabool to Mortlake or Tarrone may result in a large market impact.

Generation uptake in both scenarios is summarised in Figure 5.

[7] Available at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/National-Transmission-Network-Development-Plan/NTNDP-database.

[8] Available at: http://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Victorian_Transmission/2016/Victorian-Electricity-Planning-Approach.pdf.

Figure 5 Expansion plan for new generation in Western Victoria



CHAPTER 6. NON-NETWORK OPTIONS

6.1 Information to be provided by proponents of a non-network option

Proponents of non-network options are welcome to make submissions on any Non-Market Ancillary Services (NMAS) they can provide to address the identified need outlined in this PSCR.

Submissions should include details on:

- Organisational information.
- Relevant experience.
- Details of the service.
- Cost of service, separating capital and operational expenditure.
- Confirmation of timelines in providing the service.

6.2 Required technical characteristics for a non-network option

6.2.1 Thermal limitation

This section describes the technical characteristics of the identified need that a non-network option would be required to deliver to resolve the thermal limitations in Western Victoria.

The primary market benefit associated with the non-network option is to reduce the expected amount of pre-contingency renewable generation curtailment, to ensure network loading remains within transmission asset limitations.

Table 3 below shows the maximum MW that is curtailed within one hour due to constraints on a transmission line, the longest continuous duration of this constraint, and the total energy constrained during this time. It also shows the total energy production lost due to constraints over a year. The constraints can affect both new and existing generation. The table assumes that total generation capacity is developed based on the total applications and enquiries described in Table 1.

The tables are intended as a guide for non-network service providers to understand the extent of the network limitations.

Table 3 Worst binding constraints and energy curtailed in 2027

Transmission line	Max MW constrained	Longest continuous constraint duration hours	Total GWh of energy curtailed continuously	Total GWh of energy curtailed annually
Ballarat – Horsham 220 kV transmission line	680	109	34	1134
Horsham – Red Cliffs 220 kV transmission line	629	46	11	558
Bendigo – Kerang 220 kV transmission line	449	11	3.4	526
Red Cliffs to Kerang 220 kV transmission line	869	9	3.8	247
Terang to Moorabool 220 kV transmission line	603	9	2.0	22

Due to the MW size and duration of constraints, it is unlikely that a non-network service could completely remove the expected limitations. Partially alleviating the constraints may, however, return net market benefits, and therefore will be explored in the PADR.

The non-network service must have the following minimum requirements:

- Have an aggregated capacity equal to at least 10 MW local consumption or energy storage, which can be sustained for at least one hour.
- Be able to be remotely dispatched using Supervisory Control and Data Acquisition (SCADA).
- Have a response time of 15 minutes or less for pre-contingency action, and 5 minutes or less for post-contingency action.
- Be provided for at least a three-year term, with the option to extend.
- Be available to be fully dispatched at shade ambient temperatures up to 50ºC.
- Be located close to any of the following terminal stations:
  - Ballarat Terminal Station.
  - Bendigo Terminal Station.
  - Horsham Terminal Station.
  - Kerang Terminal Station.
  - Red Cliffs Terminal Station.
  - Terang Terminal Station.
  - Wemen Terminal Station.
  - Ararat Terminal Station.

A non-network service provider will have access to the day-ahead forecasts that AEMO produces. If an energy storage solution like a battery is proposed, the operator may need to ensure that their battery is fully discharged to provide this service.

6.2.2 System strength limitation

This section describes the technical characteristics of the identified need that a non-network option would be required to deliver to resolve the system strength limitation in Western Victoria. Any investments to address low system strength are subject to the outcome of the AEMC's System Security Market Frameworks Review and proposed rule change likely to follow it.

The primary market benefit associated with the non-network option is to increase local fault current levels, to allow Western Victorian generators to operate within the parameters of their connection agreements.

The non-network service must have the following minimum requirements:

- Be able to operate correctly when connected to a weak network.
- Increase local fault levels at the following terminal stations:
  - Ballarat Terminal Station.
  - Horsham Terminal Station.
  - Kerang Terminal Station.
  - Red Cliffs Terminal Station.
  - Terang Terminal Station.
  - Wemen Terminal Station.
  - Ararat Terminal Station.

6.3 Request for Information submissions

In February 2017, AEMO published a Request for Information (RFI) on its website[9], asking for information on Non-Market Ancillary Services (NMAS) that can help alleviate thermal constraints on new generation that is expected to connect in Western Victoria.

AEMO received a number of submissions for storage solutions, and Demand Side Management (DSM). One control scheme proposal was received. A summary of the RFI submissions (grouped into two key categories) is provided in Table 4. The average cost for storage and DSM is used. The cost for implementing control schemes is not shown because AEMO received only one submission for this service.

Storage service providers can add further value by providing Frequency Control Ancillary Services, System Restart Ancillary Services, or synthetic inertia. Service providers can participate in the ancillary service markets to receive an additional revenue stream; however, this benefit will not be considered in assessing options for this RIT-T, since these services do not address the identified need. The provision of Voltage Control Ancillary Services will be considered in this RIT-T assessment.

