AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

2020 ISP Appendix 5. Renewable Energy Zones

July 2020

Important notice

PURPOSE

This is Appendix 5 to the 2020 Integrated System Plan (ISP), available at https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp.

AEMO publishes this 2020 ISP pursuant to its functions under section 49(2) of the National Electricity Law (which defines AEMO's functions as National Transmission Planner) and its broader functions under the National Electricity Rules to maintain and improve power system security. In addition, AEMO has had regard to the National Electricity Amendment (Integrated System Planning) Rule 2020 which commenced on 1 July 2020 during the development of the 2020 ISP.

DISCLAIMER

This document or the information in it may be subsequently updated or amended. This document does not constitute legal or business advice, and should not be relied on as a substitute for obtaining detailed advice about the National Electricity Law, the National Electricity Rules, or any other applicable laws, procedures or policies. AEMO has made every effort to ensure the quality of the information in this document but cannot guarantee its accuracy or completeness.

Accordingly, to the maximum extent permitted by law, AEMO and its officers, employees and consultants involved in the preparation of this document:

- make no representation or warranty, express or implied, as to the currency, accuracy, reliability or completeness of the information in this document; and
- are not liable (whether by reason of negligence or otherwise) for any statements or representations in this document, or any omissions from it, or for any use or reliance on the information in it.

VERSION CONTROL

Version	Release date	Changes
1.0	30/7/2020	Initial release

Contents

Tables

Figures

2020 ISP Appendices

Appendix 1. Stakeholder Engagement

- Stakeholder engagement program and timelines
- Consultation on Draft 2020 ISP

Appendix 2. Cost Benefit Analysis

- An economically efficient development path

Appendix 3. Network Investments

- Network investments in the optimal development path
- Committed ISP projects
- Actionable ISP projects
- Future ISP projects recommended with preparatory activities
- Other future ISP projects
- Addressing network congestion
- Alternatives considered

Appendix 4. Energy Outlook

- Future energy supplies for a resilient power system
- Unlocking VRE through REZs
- Managing variable energy supplies through energy storages and firming technologies
- Development outlooks across scenarios
- NEM emission intensity with the least-cost optimal development path

Appendix 5. Renewable Energy Zones

- Integrating large volumes of VRE
- REZ framework and design principles
- ISP REZ development
- REZ scorecards

Appendix 6. Future Power System Operability

- Power system operability models and input
- NEM-wide operability outlook
- Regional risks and insights

Appendix 7. Future Power System Security

- Renewable Integration Study
- System strength outlook
- Inertia outlook
- REZ opportunities
- South Australia in transition

Appendix 8. Resilience and Climate Change

- Resilience in the 2020 ISP
- Forecasting climate impacts on energy systems
- Planning for a climate-resilient network
- Next steps

Appendix 9. ISP Methodology

- Overview of ISP methodology
- Inputs
- Engineering assessment
- Model outputs

Appendix 10. Sector Coupling

- Hydrogen
- EVs
- Gas
- Energy efficiency
- Bioenergy

Summary

This Renewable Energy Zones (REZs) appendix provides technical details on the determination of the 35 candidate REZs. It discusses VRE development opportunities within REZs and highlights transmission network augmentations required to support this VRE development.

AEMO has assessed 35 candidate REZs across the NEM through consideration of a mix of resources, current and future transmission network capacities and cost, and other technical and engineering considerations. Stakeholder engagement – with traditional owners, residents, broader communities, and local governments – will be essential prior to and during any large-scale development of a REZ. The co-ordination of generation and transmission development is key to the success of a REZ.

- The ideal near-term REZ locations take advantage of both attractive renewable resources and existing transmission capacities. Early development of VRE is primarily driven by regional energy targets (RETs) and other government policies.
- To connect VRE beyond the current transmission capacity, network investment will be required. The ISP considers how to best develop future REZs in a way that is optimised with necessary transmission developments, identifying indicative timing and staging that will best coordinate REZ developments with identified transmission developments to reduce the overall costs.
  - It will generally be most efficient to increase network capacity in REZs that are aligned with identified interconnector upgrades such as the already committed ISP projects, actionable ISP projects, and future ISP projects (see Appendix 3).
- The development of large-scale REZs is required prior to the expected retirement of power stations from the late 2020s and mid-2030s.
- Targeted grid augmentations are required to balance resources and unlock REZ potential. These are described in the optimal development path: see Appendix 3.

