Monash
Energy Materials & Systems
Institute

Solving Global Energy Problems

14th July 2017

Dear Mr Kiet Lee,

We are pleased to include a submission prepared by the Monash Energy Materials and Systems Institute (MEMSI) in response to AEMO's Project Specification Report for Western Victoria Renewable Integration. In it we propose a new approach to the assessment of the value of expanding the transmission system in Western Victoria consistent with the RIT-T process. With this approach, it is possible to accommodate the transformation of the electricity industry toward a lower level of carbon emissions in a system-wide manner.

MEMSI is Monash University's point of contact for energy related research. MEMSI is a cutting-edge, interdisciplinary research environment that brings together over 80 leading academics across 6 faculties working in the area of energy. Its mandate is to work in collaboration between academic, industry and government partners to address the grand energy challenges of today and tomorrow.

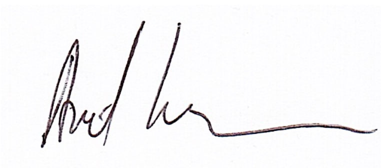
The attached report has been written by MEMSI affiliated leaders who have strong industry and academic background in the area of network techno-economic analysis and are passionate energy advocates.

Our MEMSI team is working on system modelling to support SENE's for renewables, grid-scale storage as well as options for the microgrid integration into energy systems using the PLEXOS Integrated Energy Model supported by advanced Data Science with cloud computing for enhanced speed. We have identified a need for a new methodology to support strategic planning and mapping of the uncertain factors which influence the value of various technological solutions. This new methodology has a specific focus on network development and deployment of storage and distributed generation resources. The submission outlines how we consider such methods might assist the electricity industry to find efficient solutions to maintain secure and reliable supply during the transformation already in progress.

MEMSI is keen to support this RIT-T in particular and AEMO's system planning initiatives in general including potential contributions to next year's National Transmission Network Development Plan. This support can be provided as part of our new grid related industry partnership program that include a Future Electricity Network Control Room (FCR) shortly to be announced.

Thank you for the opportunity to provide feedback around this important issue facing Victoria and the National Electricity Market. We hope that the report provides the necessary insights to positively contribute to shaping the development of transmission services in Victoria and adjacent NEM regions.

With kind regards,



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Western Victoria Renewable Integration

Monash
Energy Materials & Systems
Institute

Solving Global Energy Problems

Response to Project Specification for Western Victoria Renewable Integration

11th July 2017

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Summary

A review of the Project Specification for the development of the transmission system in Western Victoria has identified the need for a more comprehensive assessment of regional energy resources and the role of transmission augmentation and large and small scale energy storage to assist the transition to a low emission energy system.

The purpose for augmenting the network in Western Victoria is two-fold:

1. Primarily to provide for connection of additional renewable energy generation (wind and solar Power) in Western Victoria
2. Secondarily to increase system strength so that voltage is less sensitive to changes in power flow in the network and protection equipment can operate correctly to remove faulted equipment.

There is also a third purpose which is not explicit in the Project Specification and that is to provide for, or be compatible with, enhanced interconnections between Victoria, South Australia and south-western New South Wales. It is very likely that there will be opportunities to connect additional renewable energy resources in adjacent interstate regions that would have an influence on optimal network design in Western Victoria. The Project Specification mentions possible interconnection with South Australia at 500kV via Horsham as a possible development in association with a new 500kV extension in Western Victoria. However, extension of 500 kV transmission to Snowy and NSW may also be prospective if the Snowy Scheme is upgraded by 2000 MW with new pumping and storage capacity as proposed by the Federal Government.

The scope of work as proposed by AEMO would benefit from:

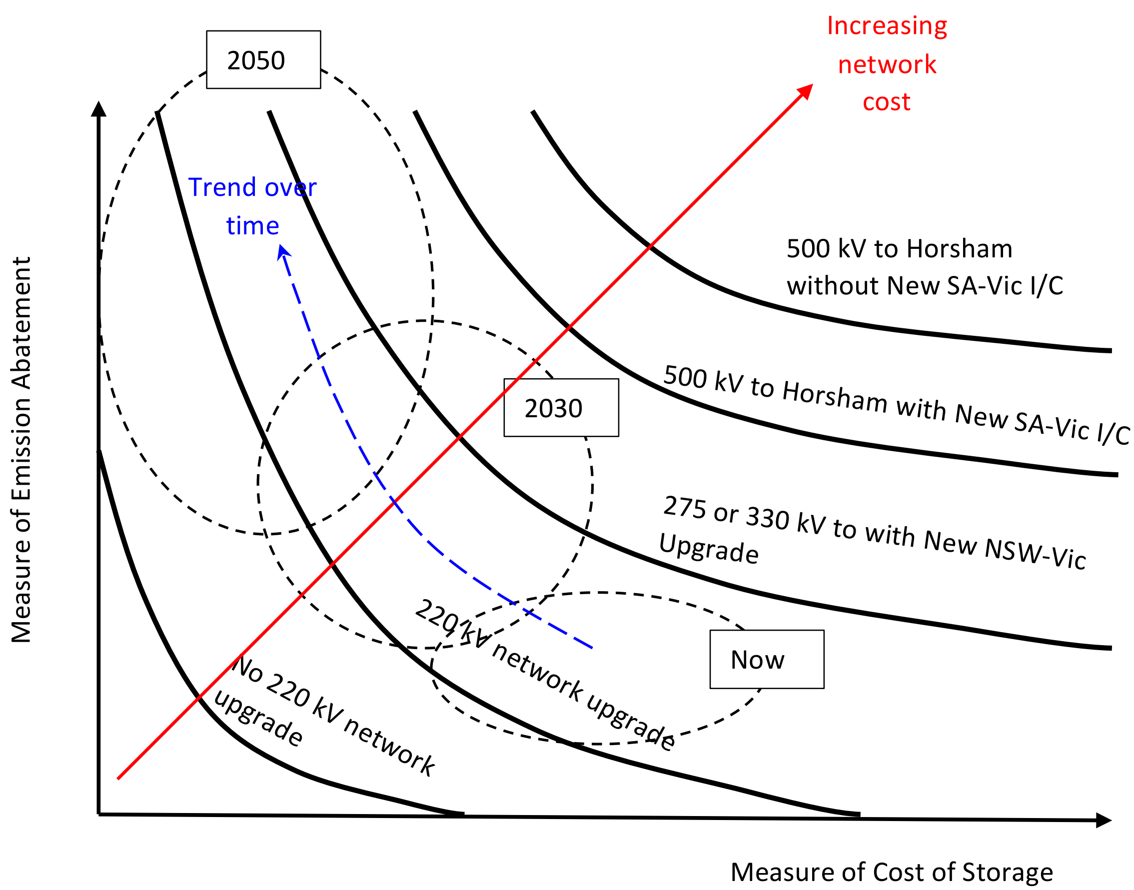
1. a Scale Efficient Network Extension (SENE) analysis of the region between southern NSW and south-eastern South Australia to examine the full potential for production of renewable energy in this region and to determine a strategy for subsidiary networks to connect the prospective generation projects and to design an ultimate network concept for the region with ultimate developments of 500kV or above
2. consideration of the interactions with interconnection developments between South Australia, Victoria and NSW
3. consideration of the impact that the proposed 2000 MW upgrade of Snowy would have in optimising the Western Victorian grid.

A SENE analysis would identify where the more favourable energy generation resources are located and the transmission plan could include new loops or radial connections to favourable sites which would help to direct and make more feasible investment closer toward these locations. Making assumptions about generation levels, connection locations and time scales without such fundamental analysis is speculative and not a robust basis for transmission network planning.

The main uncertainties are caused by possible variability in emission abatement policy and the trends in technology costs, particularly large and small scale storage. An analysis of network augmentation value for a

single year based on a range of values of the various uncertain factors could be used to identify what combinations of conditions would make particular strategies robust in the longer term. This would inform a strategy map which shows graphically for various key dimensions how the various factors combine to justify various levels of network capacity, particularly the maximum voltage level: 220 kV, 330 kV or 500 kV. The analysis would also show how the Western Victorian network design integrates with the future prospective interconnections. Figure 1 shows a conceptual example of a strategy map for the dimensions of emission abatement and storage cost. The heavy black lines show where the market conditions justify an increase in the highest system voltage and associated network developments. The black dashed line indicates the regions where the glide path from the current state to the future state are anticipated in future scenarios in various periods. The red line shows the direction of increasing network costs. The blue dashed line shows the glide path from the current to future market conditions. The strategic map illustrates that 500 kV options would have limited value and that an ultimate least cost plan would be expected to have 220 kV and 275 kV and/or 330 kV transmission options.

Figure 1 Concept for transmission potential where 220kV solutions remain sufficient



The options and analysis need to be expanded to assess:

1. The long-term development of the regional centres of Ballarat and Bendigo to support decentralization away from Melbourne together with high speed rail infrastructure. Beyond 2025, as more renewable energy is developed in regional areas, and it becomes more costly to make Melbourne's energy supply sustainable, it is likely that the regional centres will develop further because they are closer to the sources of renewable energy. This would potentially mean a relative change in the value of the transmission options depending on the pattern and rate of regional growth. It will be important that the studies show how regional growth changes the value of the options. This may be affected by high speed electric rail services and electric vehicles later this century.
2. The optimal configuration for how the renewable energy projects can be interconnected with each Terminal Station location by means of radial or looped connections so as to avoid a spaghetti network and proliferation of high voltage power lines. This may involve:

   a. 66 kV networks for connection to an ultimate 220kV grid
   b. 220 kV networks for connection to an ultimate 500 kV grid
   c. 220 kV loops that connect to new generation remote from existing easements
   d. New 500 kV connections to the regional centres to support rapid expansion of these cities with electric transportation infrastructure

   An example of what this might look like is shown in Figure 4 with four additional 220kV loops and three new 500kV Terminal Stations. This figure is derived from Figure 6 in the AEMO Report.