Table 4 Summary of RFI submissions

	Cost	Capacity	Technical capability
Storage	$15M per 10 MWh	At least 10 MWh, solution is scalable if required	A storage solution can meet the identified need of reducing thermal constraints on transmission lines, by increasing local demand (charging) during periods of high generation output and low transmission line capacity. Storage solutions can easily meet the 15-minute response requirement.
Demand Side Management (DSM)	$2,000/MWh dispatch fee with a variable availability fee	Can meet 10 MWh requirement if combined with storage	A DSM solution can meet the identified need by scheduling loads to coincide with periods of high generation and low transmission line capacity. DSM solutions may have a limited capacity, and generally have low establishment costs.

[9] Available at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Victorian-transmission-network-service-provider-role/Regulatory-investment-tests-for-transmission.

CHAPTER 7. POTENTIAL CREDIBLE OPTIONS TO ADDRESS THE IDENTIFIED NEED

AEMO is aware of five potential options that could address the identified needs described in Section 3.

1. Minor network augmentations – This refers to minor line upgrades to remove rating limiting station equipment, and to enable wind monitoring. This option will not fully remove constraints on the worst affected lines, but can be deployed quickly. Control schemes to quickly run back or trip generation after a transmission line trip can be used to prevent pre-contingency generation curtailment.
2. New 220 kV transmission capacity – 220 kV transmission capacity can be gradually added to the worst congested parts of the network, as new generation becomes committed. New 220 kV transmission capacity may be enough for up to 1,500 MW of new generation capacity in the North-West Victoria area, between Ballarat to Red Cliffs to Kerang, although localised constraints may still be present.
3. New 275 kV or 330 kV transmission capacity – 275 kV or 330 kV transmission capacity can be added from Buronga Terminal Station to Red Cliffs Terminal Station, if the New South Wales transmission network between Buronga to Darlington Point is upgraded, and if a new South Australia to New South Wales interconnector is built.
4. New 500 kV transmission capacity – 500 kV transmission capacity may be required if over 1,500 MW of new generation capacity connects between Ballarat to Red Cliffs to Kerang, or if a new South Australian interconnector is connected to the area around Horsham Terminal Station.
5. Non-network options – Non-network options to address thermal limitations have been identified by a Request for Information that AEMO published in February 2017.[10] In general, non-network options will be treated as NMAS, and would be used to reduce transmission line loadings, or to increase local fault levels.

Network options to increase local fault levels[11] include installation of synchronous plant or new transmission lines, which can also address thermal issues.

The prices quoted in this section are high-level and based on historical project costs. AEMO welcomes submissions from providers of network services on the design details and costs of potential network options.

Table 5 compares each credible option against the criteria that a credible option must satisfy, based on clause 5.15.2 of the NER.

[10] Available at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Victorian-transmission-network-service-provider-role/Regulatory-investment-tests-for-transmission.

[11] Subject to the outcome of the AEMC's System Security Market Frameworks Review. Refer to Section 2 for more information.

Table 5 Compare credible options with NER 5.15.2 criteria

Option	Addresses the identified need	Is commercially and technically feasible*	Can be implemented in sufficient time to meet the identified need
Minor network augmentation	Minor augmentations can be used to reduce the thermal constraints in Western Victoria, but are unlikely to completely remove the constraint.	Yes	Yes
New 220 kV network capacity	Additional 220 kV network capacity could remove thermal constraints in Western Victoria, depending on the amount of new generation and if augmentation is economically justifiable.	Yes	This option may not be implemented on time, depending on when and where the new generators connect. The delay could result in market impact.
New 275 or 330 kV network capacity	Additional 275 or 330 kV network capacity could remove thermal constraints in Western Victoria, depending on the amount of new generation and if augmentation is economically justifiable.	Yes	This option may not be implemented on time, depending on when and where the new generators connect. The delay could result in market impact.
New 500 kV network capacity	Additional 500 kV network capacity could remove thermal constraints in Western Victoria, depending on the amount of new generation and if augmentation is economically justifiable.	Yes	This option may not be implemented on time, depending on when and where the new generators connect. The delay could result in market impact.
Non-network option	Non-network options can be used to reduce the thermal constraints in Western Victoria, but are unlikely to completely remove the constraint.	Yes	Yes**
Increase local fault levels***	Synchronous plant can be used to increase local fault levels. New transmission lines built to address thermal limitations will also increase local fault levels.	Yes	Yes

* The options are technically feasible, and commercial feasibility will be determined during the PADR stage of this RIT-T.
** Depending on the type and MW size of the non-network option.
*** Subject to the outcome of the AEMC's System Security Market Frameworks Review. Refer to Section 2 for more information.

It is likely that the recommended option will be a combination of several options listed in Table 5, since both minor augmentations and non-network solutions are unlikely to fully address the identified need, and network augmentation can address the identified need but is unlikely to be implemented on time. The requirement for increasing local fault levels will depend on the outcome of a transmission network augmentation.

7.1 Minor network augmentations options

Minor augmentations are transmission line upgrades that can be carried out at the terminal station, rather than along the transmission line. It involves replacing primary plant that is currently limiting transmission line ratings, and installing dynamic wind monitoring. Table 6 describes the minor augmentations, their costs (±50% error tolerance), and the approximate transmission line capacity increase that is obtainable under high wind speed conditions.