A5.1. Introduction

This appendix is part of the 2020 ISP, providing more detail on the REZ development across various scenarios (see ISP Section D3).

The NEM is a long and sparsely connected power system, with concentrated load centres that are distant from one another. The current NEM transmission network was primarily designed to connect large centres of thermal and hydro generation to major demand centres some distance away.

The ISP re-confirms that the NEM power system will continue its significant transformation away from thermal generation and towards VRE. There are good wind and solar resources across all the NEM regions. There is already 8.7 GW of VRE installed[1], and another 5.1 GW expected to be operational in the next two years, as either committed or anticipated projects. Allowing for the strong growth in DER, Australia will still need an additional 34 to 47 GW of new VRE, depending on the scenario, much of it built in REZs. In the Slow Change scenario, only 4 GW would be needed by 2039-40.

The analysis of the ISP focuses on 35 short-listed candidate REZs. These REZ candidates are high-resource areas in the NEM where clusters of large-scale renewable energy projects can capture economies of scale as well as geographic and technological diversity in renewable resources. Each candidate REZ has potential for future VRE development.

Only some REZs need to be developed to facilitate additional VRE. The ISP's optimal development path is based on a robust cost-benefit analysis (see Appendix 2). The costs of upgrading the network and developing generation in each REZ is considered. Then only the highest value REZs are identified for possible network upgrades and new generation development. The integrated approach of the ISP also co-optimises major network projects that would unlock VRE capacity in some REZs.

Appendix 5 is set out in the following sections:

- **A5.2 – REZ candidates shortlisted for the ISP**. AEMO has identified and mapped 35 areas across eastern Australia as candidate REZs. This section sets out how these candidates were developed, and their respective advantages.
- **A5.3 – REZ framework and design principles**. These principles support robust and reliable REZs and are used to determine functional network designs, and preliminary costs to integrate the REZ to the transmission network. The insights from this process form inputs into the ISP to assist in identifying the co-optimised cost-effective REZ development pathway.
- **A5.4 – prioritisation and staging of REZ development.** This describes the outcomes of the ISP for REZ development, prioritisations of REZ developments and staging, timing across scenarios, and the identification of actionable REZ transmission projects (being the associated network and non-network infrastructure required to implement the REZ). Functional network designs that integrate the REZs with the wider network are highlighted together with preliminary costing.
- **A5.5 – scorecards for each REZ arranged by state.** This includes assessments of resource quality, network capability, preferred timing across scenarios, and system strength.

[1] Data is current as at April 2020, AEMO Generation Information Page, at https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information.

A5.2. Integrating large volumes of variable renewable energy

This section of the appendix describes the elements considered in the identification of REZs. It also describes the 35 REZ candidates in the 2020 ISP.

AEMO has used information about resource quality and REZ development criteria developed for the 2018 ISP (outlined in A5.2.1), as well as feedback received through consultation for the 2020 ISP, to create the list of 35 REZ candidates.