3. The optimal configuration of 275 kV, 330 kV and 500 KV powerlines to provide for future inter-regional development having regard to resources in
   a. South-eastern region of South Australia
   b. Coastal wave power or off-shore wind power should it become viable
   c. South NSW, especially solar thermal resources which may incorporate thermal storage

This work would give a short-hand answer to the question as to how the setting of emission abatement targets, both national and state, will influence the amount and location of generation that would be sought to be connected, and would inform the threshold levels that would require:

1. Upgrade beyond the current 220 kV system
2. Upgrade to 275 kV or 330 kV connections with connection between NSW and South Australia
3. Provision for 500 kV connections through to Horsham or other regional centres for potential interconnection with South Australia.

This understanding would then provide a strategic road map to support the development of the first steps towards upgrading the Western Victorian network having regard to all these uncertainties.

Figure 2 Adaptation of Figure 6 from AEMO Report to show other easement options for connection of generation

This potential expansion of scope complicates the analysis and yet if it is not completed, there is a risk of lack of clarity at the end of the currently proposed Project Assessment. An alternative approach which will give better understanding of the impact of uncertainties is proposed in this response.

Essentially there are two ways of approaching this study as illustrated in Figure 3. The current Project Specification Consultation Report (PSCR) represents the process that ultimately will lead to regulatory tests for specific projects. This is informed by the National Transmission Network Development Plan (NTNDP) and should be informed by SENE analyses that show the need to extend the network for connection of regional generation resources. The dashed blue line in Figure 3 encompasses the processes invisaged in the Project Specification Report, notably without a SENE style process and comprehensive assessment of regional energy resources and demand growth for regional development.

It is proposed that a more comprehensive assessment of energy sources for Western Victoria and neighbouring regions be progressed including generation, transmission and demand side resources to provide a master plan that should serve the region for the full transition to renewable enegry resources over the middle of this century.

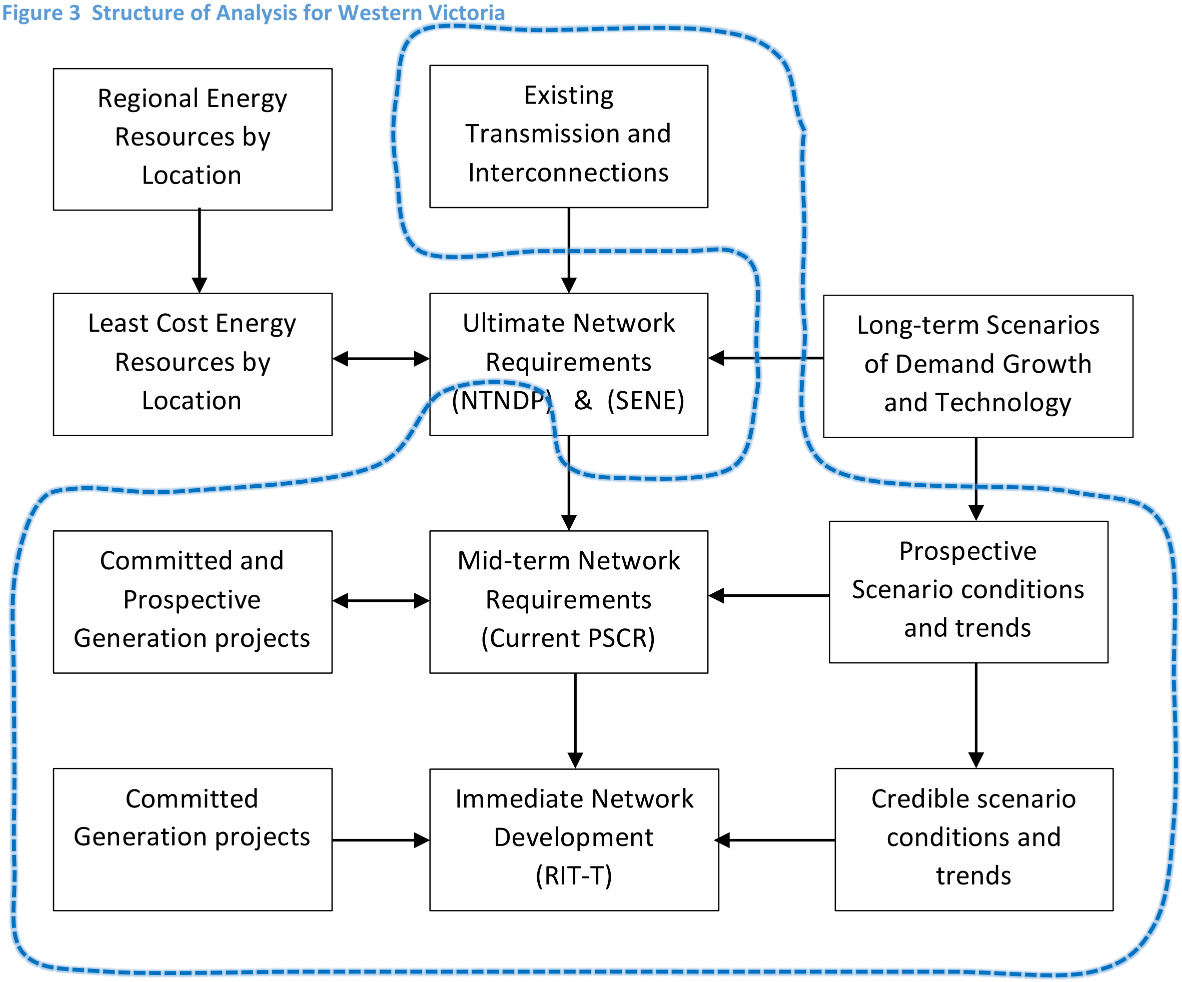


Figure 3 Structure of Analysis for Western Victoria

CONTENTS

Summary 4

Introduction 13

Purpose of the network extension 14

Options to be considered 16

Issues with options and strategy 18

- Lead time 19
- Mix and timing of options 19
- Broader focus is needed 19

AEMO's Approach 22

Integration of Generation and Transmission Planning 23

Alternative Strategy 24

- Assumptions 24
- Key uncertainties 24
- Strategy 25

Specific Comments on the Report 39

- Chapter 2 39
  - Sequential analysis for Western Victoria and interconnectors 40
- Chapter 3 40
- Chapter 4 41

Chapter 5 41
Chapter 6 42
Chapter 7 42

ABBREVIATIONS

AEMC	Australian Energy Market Commission which makes rules to govern gas and electricity markets
AEMO	Australian Energy Market Operator which operates the two large interconnected electricity markets in Australia
HVDC	High Voltage Direct Current (power transmission technology)
LET	Low Emission Target to support low emission thermal power technologies
LRET	Large Scale Generation Renewable Energy Target for Australia (currently 33 TWh by 2020 to 2030)
NEM	National Electricity Market
NER	National Electricity Rules
NTNDP	National Transmission Network Development Plan prepared by AEMO
PSCR	Project Specification Consultation Report
RIT-T	Regulatory Investment Test fort Transmission
SENE	Scale Efficient Network Extension
VRET	Victorian Renewable Energy Target

Introduction

The development of the transmission system in Western Victoria is a critically important project for the enabling of connection of renewable energy resources to support the transformation of the electricity supply to remove the burden of carbon emissions during this century. Previously, the dominant source of electricity supply in Victoria was from the brown coal reserves in the Latrobe Valley and to a lesser extent the small brown coal deposit near Anglesea[1]. Peaking power is available from the Snowy Scheme in Southern NSW and from gas fired power stations in the Latrobe Valley, the Melbourne metropolitan area and from Mortlake in Western Victoria. The interconnections with NSW, South Australia and Tasmania also provide peaking supply and allow the optimisation of the utilisation of National Electricity Market (NEM) energy resources for electricity production and utilisation.

The base load brown coal generation resources in the Latrobe Valley will be progressively replaced by:

- renewable energy resources, both large and small scale from throughout Victoria and interstate
- support from existing and additional gas fired generation at times of low renewable energy production
- large scale and distributed small scale energy storage resources
- changes in inter-regional power flows with neighbouring states due to changes in their electricity production as influenced by changes in Victorian supply and demand.

The development of the transmission system in Western Victoria to enable up to 5000 MW of additional renewable energy resources to be connected as advised by the Australian Energy Market Operator (AEMO) is intended to be designed, scaled and staged to maintain the lowest cost of electricity supply to consumers to meet the regulatory investment test for transmission (RIT-T). Achieving the lowest cost will require consideration of the impact on electricity production and utilisation across the NEM. The difficulties in conducting such an evaluation of least cost arise from many uncertainties such as follow:

1. the actual location at which proponents will seek to build new renewable energy facilities
2. when and where they will seek to connect to the transmission system
3. the rate at which renewable energy generation will grow in Western Victoria to meet new loads and displace thermal power generation
4. the rate of load growth in the Western Victorian region.