Table 6 List of potential minor augmentations

Transmission line	Description of works	Cost, $M	Approximate increase in capacity*, %
Bendigo to Kerang	Replace existing line traps and add wind monitoring	1.2	30%
Bendigo to Ballarat	Increase protection limit	0.1	<10%
Bendigo to Shepparton	Increase protection limit	N/A	N/A
Ballarat to Terang	Replace transmission line end spans and add wind monitoring	0.7	30%
Terang to Moorabool	Replace transmission line end spans and add wind monitoring	0.5	20%
Horsham to Ararat to Waubra	Replace existing line traps and add wind monitoring	0.9	20%
Horsham to Red Cliffs	Replace existing line traps and add wind monitoring	1.5	30%
Red Cliffs to Wemen to Kerang	Replace existing line traps and add wind monitoring	1.5	20%

* Based on continuous rating for a summer ambient temperature of 35°C, a winter ambient temperature of 5°C, and the maximum allowable wind speed for the conductor's design temperature.

Minor augmentations have a lead time of around 12 to 14 months.

These projects are non-contestable, and will be carried out by the asset owner, AusNet Services.

Control schemes to run back or fast trip generation after a critical transmission line outage will also be considered in the PADR.

7.2 220kV network augmentations options

This option involves progressively adding new 220 kV transmission line capacity to congested parts of the Western Victorian network. The timing and capacity of the required new lines will depend on generation connections.

Preliminary studies show that 220 kV network augmentations are only viable for up to 1,500 MW of new generation capacity in the North-West Victoria area, between Ballarat to Horsham to Red Cliffs to Kerang, although localised constraints may still be present.

New 220 kV transmission line capacity includes, but is not limited to:

- Thermal uprate of the existing transmission line.
- Re-conductor of the existing transmission line.
- Upgrade of the existing 66kV sub-transmission lines to 220 kV transmission lines, where applicable.
- Installation of a new transmission line, with single or double circuits. Any new transmission lines on new structures will require the acquisition of new easements (such as easement widening).
- New transmission lines can be built with 500 kV, 330 kV, or 275 kV transmission towers, initially operated at 220 kV, to allow these lines to be uprated to a higher voltage in future.

New reactive or dynamic reactive plant may be required, such as capacitors, reactors, static VAr compensators or synchronous condensers. Detailed studies will be carried out when determining the preferred solution, in the PADR stage.

Figure 6 shows a high-level overview of where additional 220 kV transmission network capacity may be required.

Figure 6 Potential 220 kV network augmentations in Western Victoria

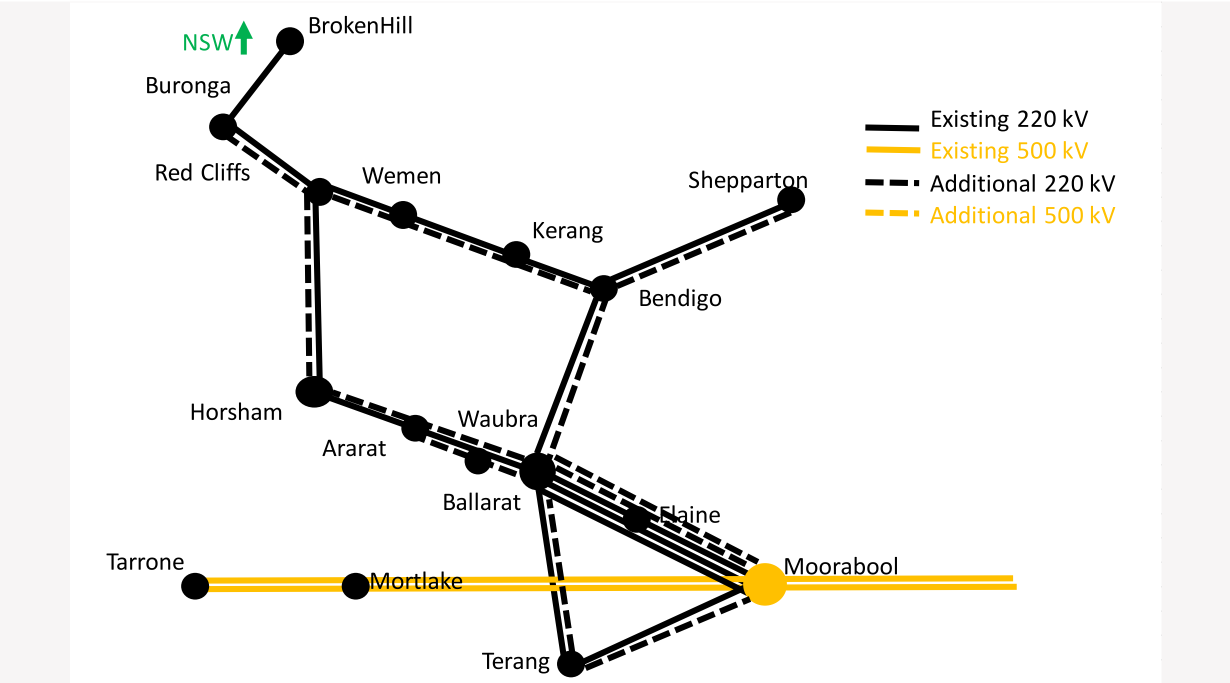


Table 6 gives a description of potential network augmentations, their drivers, and indicative costs. The indicative costs are based on duplicated transmission lines in new easements, and have an error tolerance of ±50%. Complications due to site conditions and construction staging can typically increase costs by up to three times. Further work to obtain more accurate cost estimates will be undertaken during the PADR stage.