A5.2.1 REZ identification

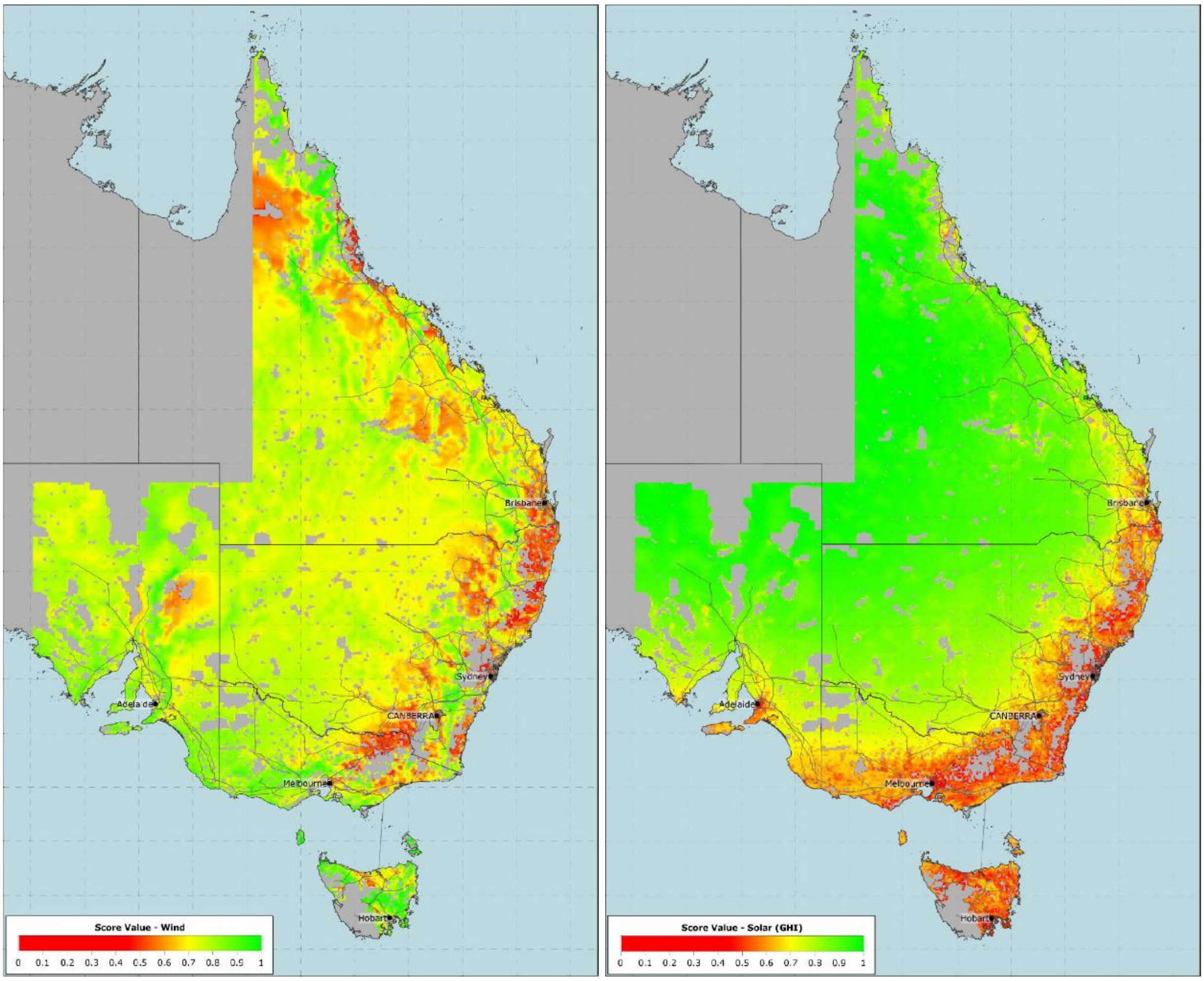
AEMO engaged consultants DNV-GL to provide information on the resource quality for potential REZs in the 2018 ISP. The wind resource quality assessment was based on mesoscale wind flow modelling at a height of 150 m above ground level (typical wind turbine height). Solar resource quality was assessed using Global Horizontal Irradiance (GHI) and Direct Normal Irradiance (DNI) data from the Bureau of Meteorology (BOM). The work undertaken for the ISP is not intended in any way to replace the specific site assessment of potential wind and solar farm sites by developers.

These 10 development criteria were used to identify candidate REZs:

- Wind resource – a measure of high wind speeds (above 6 m/s).
- Solar resource – a measure of high solar irradiation (above 1,600 kW/m^2).
- Demand matching – the degree to which the local resources correlate with demand.
- Electrical network – the distance to the nearest transmission line.
- Cadastral parcel density – an estimate of the average property size.
- Land cover – a measure of the vegetation, waterbodies, and urbanisation of areas.
- Roads – the distance to the nearest road.
- Terrain complexity – a measure of terrain slope.
- Population density – the population within the area.
- Protected areas – exclusion areas where development is restricted.

Figure 1 shows the results of this DVN-GL analysis, with the highest rating potential areas for development of wind and solar farms in green.