These uncertainties depend on many external factors as influenced by regulatory, environmental and energy policy factors.

[1] The deposit exploited by Alcoa to partially supply the Point Henry aluminium smelter, is now closed.

Key Project Development Uncertainties

1. the actual location at which proponents will seek to build new renewable energy facilities
2. when and where they will seek to connect to the transmission system
3. the rate at which renewable energy generation will grow in Western Victoria to meet new loads and displace thermal power generation
4. the rate of load growth in the Western Victorian region
5. the effect of distributed generation on transmission system loading and the value of energy storage.

This document reviews key features of the AEMO document "Western Victoria Renewable Integration Project Specification Consultation Report" dated April 2017.

It is recommended that the scope of the study should be extended to:

1. commence with a Scale Efficient Network Extension (SENE) analysis of the region between southern NSW and south-eastern South Australia to examine the full potential for production of renewable energy in this region and to determine a strategy for subsidiary networks to connect the prospective generation projects and to design an ultimate network concept for the region with ultimate developments of 500kV or above
2. consider interactions with interconnection developments between South Australia, Victoria and NSW
3. consider the impact that the proposed 2000 MW upgrade of Snowy would have in optimising the Western Victorian grid.

A SENE analysis would identify where the more favourable energy generation resources are located and the transmission plan could include new loops or radial connections to favourable sites which would help to direct investment toward these locations. Making assumptions about generation levels, connection locations and time scales without such fundamental analysis is speculative and not a solid basis for transmission network planning.

It is expected that the proposed study would include a comprehensive analysis of the impact of the growth in distributed generation in the region as affected by potential changes in network service pricing and technology cost trends.

Purpose of the network extension

The purpose for augmenting the network in Western Victoria is two-fold:

1. Primarily to provide for connection of additional renewable energy generation (wind and solar Power) in Western Victoria
2. Secondarily to increase system strength so that voltage is less sensitive to changes in power flow in the network and protection equipment can operate correctly to remove faulted equipment.

There is also a third purpose which is not explicit in the Project Specification and that is to provide for, or be compatible with, enhanced interconnections between Victoria, South Australia and south-western New South Wales. It is very likely that there will be opportunities to connect additional renewable energy resources in adjacent interstate regions that would have an influence on optimal network design for Western Victoria. The Project Specification mentions possible interconnection with South Australia at 500kV via Horsham as a possible development in association with a new 500kV extension in Western Victoria.

The identified need is "to increase the thermal capability of the Western Victorian power system to reduce constraints on anticipated new connected generation"[2]. The basic issue is that the amount of generation seeking to connect at existing terminal stations is well in excess of the spare capacity currently available that could provide mostly unconstrained access. Due to the nature of electricity demand and generation and its peaky nature, an efficient network will be expected to have some residual level of constraints which occur infrequently. The expected cost of these constraints in an efficient network is less than the cost of upgrading the network to remove any of the residual constraints. This is the basis for probabilistic network planning in Victoria where the cost of network plus expected constraints is minimised[3] .

Two scenarios for the ramp up of generation in Western Victoria are proposed:

- Develop 3000 MW by 2025
- Develop 5000 MW by 2027

In part, these targets are derived from the proposed Victorian Renewable Energy Target (VRET) which is expected to deliver up to 1,500 MW by 2020 and 5,400 MW by 2025, according to the State Government, as referenced in the AEMO Project Specification report.

In principle, there is no physical barrier to connection of additional generation, however, there is an economic barrier in that the new and existing generation in Western Victoria would be constrained by thermal power limits on the existing power lines for up to about 55% of the generation output[4]. Therefore, there is likely to be economic value in progressively upgrading the network infrastructure with support from distributed voltage control equipment to enable the Western Victorian energy resources to be expanded to meet the renewable energy and decarbonisation objectives.

Thus the identified need as stated in the AEMO Project Specification may be summarised as responding to system limitations that would result if a large amount of new renewable energy generation were to be connected in Western Victoria:

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[2] Western Victoria Renewable Integration Project Specification Consultation Report, April 2017, page 11
[3] https://www.aer.gov.au/system/files/VENCorp%20electricity%20transmission%20planning%20criteria.PDF describes the method originally adopted by VENCorp before AEMO took over planning responsibilities for Victorian transmission
[4] 55% estimated by extrapolating from 1600 GWh constrained at 3000 MW as per Figure 4 of the AEMO Report to 5800 GWh constrained at 5000 MW assuming average 25% capacity factor for new renewable generation and no storage.

1. Thermal power transfer constraints on the existing power lines would apply and limit output of Western Victorian generation such as to erode its economic value, with up to 55% of generation constrained off. This would result in inefficient generation dispatch;
2. Thermal constraints on the network outside Western Victoria, including interconnections, may also constrain generation within Western Victoria.

and arising from low system strength:

3. Emerging inability to control voltage during normal system and market operations such as switching network equipment
4. Manufacturer's design limits on power converter-interfaced devices may be violated leading to damage to equipment, system instability and disconnection from the grid
5. Protection systems not operating correctly to remove faulted equipment
6. Prolonged voltage dips after network fault clearing or switching
7. Potential high voltages on the 500kV system at times of low network loading

Options to be considered

The Project Specification Report indicates that the following options will be considered in the next stage to minimize system costs:

1. Non-network solutions that reduce curtailment of generation. Minimum requirements are specified as:
    a. At least 10 MW of consumption or storage that can be sustained for at least one hour (10 MWh of minimum storage)
    b. Facility for remote dispatch
    c. A response time of 15 minutes or less for pre-contingency action and 5 minutes or less for post-contingency action
    d. Provision for at least a three year term with scope for extension
    e. Able to be dispatched at shade ambient temperature of up to 50°C
    f. Located close to nominated Terminal Stations in Western Victoria
2. New reactive and dynamic reactive plant may be required such as capacitors to avoid voltage collapse, reactors to contain over-voltage under light loading conditions, static var compensators to provide fast voltage control and synchronous condensers to provide inertia and increase system strength
3. Providers of energy storage can add further value by providing Frequency Control Ancillary Services, System restart Ancillary Services, or synthetic inertia[5]

[5] Synthetic inertia is a new term which describes a power response of generation or demand side resource which changes in proportion to the rate of change of local frequency of the power supply. This is the same as the effect of mechanical inertia in synchronous generation machines: as frequency falls, extra power is delivered to the network which slows the rate of change of frequency and gives more time for primary control actions to respond to the power imbalance in the system.

4. A hierarchy of transmission upgrades, seemingly developed on or adjacent to existing easements between the existing Terminal Stations:
    a. Minor network augmentations that may quickly remove rating limitations on existing lines at low cost
    b. Control schemes to run-back generation quickly after a line or transformer outage
    c. Upgrading 66kV lines to 220 kV, more than likely by complete replacement on the easement. This would require new transformation from 220kV to 66kV at or near existing 66/22kV substations.
    d. New 220kV transmission capacity achieved by reconductoring or replacing existing lines with double circuit lines or adding new lines in parallel with easement widening. This provides for up to 1500 MW of new generation capacity according to AEMO.
    e. New 275 kV or 330kV transmission capacity added from Buronga in NSW and if a new South Australia to NSW interconnector is built
    f. New 500 kV transmission capacity may be viable with over 1500 MW of new generation capacity in Western Victoria, or if a new interconnection with South Australia connects into Horsham Terminal Station. The 500 kV network would be constructed via Ballarat and on to Sydenham and Moorabool[6]. This option would bring the South Australian and Victorian regions closer together electrically and assist in sharing reserves between Victoria and South Australia to manage the variability of renewable energy generation between the regions. It would markedly enhance system strength in Western Victoria.
    g. The higher voltage lines constructed for operation at 275kV and above could be operated at 220kV initially to defer the cost of transformation and switchgear for the higher voltage operation.
5. Other options have been considered but not progressed:
    a. High Voltage Direct Current (HVDC) option to collect renewable energy generation to a new HVDC node and transmit it directly to the 500 kV system. AEMO states that this option will be considered in the Project Assessment Draft Report. HVDC would not be suitable for connecting a widely dispersed collection of generation projects between while the line cost is lower per MW, the terminal cost is much greater per MW than for Alternating Current technology. HVDC may be part of a large scale inter-regional development but it is not likely to be suitable for connecting Western Victorian regional resources to loads throughout Victoria.
    b. Scale Efficient Network Extension (SENE) – These policy option in Clause 5.19 of the NER applies where a group of generators seek to extend the transmission network to connect a group of power projects where there is no existing network of sufficient capacity. The generators must seek a Design and Costing Study to initiate a SENE process (Rule 5.19.3). AEMO has not received such a request.

The current SENE policy requires proponents to seek the Design and Costing Study and to fund planning and development of the extension network. This is unlikely to lead to any economic development unless the generators have substantially common ownership and sophisticated risk sharing mechanisms to share the cost of the study and avoid stranding the new assets. It is no surprise that no such proposals have led to any network development.