Table 7 Potential 220 kV network augmentations options, costs and drivers

Description of work	Augmentation driver	Cost, $M
New transmission line capacity between Ballarat to Moorabool	High generation from Ballarat to Moorabool, and augmentation of the Ballarat to Waubra transmission line, leading to increased line flow from Ballarat.	57
New transmission line capacity between Bendigo to Shepparton	High generation from Bendigo, and upstream of Kerang	64
New transmission line capacity between Ballarat to Waubra to Ararat	High generation from Ararat to Ballarat. This constraint was reported in the 2016 VAPR.	75
New transmission line capacity between Ararat to Horsham	High generation from Horsham to Ararat	54
New transmission line capacity between Terang to Moorabool	High generation from Terang to Moorabool	72
New transmission line capacity from Ballarat to Terang	High generation between Ballarat and Terang	63
New transmission line capacity from Red Cliffs to Horsham	High generation from Red Cliffs to Horsham	144

Description of work	Augmentation driver	Cost, $M
New transmission line capacity from Red Cliffs to Wemen to Kerang	High generation at Red Cliffs, Wemen and Kerang, although generation at Red Cliffs will be constrained less than generation at Wemen and Kerang	127
New transmission line capacity from Ballarat to Bendigo	High generation from Ballarat, and low generation north of Bendigo. High generation north of Bendigo will reduce loading on the Ballarat to Bendigo transmission line.	53
New transmission line capacity from Kerang to Bendigo	High generation from Kerang	66
New transmission line capacity from Red Cliffs to Buronga	High generation around Horsham, Red Cliffs, and Kerang	8

All new transmission lines are assumed to be single circuit, except the Moorabool to Ballarat to Waubra path, which is a new double circuit. The Red Cliffs – Buronga transmission line may require augmentation if a new interconnector is built between South Australia to New South Wales that connects to Buronga. This is discussed in the next Section.

The estimated construction lead time for a new transmission line is three to seven years, subject to easement acquisition and obtaining necessary environmental and development approvals.

7.2.1 AusNet Services asset replacement plan review

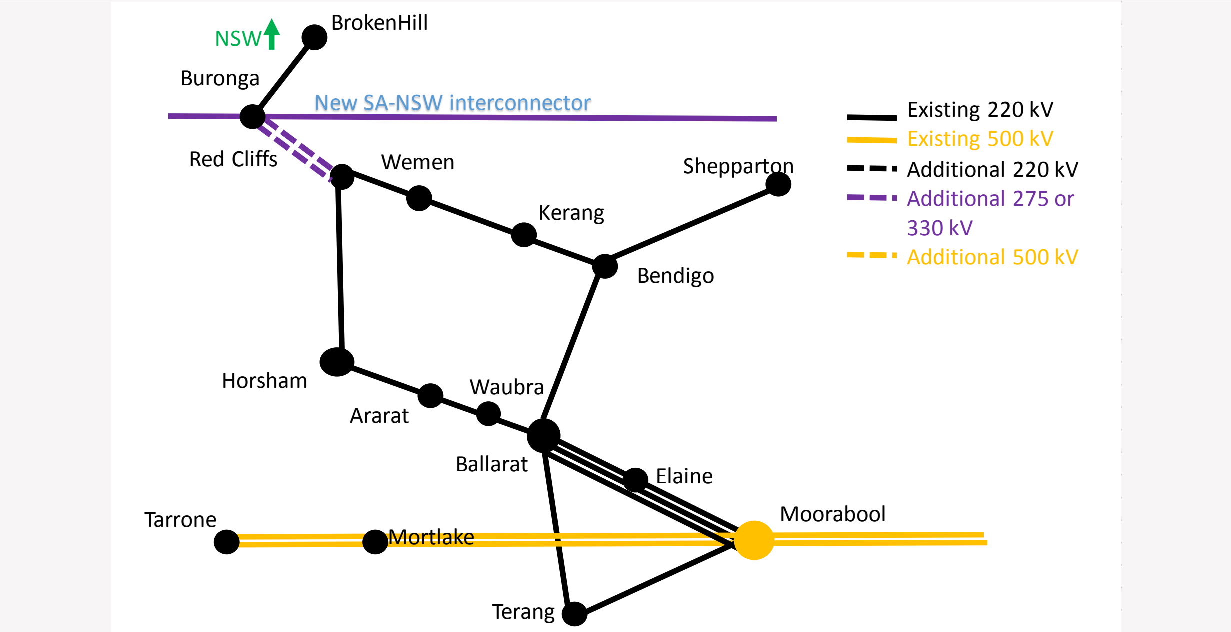
AusNet Services has the following planned replacements in Western Victoria:

- Install Optical Ground Wire (OPGW) from Ararat to Horsham by 2022, and install OPGW from Red Cliffs to Horsham by 2028. If OPGW is installed, the line trap replacement between Ararat, Horsham and Red Cliffs described in Section 7.1 will no longer be required. In addition, if new 220 kV capacity is built between Ararat, Horsham and Red Cliffs, OPGW can be built at the same time.
- Replace four transmission line structures, with conductors and insulators between Bendigo to Kerang, by 2025. This work could be carried out with the minor line works proposed in Section 7.1, or if new 220 kV network capacity is built between Bendigo to Kerang, OPGW can be built at the same time.