Figure 1 Weighted wind (left) and solar (right) resource areas

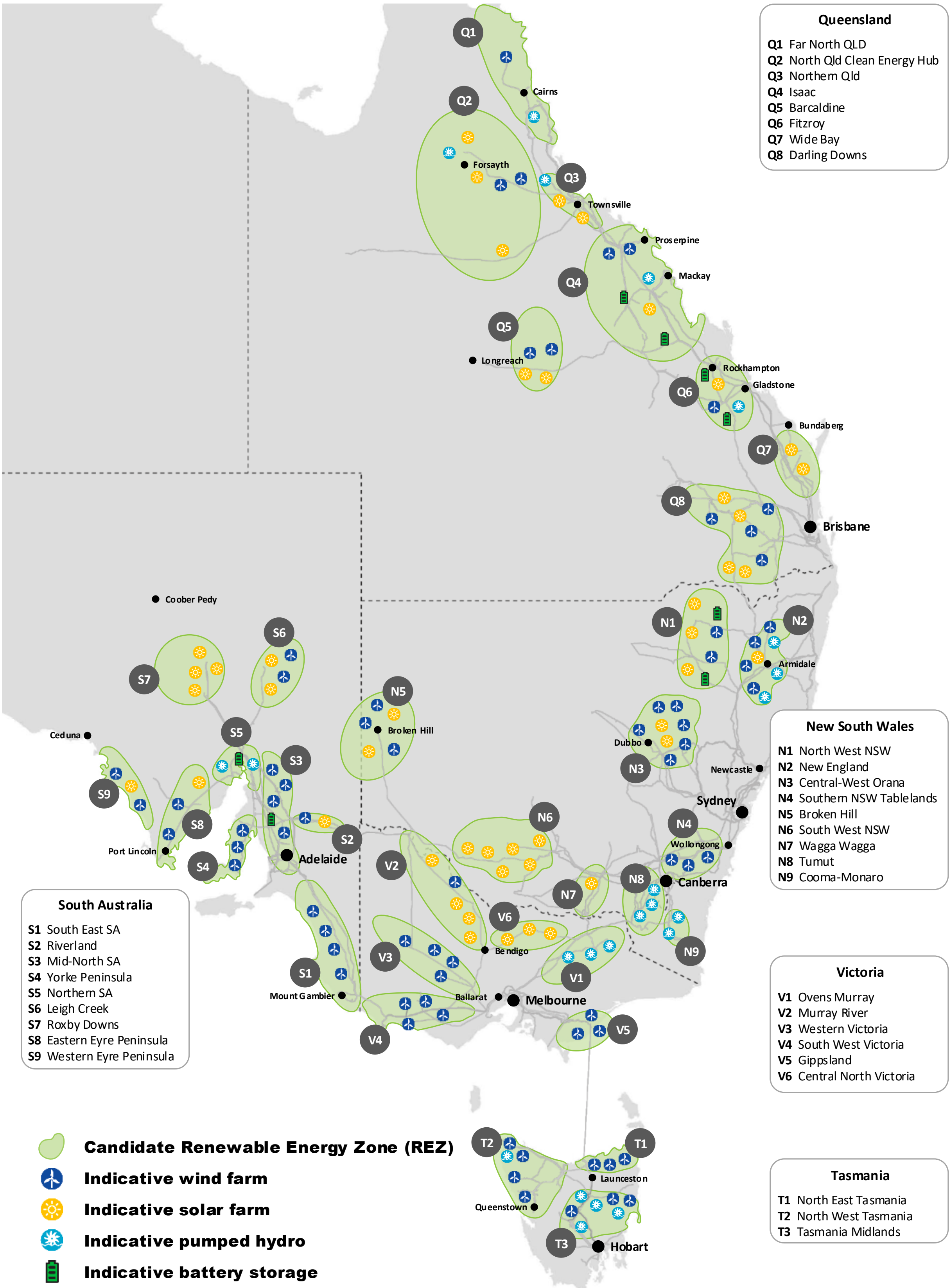


A5.2.2 REZ candidates

Using the resource quality and the development criteria together with feedback received throughout the 2020 ISP consultation, AEMO has identified 35 candidate REZs for the 2020 ISP.

Figure 2 shows the geographic locations of the 35 final REZ candidates.