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[6] Ibid Page 27

The absence of SENE initiatives is partly due to the remaining opportunities to develop generation resources near existing networks and recent developments in renewable energy technology that more efficiently use lower grade wind power sites that are close to existing networks. However, there remains a significant competition and investment risk barrier which is likely to discourage independent generators seeking to fund a comprehensive study of network extensions which could undermine the viability of their intended investment. The concept of network extension to accommodate regional development of supply and demand needs a stronger impetus than just the business plans of one or more prospective generators. The box below outlines the broader context for development in Western Victoria as an exploration of network extension to service regional development needs.

Significance of SENE's for long term planning and Finkel Recommendations

The areas between the existing 220 kV transmission line easements, the 275kV line easements in South Australia and the Darlington Point to Buronga line in NSW are prospective areas for a SENE study which, if conducted, could have a material and beneficial effect on the optimal development of the 220 kV easements in Western Victoria.

Such an analysis should have regard to longer term interconnection requirements between the southern states so a full range of possible ultimate network developments can be identified over the period from 2025 to 2050 when electricity supply will be substantially decarbonised. This study should confirm the conditions of economic growth, renewable energy deployment and storage development under which major interconnection development would be prospective. It would then provide a basis for understanding the conditions under which interconnections to Horsham or through Redcliffs would be considered in more detail as market conditions move towards the favourable requirements for economic development.

Issues with options and strategy

There are some potential issues identified with some options detailed in the report that have the following implications:

1. There is not sufficient lead time to develop the transmission system to meet the prospective desired growth in generating capacity in Western Victoria
2. Therefore a mix of network and generation and demand-side resources will be needed to achieve the best results
3. The connection of the generators radially to existing easements may not produce the most economic and environmentally acceptable development scheme
4. A broader focus is needed to combine options for storage, easement upgrades, development of new easements for connecting generation sites together, as well as integration with future interconnection development.

Lead time

Of prime concern to AEMO is the matter of lead time especially for the new transmission line options. AEMO says the estimated construction lead time for a new transmission line is three to seven years, subject to easement acquisition and environmental and development approvals[7].

There is concern that new powerlines may not be built in time to meet the growth in generation capacity sought by the market. This may be based on previous experience in Australia and overseas where local communities oppose new power line developments based on the visual environment and concerns about the health impacts of electromagnetic fields produced by high voltage power lines. This lead time risk is why powerline planning needs to start early but is exposed to the risks associated with these long lead times.

Non- network solutions often have much shorter lead times and could provide a temporary solution until longer term options are delivered. For example, local energy storage could be developed to better use the existing transmission line capacity with a view to relocating the storage facilities when the power line developments would result in the same storage capacity having greater value elsewhere.

Lead Time

Lead time is a critically important feature of a viable option. Major transmission line development may be less than optimally timed if the need is not anticipated in time for work to start on implementation. Demand side options and battery energy storage can provide an interim partial solution and generation developments may be delayed if the transmission network is not upgraded at the required time.

Mix and timing of options

Accordingly, AEMO states that the recommended option will likely be a combination of several options identified above: non-network and network options. There is also the progression to higher voltage operation if the higher voltage power line options are chosen. Essentially, least cost is achieved when the progression of power generation and transmission options are closely aligned in both capacity and timing. The big challenge for the current regulatory framework is that there is insufficient information to effectively integrate the network and generation planning, and to understand the combinations of assumptions which make a particular option clearly preferable and strongly economic.

Broader focus is needed

The Project specification Report illustrates where new powerlines may be required along or near existing easements[8]. However, this layout assumes that all new generation will be connected radially to the existing Terminal Stations or into the existing alignments with new Terminal Stations, such as Wemen, Ararat and

[7] Ibid Page 25
[8] Ibid Page 24 (Figure 6)

Waubra which have been added to the original 220kV network for this purpose. This suggests that the Project Specification is incomplete, especially if a 500 kV overlay is considered between Moorabool and Redcliffs. The Finkel Review has highlighted the need for regional assessments of connection of new renewable energy resources in places where there is no strong electricity network. This study proposed by AEMO could be extended to satisfy this need for Western Victoria and adjacent state regions. There remains a strong need for a resource analysis and SENE style network extension analysis to show how networks can provide for the most economic generation and network resources.

Broader Focus

A broader focus is needed to consider:

- Regional economic development in conjunction with State and Federal Governments
- The impact of future decentralization of population, transportation, industries and services to regional cities – Geelong, Ballarat and Bendigo as an example
- Integrated generation and transmission planning for renewables in south-east Australia
- New easements to connect the regional generation centres to the main grid.

The options and analysis need to be expanded to assess:

1. The long-term development of the regional centres of Ballarat and Bendigo to support decentralization away from Melbourne together with high speed rail infrastructure. Beyond 2025, as more renewable energy is developed in regional areas, and it becomes costlier to make Melbourne's energy supply sustainable, it is likely that the regional centres will develop further because they are closer to the source of renewable energy. This would potentially mean a relative change in the value of the transmission options depending on the pattern and rate of regional growth. It will be important that the studies show how regional growth changes the value of the options. This may be affected by high speed electric rail services and electric vehicles later this century.
2. The optimal configuration for how the renewable energy projects can be interconnected with each Terminal Station location by means of radial or looped connections so as to avoid a "spaghetti" network and proliferation of criss-crossing high voltage power lines. An efficient network topology may involve:
    a. Local 66 kV networks for connection of smaller scale energy farms to an ultimate 220 kV grid
    b. 220 kV networks for connection to an ultimate 500 kV grid
    c. 220 kV loops that connect to new larger scale generation remote from existing 220 kV easements
    d. New 500 kV connections to the regional centres to support rapid expansion of these cities with electric transportation infrastructure

    An example of what a more desirable outcome might look like is shown in Figure 4 with four additional 220kV loops and three new 500kV Terminal Stations. This figure is derived from Figure 6 in the AEMO Report. The loops would be preferred to multiple criss-crossing radial transmission lines and multiple terminal stations at lower voltage levels, each one associated with each new generation project. If the 500 kV overlay network is developed, the nearby 220kV network can be reconfigured into loops out of each Terminal Station if needed so that the 220 kV line capacity does not constraint power flow on the 500kV system.

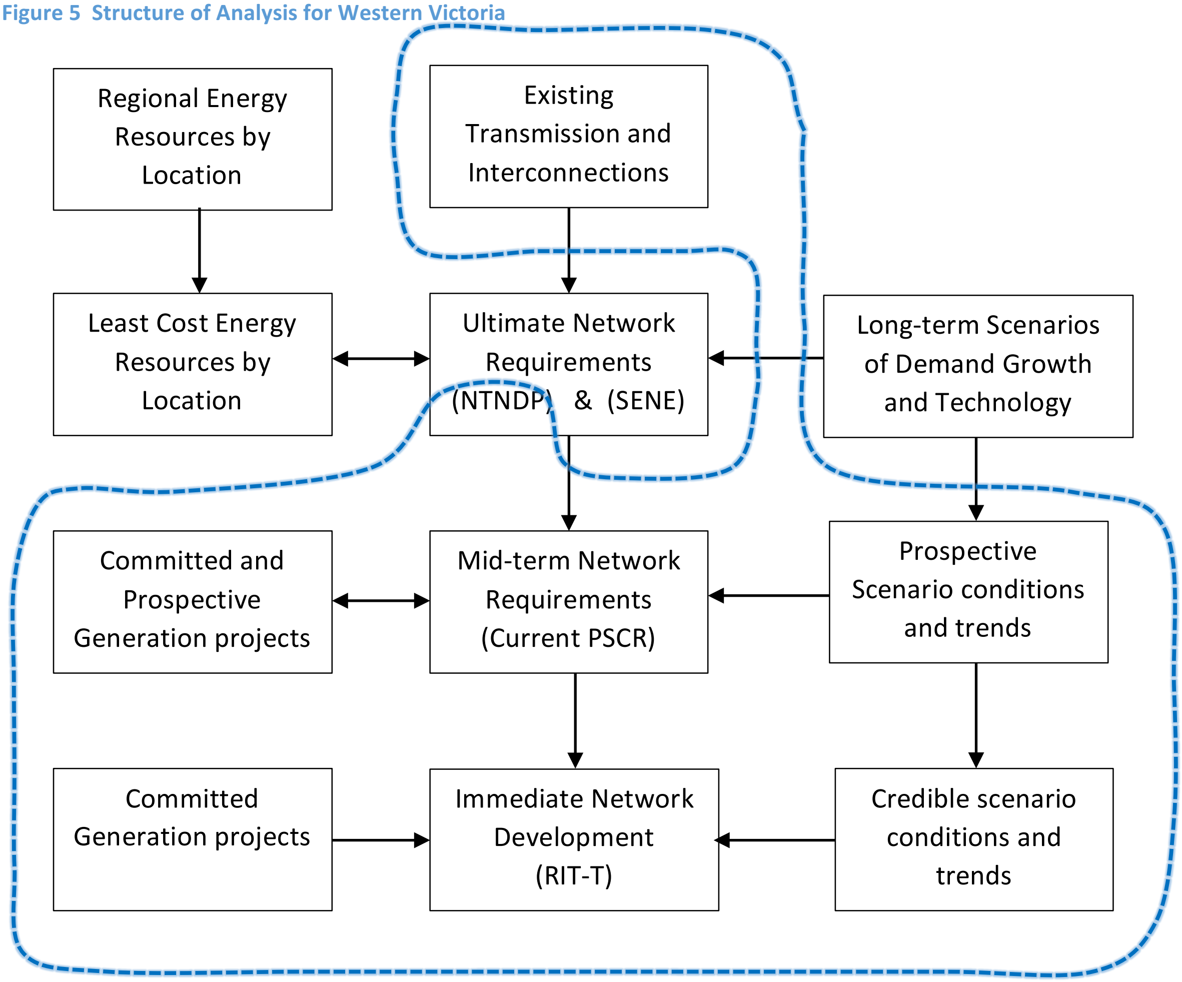
Figure 4 Adaptation of Figure 6 from AEMO Report to show other easement options for connection of generation

3. The optimal configuration of 275 kV, 330 kV and 500 KV powerlines to provide for future inter-regional development having regard to resources in
    a. South-eastern region of South Australia
    b. Coastal wave power or off-shore wind power should it become viable
    c. South NSW, especially solar thermal resources which may incorporate thermal storage

This potential expansion of scope complicates the analysis and yet if it is not completed, there is a risk of lack of clarity at the end of the currently proposed Project Assessment. An alternative approach which will give better understanding of the impact of uncertainties is proposed in the following sections.