7.3 275 kV or 330 kV network augmentations

This option is contingent on a new interconnector from Robertstown in South Australia to Buronga in New South Wales, with a voltage of either 275 kV or 330 kV. It involves extending the transmission network from Buronga to Red Cliffs, to allow import and export of generation via the new interconnector. The new transmission capacity can be extended to other congested parts of Western Victoria, as required, or this option can be implemented with 220 kV network capacity, as described in Section 7.2.

Figure 7 Potential 500 kV network augmentation



The estimated cost of building a new 275 kV line augmenting between Red Cliffs to Buronga is $23 million (±50%). Complications due to site conditions and construction staging can typically increase costs by up to three times. Further work to obtain more accurate cost estimates will be undertaken during the PADR stage.

The estimated construction lead time is three to seven years, subject to easement acquisition and obtaining necessary environmental and development approvals.

7.4 500 kV network augmentation

This option involves building a new 500 kV transmission backbone at the most congested parts of the Western Victoria network, most likely between Horsham, Ballarat, and Moorabool, or between Horsham, Ballarat, and Sydenham.

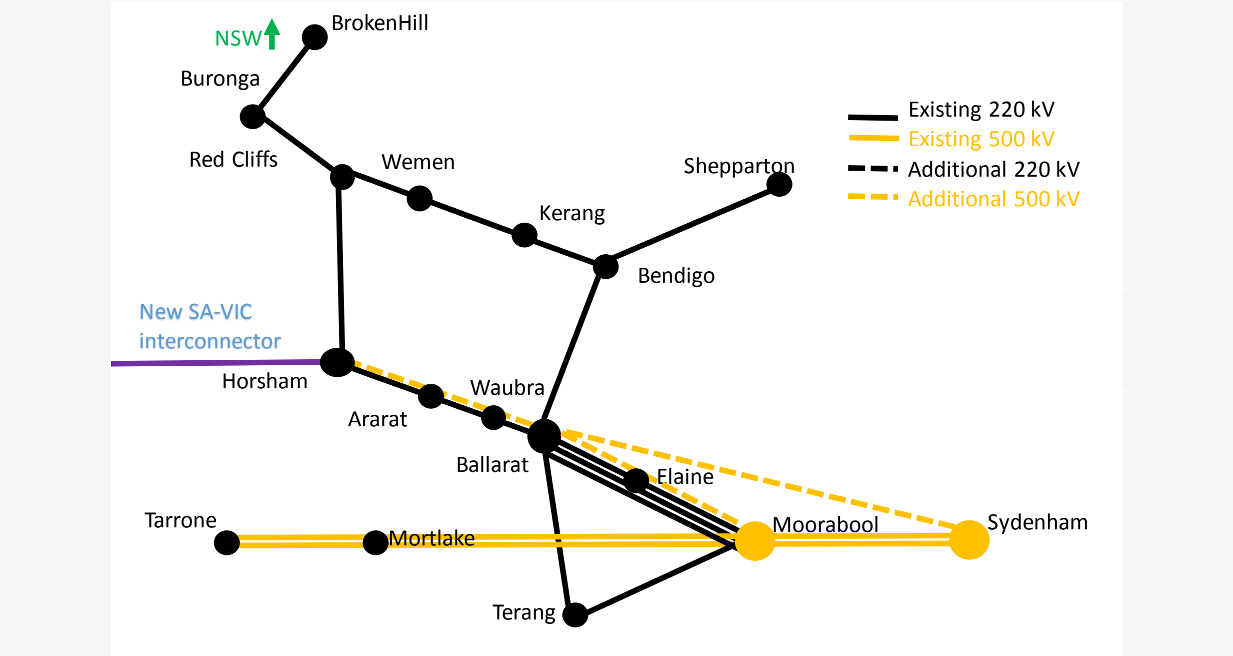
This option can be combined with the 220 kV, 275 kV, or 330 kV network augmentations described above. The timing and capacity of the required new lines will depend on amount and location of generation connections.

Building new 500 kV transmission lines will require new easements, and potentially land acquisition to set up a 500/220 kV switchyard. The benefits of this option will increase if a new South Australian interconnector is connected to Horsham Terminal Station, and if more renewable generation is connected in Western Victoria.

The estimated cost of this option is $600–$1,100 million (±50%). Complications due to site conditions and construction staging can typically increase costs by up to three times. Further work to obtain more accurate cost estimates will be undertaken during the PADR stage.

The estimated construction lead time is three to seven years, subject to easement acquisition and obtaining necessary environmental and development approvals.

Figure 8 Potential 500 kV network augmentation



7.5 Increase local fault levels

This option involves building new synchronous plant in Western Victoria, to increase local fault levels.[12] A preliminary study based on assumptions used in the 2016 NTNDP showed that new synchronous condensers may be required around Red Cliffs Terminal Station, Horsham Terminal Station, and Ballarat Terminal Station with a combined size of approximately 350 MVAr and an indicative cost of $150 million (±50%).