Figure 2 2020 Renewable Energy Zone candidates



The 2020 ISP has made several updates to the REZ candidates used in the 2018 ISP, based on further analysis and consultation:

1. The following new REZs are included in the analysis:
   - Wide Bay in Queensland (Q7).
   - Wagga Wagga in New South Wales (N7).
   - Central North Victoria (V6).
2. The former Murray River REZ, capturing resources to the west of New South Wales and Victoria, has been separated to form the:
   - Murray River REZ in Victoria (V2), and
   - South West New South Wales REZ in New South Wales (N6).
3. The New England and Northern New South Wales Tablelands REZs have been combined in the New England REZ (N2).
4. The former Central New South Wales Tablelands and Central-West New South Wales were refined to form the Central-West REZ (N3). Following the recent announcement by the New South Wales Government[2], this REZ's name has changed to Central-West Orana REZ (N3).
5. The Far North Queensland REZ (Q1) has been extended north to include wind resource capacity.

A5.2.3 Resource quality and correlation

Diversity of resources

An important consideration for large-scale development of renewables in a REZ is the diversity of resources available within the REZ and between other REZs in the NEM. High diversity means the REZs are valuable as they will generate power at different times. For example, when one has a low output, the other has a high output.

The analysis of REZs in the NEM shows:

- There is high solar energy correlation across the NEM for all REZs.
- Wind resources in Queensland provide the most diversity to wind generation in other areas. Wind generation in Tasmania is somewhat diverse to wind generation on the mainland – particularly wind generation in Queensland, New South Wales, and South Australia.
- Wind generation within states is generally highly correlated.

There are five REZs that have low correlation with most of the NEM, meaning they are expected to generate electricity at different times to the rest of the NEM. These five REZs are all situated in Queensland and show good diversity with wind in the other regions of the NEM:

- Far North Queensland.
- North Queensland Clean Energy Hub.
- Isaac.
- Fitzroy.
- Wide Bay.

Wind development in these areas would allow for the diversification of renewable resources across the NEM and contribute to a firmer resource portfolio across the NEM. Development in these areas would also be

[2] New South Wales Government, 23 June 2020, at https://energy.nsw.gov.au/renewable-energy-zone-sparking-investment-boom.

impacted less by wind generation in other REZs, as the transmission paths to load centres would be less congested.

Generation diversity and demand matching

Integrating a large amount of highly correlated variable renewable generation can be more complicated for managing power system reliability than connecting poorly correlated generation. High levels of correlation – when a lot of nearby variable generation is producing (or not producing) energy at the same time – will increase congestion on the transmission network and volatility in electricity market dispatch.

Generation correlation can be influenced by technology, location, and time of day.

There are several ways to achieve diversity with renewable generation, and improve system efficiency:

- Diversify the type of renewable generation built. For example, wind generation within a REZ is likely to be highly correlated to other wind generation within the same REZ, whereas solar generation is likely to be relatively uncorrelated to wind generation in the same area.
- Diversify the geographical location of the renewable generation built. For example, wind generation located in different geographical areas is likely to be less correlated than wind generation within the same geographical area.
- Select REZs where the combined output from renewable resources is positively correlated with grid demand.
- Co-develop energy storage and variable renewable generation in the same REZ, to allow the net REZ output to be more correlated with demand or within transmission capacity. Resource and demand are both variable, based on seasons and time of the day. If the availability of energy is coincident with the demand, it can be accommodated more economically. In assessing the REZs for analysis in the ISP, the optimisation considered the correlation of REZ resource with demand.

A5.3. REZ framework and design principles

The ideal near-term REZ locations would take advantage of both attractive renewable resources and spare transmission capacity. VRE in these REZs will be cheaper than building the network infrastructure needed to unlock a new REZ.

As the existing network reaches capacity, large-scale transmission infrastructure extensions, into new regions with good diverse resource capacity, will be required to connect REZs. Any new transmission network built to connect REZs should be cost-effective while:

- Providing reliability and security.
- Minimising environmental impacts during and after construction.
- Adhering to relevant design standards.
- Meeting regulatory requirements.
- Creating maximum flexibility and expandability.
- Addressing future needs of the power system.
- Maximising efficiencies through coordination of the various development needs within the REZ together with the integration of needs for augmentations to the shared network.

This section discusses the frameworks and design principles in planning network augmentations for REZs.

A5.3.1 Network and non-network requirements in the future power system

Transmission connection in the NEM is currently open access. That means, subject to meeting connection requirements (including generation performance standards and other technical, legal, and financial requirements) a new development is permitted to connect to any part of the transmission network. The connection may be conditional upon the project remediating any negative impact on system strength.