Essentially there are two ways of approaching this study as illustrated in Figure 5. The current Project Specification Consultation Report (PSCR) represents the process that ultimately will lead to regulatory tests for specific projects. This is informed by the National Transmission Network Development Plan (NTNDP) and should be informed by SENE analyses that show the need to extend the network for connection of regional generation resources. The dashed blue line in Figure 5 encompasses the processes invisaged in the Project Specification Report, notably without a SENE style process and comprehensive assessment of regional energy resources and demand growth for regional development.

Figure 5 Structure of Analysis for Western Victoria



AEMO's Approach

AEMO's approach to this identified need is to:

1. Focus on Western Victoria where the potential network overloads are highest
2. Consider consequential upgrades to the network outside Western Victoria in a separate and subsequent RIT-T
3. Consider the need for new synchronous plant in Western Victoria to bolster system strength
4. Develop a coordinated approach to development of synchronous plant to enable new generation connections subject to the outcome of the AEMC's review on System Security Market Frameworks
5. Assume two generation growth scenarios for Western Victoria:
    a. Base Case with 3000 MW by 2025
    b. Sensitivity Case with 5000 MW by 2027

6. Assume the AEMO's 2016 "Neutral" scenario and associated generation connections. Generation uptake in Western Victoria is illustrated in Figure 5 of the Project Report[9] assuming no transmission constraints in Western Victoria.
7. Consider non-network options that reduce constraints and generation curtailment.

Integration of Generation and Transmission Planning

The key problem faced by AEMO is that it within its power and jurisdiction it can only really do parts of the planning project. In the absence of clear commitment to generation projects but with some 5,000 MW of options being announced and the risk of new projects being conceived during the analysis of the transmission options, it is possible that the work could be of limited value or require several revisions before commitments are made.

There are four other classes of players in this process, as well as AEMO:

1. The customers who are planning their small scale projects, largely based on current information on electricity pricing and the threat of a real escalation in the cost of delivered electricity
2. The aggregators who are planning to integrate small scale resources into a response to the Project Specification, such as with distributed storage and demand side response
3. The network asset owners who may seek to upgrade their network technologies to enhance the performance of their network and deal with aging assets.
4. The generators who are planning their renewable energy projects in the absence of detailed information about transmission system performance

AEMO can deal directly with the last three groups, but can only estimate what the customers will do based on existing trends and market surveys. The main challenge for the electricity market and AEMO is how to:

1. Keep the network and generation plan in alignment for the very long-term by choosing new easements and the maximum voltage level for the upgrades and augmentations
2. Keep the development plan in supply/demand balance between the network, generation commitment and customer response with roof-top solar and distributed storage
3. Develop a plan which is flexible and comprehensible so that market participants can make wise decisions.
4. Deal with the absence of sufficient lead time to deploy large scale transmission capacity with the threat that renewable energy targets will either not be met or are mostly met but at higher cost by resources outside Western Victoria.

[9] Ibid Page 17

Alternative Strategy

Here it is proposed that a more comprehensive assessment of energy sources for Western Victoria and neighbouring regions be progressed including generation, transmission and demand side resources to provide a master plan that should serve the region for the full transition to renewable energy resources over the middle of this century.

Assumptions

In this submission we propose an alternative strategy based on the following assumptions. We suggest that these assumptions would be tested in the course of the analysis:

1. Low cost, near term network and non-network options will be deployed eventually because the renewable energy transformation is inevitable, yet timing is uncertain due to volatile national policy on the mechanisms for carbon abatement, and the recent lack of bipartisan commitment to a long-term scheme.
2. Transmission augmentation at some scale is inevitable because by the end of technical life of the current network, renewable energy resources will be the dominant source of electricity and Western Victoria has competitive renewable energy resources, both wind and solar, and possibly some wave and geothermal power.
3. Storage is an alternative to transmission capacity until energy flow on transmission lines is substantially constant.

Future Role of Transmission

Conceptually, if storage is low cost and widely deployed, the role of transmission will be energy transfer at high utilisation rather than the current mode of power transfer at moderate to low utilisation. The timing of assets and the ultimate scale of the Western Victorian network are both materially affected by the deployment of storage, both large and small scale.

Therefore the optimal amount of transmission capacity must have regard to distributed storage deployment.

Key uncertainties

The key uncertainties in this study for the long-term relates to the following issues in approximate order of importance:

- The policy for emission abatement with a combination of renewable energy targets and carbon pricing will influence the trajectory of energy transformation and the timing of renewable energy development in Western Victoria. The rate of growth of renewable energy development and its ultimate potential will be the key driver which influences the ultimate network maximum voltage level and optimal configuration. Some flexibility will be needed in the plan to adapt to changes in these factors.

- The mix of wind and solar resources to be developed – for each available area; which resource is preferred as a function of its unit capital cost? As more of one type of generation is deployed in an area, its economic value will be degraded due to coincident peak generation from similar resources. The life cycle cost of each technology will ideally determine an optimal mix in each area based upon proximity to loads, the cost of energy storage and the cost of removing transmission constraints. For example, solar and wind resources are complementary because they rarely provide peak output at the same time. The network capacity that is required on an economic basis should be assessed in conjunction with an optimal generation mix if it can be assumed that generation markets are competitive and efficient. For generation development to efficient, it must be informed by a strategic and efficient network development plan that can accommodate the efficient generation resources in the region.
- The rate of decline in the cost of large and small-scale storage per kW and per kWh is a critical factor in the viability and timing of large scale transmission in the longer term. If storage is of low enough cost, then local storage can absorb the peak power generation, deliver the local load peaks and use the transmission system for bulk energy transfer.
- The pattern of demand and embedded generation growth in the outer regions (Kerang, Redcliffs, Horsham, Ararat) and inner regions (Ballarat, Bendigo, Shepparton, Terang) will determine the timing of upgrades and may make some options have a limited economic life. Key demand outlook factors driving uncertainty are:
    - Rate of uptake of PV, residential storage, distributed energy resource control (smart-grid related)
    - Rate of electric vehicle uptake and electric railway development including high-speed inter-city trains
    - Impacts of energy efficiency actions and energy efficient appliance proliferation.
    - Tariff reform progress rate and its impact on the uptake of embedded generation, particularly roof-top solar PV
    - Implementation of microgrids at the edge of the grid

Strategy

In order to facilitate the implementation phase of this project, it would seem that a resource analysis is required to consider the ultimate development of resources in Western Victoria and to confirm the thresholds at which various solutions are expected to reach their limit. AEMO has already identified that 220 kV upgrades could meet up to 1,500 MW[10] of new generation capacity assuming a double circuit loop between Bendigo, Kerang, Redcliffs, Horsham, Ararat and Ballarat, with the intermediate stations. It is not clear what the 500 kV connection to Horsham would achieve with and without the interconnection to South Australia. This would be a matter for study in the Assessment Draft Report. It is possible that a 500 kV configuration more like Figure 4 above might provide for regional development as well as integration with future interconnection developments.

It would seem that an ultimate resource assessment should precede the proposed study, or at least be conducted in parallel for the early phases to identify how the choice of ultimate transmission level with and without interconnection options would support generation levels versus a wind and solar mix. Such a study would provide a strategy map for each zone based on the key parameters.