The estimated construction lead time is two years.

Detailed technical studies and additional consultation between AEMO, the local Network Service Provider and relevant generators will be required to accurately identify the minimum level of system strength required in Western Victoria, and to determine the size, locations and cost of new synchronous condensers.

A staged approach will be used when implementing network options, with the construction of transmission line prioritised (if economically justifiable), due to transmission lines requiring the longest lead time. Synchronous condensers (if economically justifiable) will only be built if maintaining minimum system strength is AEMO's responsibility (as a declared network function), and as new generators become committed.

7.6 Options considered but not progressed

The following options were considered but not progressed:

- High voltage direct current (HVDC) option – HVDC based on a voltage source converter is a viable option to connect renewable generation in Western Victoria to the Victorian 500 kV network. The feasibility of this option will be further explored in the PADR.
- Scale Efficient Network Extension (SENE)[13] – This involves comparing the cost of potential new generator connections to a transmission network augmented by a SENE, to the cost of connecting the same capacity of new generators in the absence of the SENE extension. This RIT-T does not consider SENE design and costing, because AEMO has not received a request for a SENE Design and Costing Study as specified in clause 5.19 of the NER.

[12] Subject to the outcome of the AEMC's System Security Market Frameworks Review. Refer to Section 2 for more information.

[13] AEMC NER. Available at: http://www.aemc.gov.au/Energy-Rules. Scale Efficient Network Extension means an augmentation to a transmission network which is capable of facilitating the future connection to the transmission network of two or more generating systems in the same geographic area that have different owners, operators, or controllers.

7.7 Material inter-regional impact

The generation development in Western Victoria is expected to have the following inter-regional impact:

- Murraylink – This is a ±220 MW HVDC interconnector connected to Red Cliffs at 220 kV in Victoria and Monash at 132 kV in South Australia. High generation in Western Victoria is expected to increase congestion in South Australia when Murraylink flow is from Victoria to South Australia, due to thermal limitations around Robertstown. The constraints will not cause unserved energy. The existing Murraylink runback schemes will have to be redesigned to account for new generators in Western Victoria.
- Heywood interconnector – This is a 275 kV interconnector connected to Heywood in Victoria and South East in South Australia. High generation connected to the 500 kV network in Western Victoria is not expected impact the interconnector.
- Red Cliffs to Buronga 220 kV transmission line – The loading on this transmission line will be increased by high renewable generation in Western Victoria. The line flow will also increase if a new interconnector is built between Robertstown in South Australia and Buronga in New South Wales. Constraints on the Red Cliffs to Buronga 220 kV transmission line, as well as other transmission lines in Western Victoria, may constrain the transfer capacity of this new interconnector.
- Victoria to New South Wales interconnector – This refers to five transmission lines between Victoria and New South Wales, including the Red Cliffs to Buronga transmission line above. High generation from Western Victoria will increase the flow from Victoria to New South Wales, and increase the frequency of Victoria to New South Wales interconnector constraints.
- Tungkillo to Horsham 275 kV interconnector – This is a proposed new interconnector from South Australia to Victoria, which is likely to increase transmission line flows from Horsham to Ballarat to Moorabool. Without augmentations, local constraints within Victoria are likely to constrain the interconnector capacity.

7.8 Next steps

AEMO will assess the net market benefits of all credible options and publish the results in the PADR within 12 months from 14 July 2017.

In addition to the work carried out for the current report, the PADR will also:

- Carry out scenario studies for:
  - Different demand scenarios.
  - Different generator expansion plans.
  - A new interconnector from South Australia to Victoria (Horsham).
  - A new interconnector from South Australia to New South Wales.
- Assess optimal transmission line routes for proposed new transmission lines.

The PADR will recommend network investment based on the option that returns the highest market benefit, under all assessed scenarios.

AEMO will also take into consideration any external variables that will influence the RIT-T outcome, including:

- The proposed Victoria Renewable Energy Target.
- Any new committed generation in Western Victoria.
- The outcome of the South Australian Energy Transformation RIT-T.
- Relevant findings from the VAPR.
- The outcome of the AEMC's System Security Market Frameworks Review.

CHAPTER 8. MATERIALITY OF MARKET BENEFITS

AEMO is required to consider all classes of market benefits as material, unless it can, in the project specification consultation report, provide reasons why:

- A particular class of market benefit is not likely to materially affect the assessment outcome of the credible options for this RIT-T; or
- The estimated cost of undertaking the analysis to quantify the market benefit is likely to be disproportionate to the scale, size, and potential benefits of each credible option being considered in the report.