Further development of renewable resources in the REZ may require additional augmentation of the shared network. An incremental approach risks an overall higher cost of developing the REZ. For example, it is generally less expensive to build one high capacity transmission line than to build one lower capacity transmission line which is later duplicated. These risks to generators could be reduced through effective REZ development, aligning the development of transmission network capacity with likely renewable energy build in the REZ, with a view to both current and future requirements.

This highlights the importance of coordinated staging of generation and transmission development that minimises risks of under- and over-utilisation while ensuring reliability and security of the power system is maintained. Ways to stage a transmission development include, but are not limited to:

- Acquiring strategic easements ahead of their build.
- Building a double-circuit tower but stringing a single-circuit initially.

- Developing a substation incrementally but having a footprint that accounts for an ultimate development.

It will be essential in the development of transmission to support REZs that these options are explored, to minimise any stranding risk and maximise option value. In the development of the ISP, AEMO has sought to optimise REZs in conjunction with transmission development to achieve the lowest overall cost of development.

A5.3.2 Regulatory framework

In developing the ISP, AEMO recognises work the AEMC is undertaking into the Coordination of Generation and Transmission Investment (COGATI) review including improved access arrangements, and also the work that the ESB is undertaking on interim options for coordinated development of REZs. The COAG Energy Council on 20 March 2020 asked the ESB to support the development of REZs with a two-stage approach that includes rules for an Interim REZ Framework and later a REZ Connection Hub development:

- Stage 1 rules would require TNSPs to prepare detailed staged plans for each priority REZ identified in the ISP. These detailed designs would consider the required transmission infrastructure and the best place to locate the connection hubs within the REZ.
- Stage 2 rules are intended to provide for REZ Connection Hub Development, described as the development of stages (or connection hubs) within REZ development plans. In this stage, the ESB will also consider how access is defined and how costs related to augmentation of the shared network should be recovered.

The intention of these programs is to apply the outcomes of the ISP for REZ development. This ISP identifies and prioritises REZs for development as part of the optimal development path.

AEMO also recognises the initiative by the New South Wales Government to accelerate the development of the Central-West Orana REZ together with arrangements to provide firmer connection access. This ISP incorporates the consequential shared transmission network upgrades as an actionable ISP project. Finally, AEMO recognises the proposals by TransGrid to accelerate development of the New England REZ. These proposals were only in the early stages of development when this ISP was finalised and are therefore not included.