[10] Ibid Page 21

The strategy mapping could be based on a one year analysis for a particular set of combinations of:

- Network upgrade cost for specified projects
- Carbon emission abatement target for Australia
- LRET for Australia
- LET for Australia
- VRET for Victoria
- Carbon cost
- Gas cost
- Regional and NEM demand
- Interconnection capacity with or without upgrades as required (Buronga, Horsham, Heywood, Snowy, QNI)
- Solar and wind costs relative to transmission costs
- Large and small scale storage costs relative to transmission costs
- Aggregated impacts of demand-side trends affecting growth

The following outputs would be calculated for each combination based on avoidable costs and revenues. They need not be input assumptions:

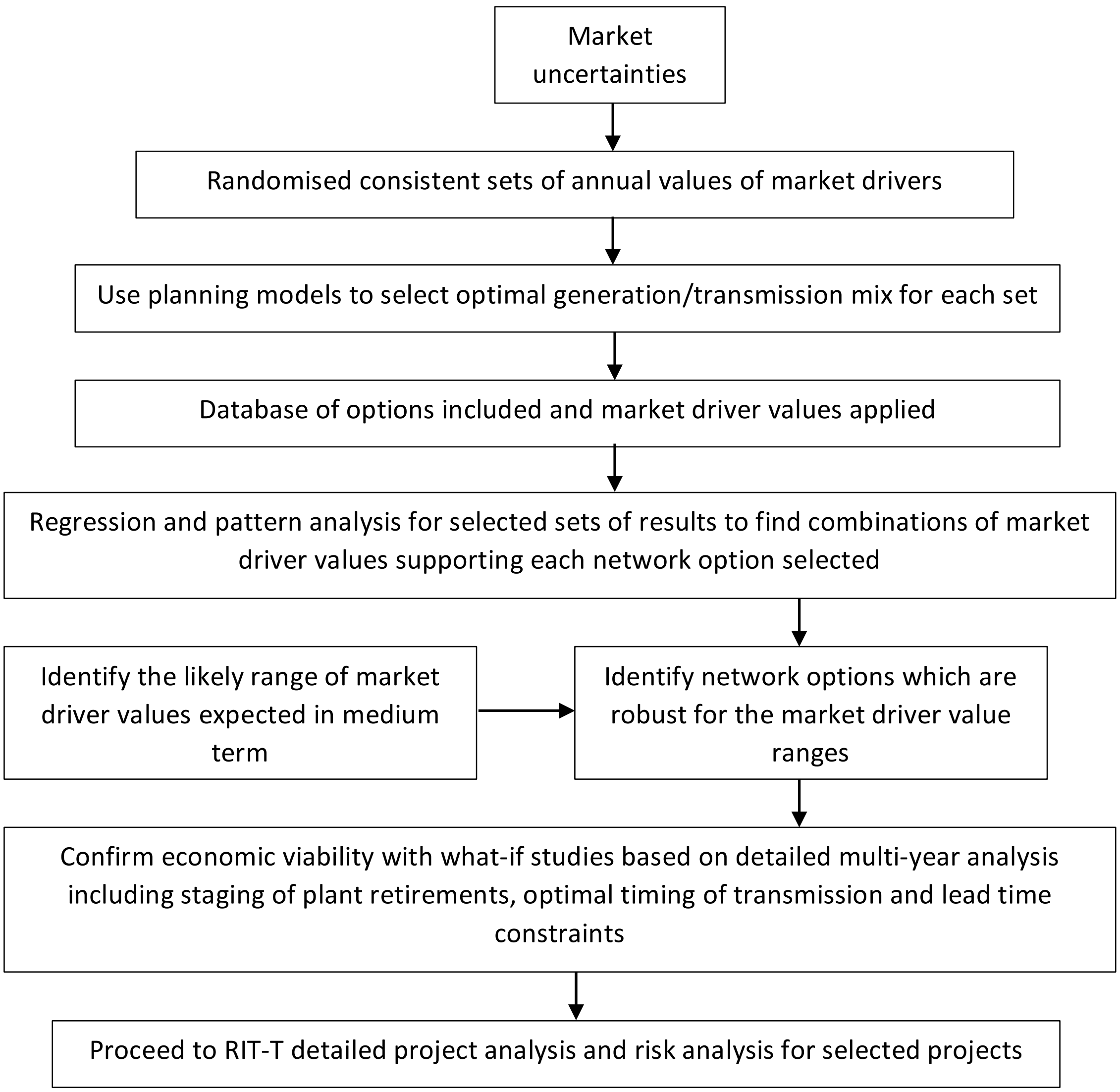
- Thermal plant retirements
- Network upgrade state (lines and connections added for optimal generation resources)

Factors that could be considered as fairly stable and not strong value determinants or material uncertainties could be: coal costs, thermal plant performance, hydro energy yield for example.

A series of dispatch studies would be conducted for the one year of the NEM to assess total system costs for various combinations of the key value drivers. The rationale for evaluating only one year is that change in the electricity market is relatively slow over time and likely to trend toward decarbonisation rather than away from it. The broad assumption here is that change is mostly unidirectional toward decarbonisation. In the first instance, it is satisfactory to assume that any values created by transmission that are robust would be sustained over time. The potential for long-term stranding can be assessed using the annual analysis and then refined by detailed year by year scenario analysis once the impact of the key value drivers has been confirmed. The concept is illustrated in Figure 6. Lead times are not considered until the final multi-year analysis is conducted.

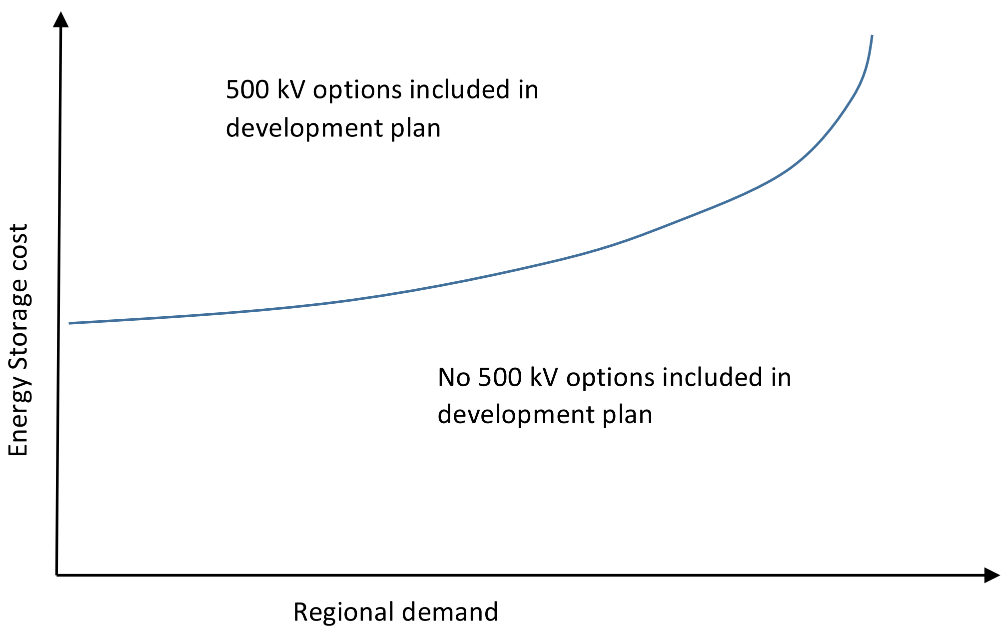
As a screening tool, based upon these single year studies, it should be possible to develop a set of regression functions that quantify total system costs as a function of the key variables over the range of variables considered. Network options would be binary variables (1 for present, 0 for absent), LRET and VRET as measured by the long-term target or annual value as appropriate, carbon and gas costs based on a market measure, interconnection capacity as a nominal market measure, solar and wind and storage costs based on a unit measure. These regression functions would be expected to show mostly linear characteristics in the practical range of interest with some non-linear terms to be derived where needed to obtain a useful measure

Figure 6 Concept of strategic screening analysis



of value. The regression value functions can then be used to identify sets of market conditions where two network options have close to equivalent value, essentially the boundaries between preferred options, as illustrated in Figure 7 for two variables, assuming all other variables fixed. Sets of contour curves could be developed for differing levels of aggregate emission abatement which drive the total amount of renewable

Figure 7 Example of two-dimensional strategic planning map



energy generation needed in the region. This contour line represents the combination of storage cost and growth for which key 500 kV developments have no net value relative to 220 kV or 330 kV solutions.

For consideration, we consider the following key parameters as part of the assessment of the network potential as shown in Table 1. It may be seen that there are two precursors to the proposed study for Western Victoria which have yet to be delivered:

1. An assessment of the NEM wide renewable energy deployment of wind and solar power to meet an increasing level of abatement. This would give an indication of how much of Victorian resources would be developed for various levels of aggregate emission abatement.
2. A sensitivity of (1) to the VRET: how much extra resource would be valuable in Western Victoria if VRET is adopted.

This work would give a short-hand answer to the question as to how the setting of emission abatement targets both national and state will influence the amount and location of generation that would be sought to be connected, and would inform the threshold levels that would require:

1. Upgrade beyond the current 220 kV system

2. Upgrade to 275 kV or 330 kV connections with connection between NSW and South Australia
3. Provision for 500 kV connections through to Horsham or other regional centres for potential interconnection with South Australia.

Table 1 Key Uncertainties and their Treatment

Stage	Key Factor	Value Driver Influence	Proposed Treatment	Key Information
Strategy	Long-term abatement targets	Determines the amount of energy resources than might be developed in Western Victoria as a proportion of the national energy target for carbon abating resources along the pathway to 2050, with sensitivity to the VRET.	A NEM wide optimisation study is needed to assess the pattern of deployment of renewable energy across the grid as a function of the development of interconnection capacity, assuming inter-regional constraints are negligible. The effect of the VRET would be treated as a sensitivity to show how much extra of the Western Victorian resources would be required to meet the VRET as an added target.	Show the relationship between the amount of emission abatement required nationally and Victoria and the amount of solar and wind resources that would be optimal in Western Victoria and other regions. Informs rate of growth of generation and ultimate potential and guides generation investors.