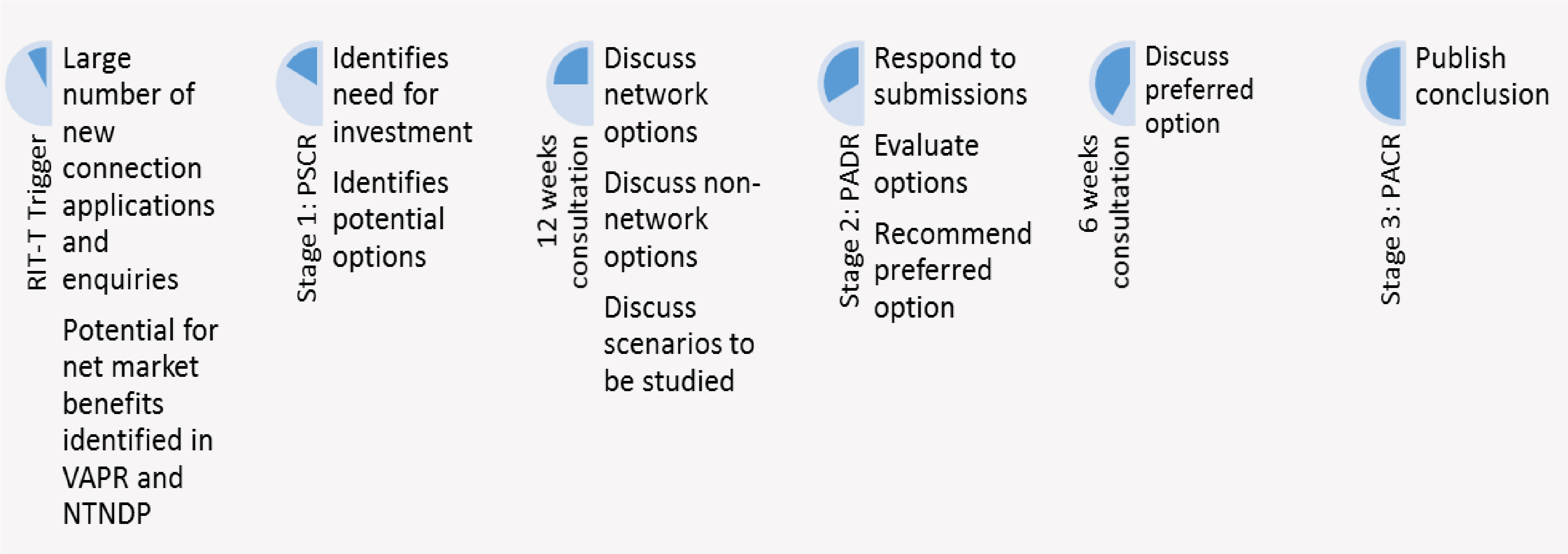
At this stage of the consultation, AEMO considers that the following classes of market benefits are not material for this RIT-T assessment for any of the credible options:

- Changes in ancillary services costs – There is no expected change to the costs of Frequency Control Ancillary Services (FCAS), Network Control Ancillary Services (NCAS), or System Restart Ancillary Services (SRAS) as a result of the options being considered. These costs are therefore not material to the outcome of the RIT-T assessment. The AEMC is reviewing the regulatory frameworks used to manage NEM security, and has identified potential new services that may be required due to the rapidly changing generation mix.[14] The results of this review may have an impact on ancillary service costs, and will be studied in the PADR stage, if required.
- Changes in voluntary/involuntary load curtailment – This RIT-T is driven by new generation connections and there is no expected change to voluntary or involuntary load curtailment as a result of the options being considered.
- Competition benefits – There is no expected change to competition benefits, because Victoria currently has multiple different generation service providers, and is connected to the NEM via three interconnectors.
- Differences in the timing of transmission investment – The outcome from this RIT-T is not likely to defer any planned transmission investment. It may impact the benefits of building a new South Australia Interconnector, and this will be studied in the PADR stage.
- National Renewable Energy Target (RET) – Some of the generation affected by the congestion will be registered in the RET, while stage two (post 2020) VRET generation will be additional to the RET. Removing network congestion may therefore create some benefit by assisting the industry's achievement of the RET. However, it is not possible to identify the extent of this, because exactly which generators suffer the congestion will depend on unknown dispatch outcomes. At this time, AEMO has not ascribed an additional benefit associated with meeting the RET.

[14] Available at: http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review.