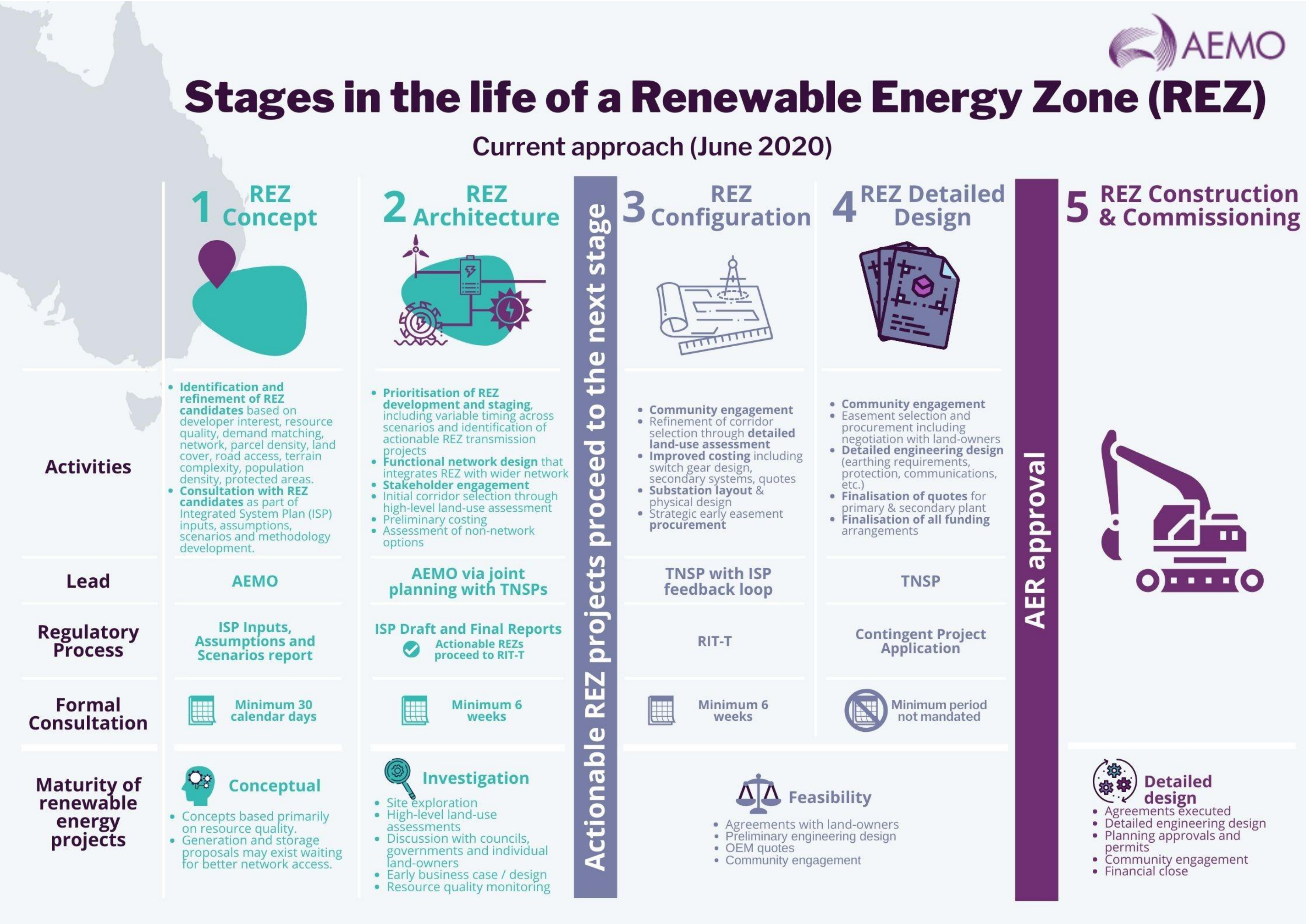
A5.3.3 Stages in the life of a REZ

In June 2020, AEMO published information outlining the developmental stages of a REZ[3]. Figure 3 outlines the stages in the life of a REZ under the current regulatory frameworks.

The process outlines activities currently carried out by AEMO as part of the ISP and those carried out by the TNSP through the RIT-T and the contingent project application.

[3] AEMO, 15 June 2020, at https://aemo.com.au/en/news/isp-rez.

Figure 3 Stages in the life of a renewable energy zone, as of June 2020



A5.3.4 Network topology

Network topology refers to how various substations, generators, loads and other electrical transmission devices are physically or logically arranged in relation to each other. The network topology is important as it directly influences how well the network will function during system normal conditions and under credible and non-credible contingencies.

The following should be considered in the design of a reliable REZ:

- Staging and interconnection.
  - Where possible, the REZ design should leverage off and/or contribute to the efficient and optimised design of the shared transmission network. REZs should be staged to increase transmission capacity at appropriate levels to co-optimise investment in transmission and generation. For example, staging can be achieved by building a double-circuit tower but stringing a single-circuit initially and early acquisition of strategic easements for later stages. The design would be enhanced by understanding the long-term strategic transmission development in the area such that the staging of the REZ development and costs can be optimised. Where REZs have the capability to form part of interconnectors, the REZ design should take this into account, to enable efficient interconnector development.
- Number of connections to the main grid and route diversity.
  - When a REZ reaches a certain critical capacity, it should connect to the main transmission network with at least two connection points. This looping allows for additional network reliability and route diversity. This would increase resilience, for example, to climate impact and bushfires.
- Network architecture.
  - Well-designed REZs should consider the architecture of the network needed to avoid the application of constraints on generation for contingency size. For example, if single easement radial connections were applied to large a REZ, this would imply a large single critical contingency size (possibly in excess of the current largest single contingency in the NEM). Contingency size is critical to the security of the NEM to manage frequency within the operating standards post a single contingency. A looped or more meshed integration, if designed well, could reduce the potential contingency size and reduce or avoid potential operational limits that may otherwise need to be applied to generation in the REZ.
- Sharing of connection assets.
  - Allowing for the connection of proponents at hubs, rather than connecting on a stand-alone basis along transmission lines, has the potential to provide a more reliable and cost-effective network connection. The hub connection reduces capital expenditure by minimising the duplication of connection infrastructure.
- Switching arrangements.
  - Adequate switching arrangements to allow for outage flexibility of equipment, minimising the impact on the transmission network.
- Adequate sizing and voltage levels selected.
  - The long-term ultimate arrangement for transmission development in the area can inform the appropriate site sizing and voltage levels at the relevant substations connecting proponents to the transmission network. In this way costs can be optimised through gains in economies of scale when executing major construction projects, like substations. Most of the substation engineering, procurement and construction work can happen at one time. This limits the exponential costs of retrofitted expansion projects that would be required into the future, if proper design principles were not considered.