Stage	Key Factor	Value Driver Influence	Proposed Treatment	Key Information
	Relative cost of solar and wind technology	Determines how the regional energy resources will be developed, the likely location of generation resources and the peak power flow characteristics on the network.	Generation optimisation study to estimate the optimal mix of resources across Western Victoria as a function of the required energy production in Western Victoria assuming no intra-regional network constraints with approximate association with relative network costs. A key sensitivity may be regional demand as a variable in this analysis, as summer peak demands are more aligned with solar power than wind power in the absence of storage. The cost of energy storage would also be an important driver of the choice of renewable energy resources, as noted in the next stage.	Provides a development plan to show how an efficient investor would deploy renewable energy assets across Western Victoria as a function of the level of emission abatement and market transformation. The sensitivity to the relative cost of solar and wind would show the uncertainty of technology deployment in each Terminal zone: predominantly solar, predominantly wind, or a mix of both. We would expect solar in the north and wind in the south. Wave and geothermal are probably negligible for the current state of development.

Stage	Key Factor	Value Driver Influence	Proposed Treatment	Key Information
Strategy	Cost of controllable storage, large and small scale	Storage is a direct competitor with transmission capacity while the transmission capacity utilisation is at low to moderate levels. Cheaper storage will reduce the value of transmission capacity and defers its efficient timing.	Identify the potential for off-river pumped hydro storage in Western Victoria as well as the cost of distributed and large scale battery storage. Develop a generation/network optimisation for Victoria and the adjacent interconnections to NSW and SA to show how the optimal mix of renewable energy generation and local and large scale storage is affected by the relative cost of storage and transmission technologies.	Show the threshold levels of wind and solar capacity that can be supported by each main level of network upgrade as a function of the cost of battery and pumped hydro storage.
	Regional demand growth	More regional demand requires less transmission capacity as long as the regional peak can be supplied by the regional generation plus storage.	Analysis can be limited to three levels of regional demand as it is not expected to be a major determinant of the optimal network configuration.	Confirm that sensitivity to regional load growth is not a major driver of value, or at least assess its relative importance to other factors so that it is apparent when it might be a decision maker.

Stage	Key Factor	Value Driver Influence	Proposed Treatment	Key Information
Strategy	Connection of projects to Terminal Stations and existing easements.	**If multiple projects need to be connected to each Terminal Station, then some guidance will be needed as to whether radial connections or loops may provide the least cost overall.** **If loops can be developed to run in parallel with existing easements, then greater value may be obtained from the transmission infrastructure.**	The development of the quantities of generation to be connected to each Terminal and their locations can provide the basis for a local spatial optimisation of the connecting network as would be undertaken for a SENE Project. AEMO could provide guidance on where there is scope to avoid multiple radial connections through a more integrated approach to easement acquisition for connections to the existing easements.	Identify where loops may be preferred for connection of multiple projects rather than radial connections and new Terminal Stations. Refer to Figure 4 above.
	Market Uncertainties	Identify impact of combined uncertainties	Using annual market analysis only, formulate the total system cost as a function of the key uncertainties using a regression analysis of a group of studies covering the range of interest.	A regression equation which defines total system cost as a function of the key variables so that combinations of variables can be applied to find the minimum cost network configuration for any combination. This is a screening tool to help focus in on the optimal conditions and robust solutions.

Stage	Key Factor	Value Driver Influence	Proposed Treatment	Key Information
Project Assessment	Timing of generation development	The sooner new generation capacity is added, the more likely that non-network solutions will be required to minimise constraints should the project proceed.	For each transmission component, search the critical combinations of wind and solar from the schedule of committed plus efficient generation options that confirm the value of each upgrade. The regression equations from the Strategy studies may reduce the analysis required to set up robust cases. By using the thresholds for the transmission strategy identified at the Strategy phase, it should be possible to formulate the studies at the critical levels of generation for decision making rather than ascribing levels ex-ante as currently proposed by AEMO.	From these studies at the critical levels of generation, it should be possible to identify a set of generation additions, committed or not that would trigger a particular line upgrade. This information could be used to attract generation proponents to a preferred region and achieve a closer balance of generation and transmission capacity. The RIT-T process would seek to attract the efficient level of generation connection to confirm commitment to the network project is robust.

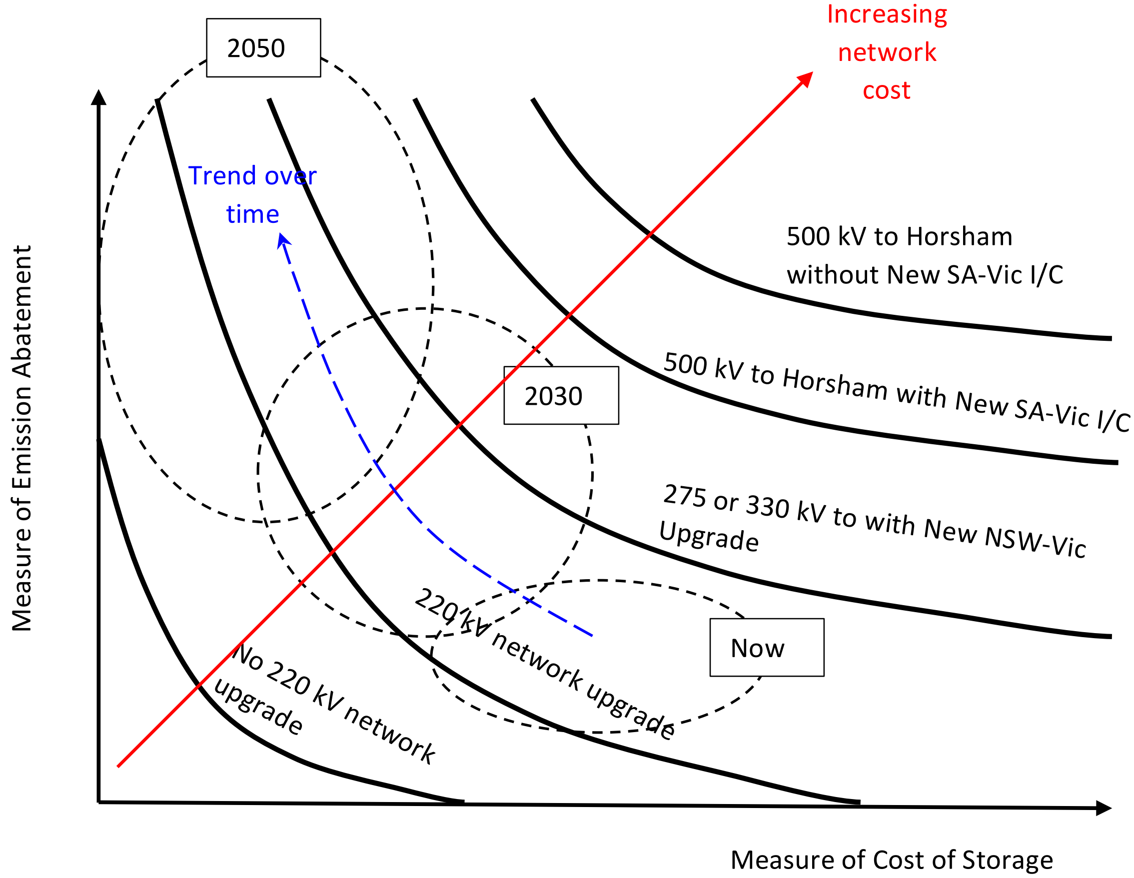
Stage	Key Factor	Value Driver Influence	Proposed Treatment	Key Information
	Project Commitment	For the projects that are approaching commitment at the time of the analysis, it would be possible to show the network commitments and non-network solutions that would pass the RIT-T for that level of commitment and what subsequent generation commitments would exhaust the capacity of that stage.	For the committed projects develop long-term scenarios that show the network performance and total costs with and without the proposed upgrades with sensitivities to show that alternative options are inferior. From the efficient generation mix, determine how much additional generation can be added for the proposed network stage.	Demonstrates a planned state of the network that is efficient for committed projects and shows the remaining spare capacity available thereafter, perhaps as a function of subsequent demand growth.
Project Assessment	Storage evolution and cost	Addition of further storage or removal of planned storage would influence the network capacity.	Sensitivity of optimal network capacity to further addition of storage may be informative for the market.	Assuming storage is contracted and controlled by AEMO, overall network performance should be guaranteed. If storage performance is eroded, or if customers add their own storage to enhance system performance, this may affect the overall network performance.

Stage	Key Factor	Value Driver Influence	Proposed Treatment	Key Information
	SENE Loops	The feasibility of network extensions to connect the new generation resources and to enhance the performance of the existing network by providing new flow paths should be considered despite the absence of a formal SENE request. Individual generators may not have visibility of the potential for such arrangements to be able to seek them as required by the NER Rule 5.19.3.	The preliminary Strategy analysis would identify where additional network capacity will be needed to close that gap between the existing easements and the locations of the wind and solar projects.	A network plan which shows where new easements could be considered to connect the lowest cost generation (having regard to the SENE network cost) would have an enabling effect on encouraging scale efficient generation development. It may show that it is better to develop 1000 MW solar and wind farm clusters with 500 kV connections rather than multiple 150 MW projects with multiple 220kV and 330 kV lines crossing the region.