APPENDIX A. RIT-T PROCESS

Figure 9 RIT-T process and next steps



APPENDIX B. ASSUMPTIONS

B.1 Demand

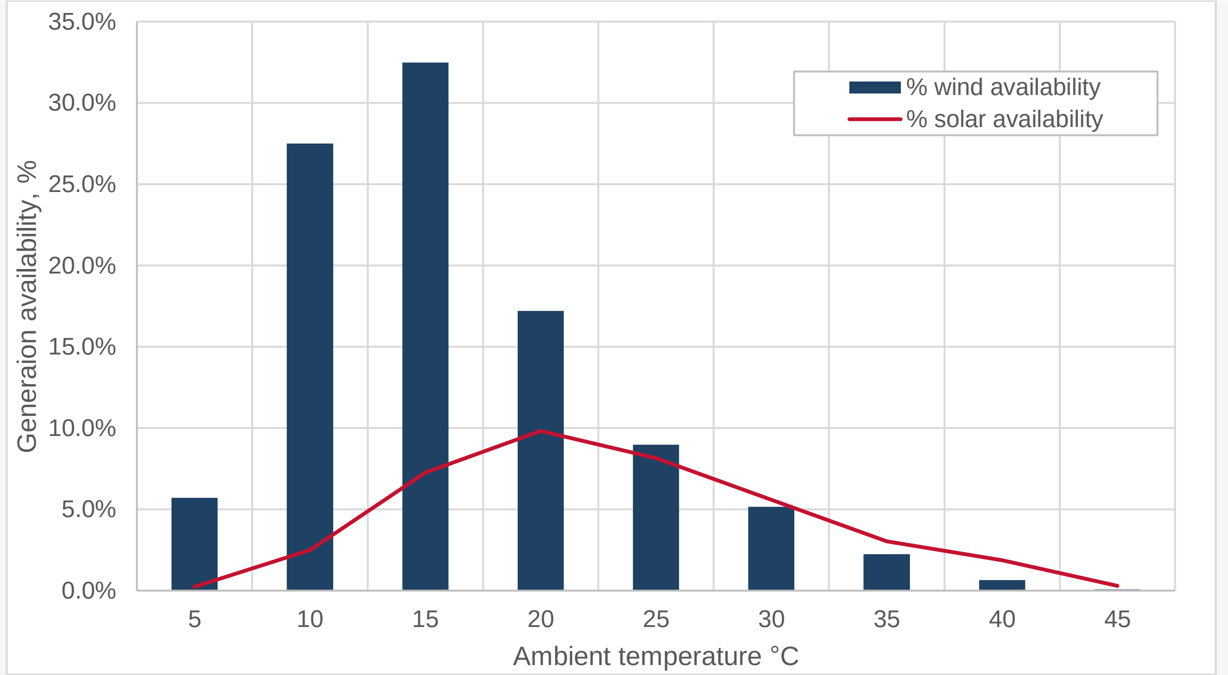
The 2017 VAPR connection point demand forecasts have been used in these RIT-T market simulations. As the congestion in Western Victoria referred to in this RIT-T is generation-driven, only a 50% POE scenario under neutral economic growth, using a 2013–14 reference year, was considered. The 2013–14 reference year is consistent with the 2016 NTNDP and 2016 National Electricity Forecasting Report (NEFR) studies. A 10% POE scenario has not been considered in the PSCR, due to only minor increases in constraint binding hours from the 50% POE scenario.

B.2 Availability of renewable resources

A 2013–14 reference year was used to forecast wind and solar resource availability. This methodology is consistent with what was used in the 2016 NTNDP and the 2016 NEFR.

The limitations to this approach are that 2013–14 had low wind and solar output when the ambient temperature is high and the transmission network is the most thermally limited, which may result in less generation curtailment. Using a different reference year would result in different availability of renewable resources, and may impact the potential market benefits. This will be considered in more detail in the PADR.

Figure 10 Percentage of generation availability vs ambient temperature



B.3 Transmission network parameters

B.3.1 Ratings

All thermal ratings were developed using dynamic parameters and a 2013–14 reference year ambient temperature trace. Some transmission lines are limited by substation equipment, or their protection settings.

15-minute short term ratings were used for contingency constraint equations.

Stability and voltage limitations in Western Victoria were not considered in the PSCR, and will be explored further in the PADR.

B.3.2 Constraints

Thermal constraints were built under system normal and contingency [(N-0) and (N-1)] conditions for all lines in Western Victoria, with a voltage level of 220 kV and above. Constraints were validated against different demand, interconnector, and generation dispatch scenarios within an error margin of 25 MW. The single worst critical contingency was considered for each line under a high wind output and a high solar output scenario.

Limitations driven by the VRET outside of Western Victoria are not considered as part of this RIT-T, and will be studied in detail in the 2017 VAPR.

B.3.3 Augmentations & retirements

The following augmentations were included when developing constraint equations for Western Victoria:

- Deer Park Terminal Station.
- New Ballarat to Moorabool 220 kV No.3 transmission line.
- Decommissioning of Templestowe and Brooklyn synchronous condensers.
- Retirement of Hazelwood Power Station generation.

B.3.4 Market modelling

Market simulations were consistent with the methodology outlined in the AER's RIT-T Methodology Guideline.[15] That is, for each scenario, the *state of the world* with the credible option in place was compared to the *state of the world* in the base case. To identify market benefits, the *state of the world* with the credible option in place was assumed to be a scenario where all renewable generation was allowed to run unconstrained by network limitations in Western Victoria. The difference between the dispatch cost in this scenario and a scenario with the network limitations in place shows potential market benefits of removing Western Victoria network limitations.

B.3.5 Generation dispatch

Re-dispatch of generation is valued using the SRMC of generation. The SRMC of generation used in this RIT-T derives from the 2016 NTNDP database.[16]

Market dispatch is undertaken on a least-cost basis, oriented towards minimising the cost of serving load, while meeting minimum reserve levels (least-cost market development modelling), meeting relevant Renewable Energy Targets, and staying within the parameters of any transmission network constraints.

[15] Available at: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/regulatory-investment-test-for-transmission-rit-t-and-application-guidelines-2010.

[16] Available at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/National-Transmission-Network-Development-Plan/NTNDP-database.

B.4 Generator parameters

A new generator's active power capacity is modelled based on the connection enquiry or application received by AEMO. The generator is assumed to be capable of supplying and absorbing an amount of reactive power equal to 0.3 times its active power capacity, based on recent wind generator parameters. Details of new generators will be required during the PADR stage for increased modelling accuracy.