Stage	Key Factor	Value Driver Influence	Proposed Treatment	Key Information
Project Approval	Market Conditions are consistent with project value drivers	An approved project would be consistent with a wide set of conditions for ultimate network development with a low risk of stranding and would be timed to optimise its value for committed and prospective generation projects.	The regression analysis would be used to define and visualise the set of future market conditions that would maintain the value of the approved project. Then more detailed multi-year scenarios would be formulated to satisfy the needs of the RIT-T to show the net present values of the project for specific long-term scenarios considering all uncertain variables. This work would correct any approximations inherent in the regression analysis of annual value.	The long-term scenarios would be derived for conditions that are credible and which maintain the long-term value of the network project, rather than doing what-if analysis and formulating scenarios that may or may not inform the value of the project clearly.

Rather than basing the Project analysis on relatively arbitrary levels of 3000 MW by 2025 or 5000 MW by 2027 as proposed, it would be more apparent what envelope of how much generation by when would provide an efficient frontier for each tier of development as illustrated in Figure 8. The heavy black lines show where the market conditions justify an increase in the highest system voltage and associated network developments. The black dashed line indicates the regions where the glide path from the current state to the future state are anticipated in future scenarios in various periods. The red line shows the direction of increasing network costs. The blue dashed line shows the glide path from the current to future market conditions. The conceptual strategic map illustrates that 500 kV options would have limited value and that an ultimate least cost plan would be expected to have 220 kV and 275 kV and/or 330 kV transmission options.

Figure 8 Concept for transmission potential where 220kV solutions remain sufficient



This analysis would be largely static in the sense that there would be an assumed level of regional demand. The analysis could be conducted for three levels of regional demand and national demand to check the sensitivity to that variable. A similar set of maps could be developed to show how the volume of new generation capacity in key areas influences the viability of each level of network development, versus the cost of storage. Interconnection capacity may also be a key value driver influencing ultimate network voltage levels.

This ultimate presentation would have underlying information about the generation mix for each area of the space of emission abatement and the relative cost of solar and wind technology. The cost of storage would be relative to transmission technology as its next nearest competitor. The circles show the region of uncertainty for emission abatement and cost of storage for three time periods: now, 2030 and 2050.

It may be noted that storage cost would influence the trade-off between wind and solar, with higher levels of solar PV being more competitive with lower storage cost because of its diurnal production cycle.

The measure of emission abatement could be a composite variable that combined the national target with the VRET to give a measure that represents the influence for Western Victorian generation.

The diagram shows three circles that represent the expectations for trends in emission abatement and cost of storage over time and which would support a focus on a particular set of transmission solutions that could be robust. In this example, the strategy map indicates that the preferred strategy would be to plan for 220 kV transmission upgrades with potential for 330kV options dependent on inter-regional development between South Australia and NSW. This conceptual diagram clearly shows a case where 500 kV development is not an immediate priority for optimising Western Victorian generation connection because the projected glide path for combinations of emission abatement targets and energy storage cost (as represented by the circles) remain outside the space where 500kV options are viable.

Specific Comments on the Report

The following comments are provided to support the above review of the project specification.

Chapter 2

The Figure 1 of the PSCR shows the region of interest. It appears to be unduly limited by state borders, perhaps affected by institutional arrangements for planning responsibility. It would seems that the region should be extended to include the neighbouring networks in South Australia and NSW to obtain a more accurate assessment of how to connect the renewable energy generation that is available throughout this area. State borders and institutional arrangements should not bind efficient network planning. This will result in larger costs and potentially stranded assets over the horizon.

AEMO says that 80% of the potential 5000 MW of generating capacity is seeking to connect to the 66kV and 220 kV networks. This is clearly much greater than the existing network capacity and suggest a major upscaling of the network in Western Victoria. This level of generation would mostly likely need a

330kV or 500kV ring around north-western Victoria as well as the 500kV connection through to Horsham as described in Figure 8 of Chapter 7.

The urgency of proceeding with this RIT-T project is influenced by the long lead times for new powerlines, the lack of recent experience in developing new powerlines in Victoria and the rapid development and scale of new renewable energy generation resources that will be needed to achieve prospective emission abatement targets.

Sequential analysis for Western Victoria and interconnectors

The conclusion in section 2.3.2 that interconnection related constraints can be neglected at this stage because the thermal limitations are more severe in Western Victoria will need to be tested in the project assessment phase.

At the very least the optimal timing of developments in Western Victoria may need to be reassessed if changes are made to the interconnectors. This should be recognised and tested in the next phase of work.

The network loading from Bendigo to Dederang is influenced by Victorian export to Snowy/NSW areas and injecting generation into this region will increase those power flows. If a voltage level higher than 220 kV is shown to be needed for the outer ring through Redcliffs, then it is unlikely that upgrades in Western Victoria and the interconnectors can be treated sequentially or independently, because this upgraded network would become part of the power flow path between NSW and South Australia

Chapter 3

The Table 1 on page 11 highlights the huge gap between existing capacity and the new generation connection enquiries. This gap indicates the need for a SENE style analysis because in effect the existing network is incapable of carrying the projected generation connections. It could well be more efficient to design a new network for Western Victoria at say 500 kV ultimate potential and then work out what parts of the 220kV network would still have a role to play as a subsidiary network for connecting to the generators. It indicates that incremental changes to the existing networks may not be efficient to meet the potential demand for new generation connections.

Following on from the comments on Chapter 2, it would appear that a double circuit 500 kV link through Western and Central Victoria from Tungkillo to Horsham to a place north of Bendigo and Fosterville through Shepparton to Wodonga and on to Marulan would provide for collection of the power and the bulk transmission of power between regions according to regional variability. It could be built in stages and operated at 220kV in stages to match regional generation and transmission capacity. Thus solving interconnection opportunities as a subsequent stage of analysis and commitment to RIT-T may be sub-optimal.

Chapter 4

Option benefits will be very important in formulating the regional network development plan. It will need to consider:

- Favourable generation sites for which there is no current proponent because network connection costs are high to the existing network and a SENE style analysis is not highly regarded or sought by prospective proponents
- How changes in storage costs and deployment could undermine large scale network development, such as a large scale 500 kV development across the whole region
- How changes in interconnection capacity would influence optimal timing for Western Victorian investments and vice-versa.

It is agreed that a flexible approach will be needed to manage uncertainty in the size, location and timing of new generation. However, the study itself could reduce these uncertainties and guide generation investment by showing how the development plan is aligned to where the most favourable energy resources are located, and ow the plan will progress if these resources are developed in a timely and economic manner.

Chapter 5

The underlying issue relevant to this chapter is the lack of a comprehensive resource analysis which shows how generation expansion in Western Victoria can economically support emission abatement and renewable energy targets. If this were available, then it would not be necessary to make assumptions about generation levels. Rather assumptions would be made about emission abatement and this would better link the development plan back to environmental and energy policies.

The proposed used of relatively arbitrary generation volume and timing scenarios implies that the strategic analysis of where the more favourable generation sources are located has yet to be completed. Rather than have fixed generation scenarios, it would be better to define what generation levels in each place would make particular options viable so that generation can be attracted to the locations where a viable, least cost transmission development plan can support that generation. Refer to the discussion above about how to formulate an annual analysis which can be used to find the efficient frontiers where particular network assets or groups of assets are optimal. Rather than have a particular expansion profile as shown in Figure 5 of the PSCR, it would be better to determine what profile would make each generic scheme viable, particularly when choosing ultimate voltage levels. For example, Figure 8 above shows what a strategic planning map might look like relevant to emission abatement targets and storage costs.

Chapter 6

Non-network options will be important in addressing lead time issues. Storage will be a key technology to maximise utilisation of the existing network. However, it is agreed with AEMO that it is unlikely that non-network service could completely remove the expected or potential network limitations.

The limitations on minimum size of 10 MWh at a site is not necessary except from the point of view of being of such a scale that it would be controlled by AEMO to ensure appropriate network support. Conceivably there could be hundreds of 10 kWh installations that could be controlled in aggregate and provide the additional advantage of supporting the 66kV and distribution networks. The important factor is not the minimum size of an option but rather that it can be controlled to support the network through an aggregation process, and there is enough of these small scale projects to make a measurable difference to system reliability and the optimal timing of the network development options. If the 10 MWh limit refers to an aggregated service due to economies of scale in control and management, then that may be reasonable.

Chapter 7

The list of credible options in comprehensive, except that 500 kV development should also consider links from Ballarat or Horsham through to Snowy/NSW, particularly if the Snowy capacity is to be increased by 2,000 MW as proposed by the Federal Government. Strong access between Western Victoria and Snowy would be needed to maximise the value of the additional energy storage, particularly if there is a greater development of solar rather than wind resources. It is difficult to see that a Snowy upgrade could be considered independently of a strategy to substantially upgrade the Western Victorian network. It is more likely that a stronger 330 kV connection between Snowy and Western Victoria could maximise the value of a large scale Snowy augmentation as indicated by the Federal Government proposal. If the current study does not consider the Snowy option as potential option for large scale storage, then its value in informing State and federal Governments will be diminished. It would be useful to examine under what conditions a 330 kV or 500 kV interconnection to the Snowy area as indicated in Figure 4 would make sense with large scale wind and solar development in Western Victoria and South Australia as part of this study.

We again note that SENE studies for Western Victoria may be beneficial to ensure that the subsidiary network for connecting all the generators to the main grid is not a swathe of radial power lines, one for each project. The layout of the main grid and the subsidiary networks should be designed to be able to be scaled up to meet the regional generation potential.