A5.3.5 Managing local power system requirements

AEMO's Power System Requirements Reference Paper[4] sets out the operational prerequisites which give AEMO the levers needed to operate the system securely and reliably. It also summarises the fundamental technical attributes for a resilient power system. These technical attributes should be considered when designing a REZ.

System operability

Under system normal conditions, in a well-designed REZ, generators should be able to operate and transfer energy to the shared network and thereon to consumers without undue thermal, voltage, or stability issues limiting their output. A well-designed REZ will also have a robust marginal loss factor (MLF) that will not deteriorate rapidly as more generation connects.

The REZ itself, being a cluster of varied types of resources, must remain stable following a credible single contingency and within the thermal, voltage, and frequency limits of the network. Further, AEMO must also be able to restore the system to a secure operating state within 30 minutes following a contingency event. Therefore, the design of a REZ needs to also consider the network topology both within the REZ and to the shared network, as well as contingency sizes that arise from its network design. Otherwise, AEMO may be forced to constrain generation within the REZ to manage the risks from a contingency.

Thermal capacity

The thermal capacity of a REZ is its maximum output without exceeding the ratings of a network elements following a credible contingency. It may be possible under certain circumstances to install generation in excess of this thermal level, provided that a fast-acting special protection scheme, such as a runback scheme, is implemented. The runback scheme would very quickly reduce and limit generation following a contingency to avoid thermal overloads (and thereby create safety hazards). Runback schemes allow the network to operate closer to its technical limits, reducing the need for network expansions.

The following should be considered for runback schemes:

- The loading of the network during system normal should remain within thermal limits.
- The impact on MLFs due to increased loading on the transmission network.
- The amount of generation to be reduced by the runback scheme must consider the effects it may have on the frequency. All relevant standards must be met.
- The need for close coordination with other schemes within the area.

Frequency

The REZ should be designed such that the loss of a single credible contingency does not cause the loss of significant generation that would result in frequency excursions exceeding the safe limits of the frequency operating standards.

Furthermore, following a contingency, AEMO is required to return the network to a secure operating state within 30 minutes. The deployment of runback schemes and the design of the network to and within the REZ should consider the implications for frequency, as very large quantities of generation are being projected in this ISP. Some REZs in the next decade are projected to be in excess of not just the largest unit in the current NEM, but the largest power station. Accordingly, the design of the REZ will need to ensure that contingency size is manageable.

[4] AEMO, Power System Requirements Reference Paper, updated July 2020, at https://aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power-system-requirements.pdf.

Voltage management

The power flow and voltage profile on the transmission network is determined by both generation and load. Large fluctuations in load and/or generation can have impacts on the transmission voltages. The intermittency of solar and wind generation will have an impact on voltages across the REZ as well as on the network where the REZ connects. Furthermore, the loss of a contingency such as transmission line can also impact the network voltages.

To manage fluctuating generation outputs and network contingencies, REZs should include the combination of active and passive voltage control equipment to manage voltages within acceptable levels. The reactive support required for the REZ would be dependent on the network topology and the technology mix within the REZ and can be provided through capacitor banks, reactors, Static Var Compensators (SVCs), and/or synchronous condensers.

System strength is a critical requirement for a stable and secure power system. A minimum level of system strength is required for the power system to remain stable under normal conditions and to return to a steady state following a disturbance. AEMO defines system strength as the ability of the power system to maintain and control the voltage waveform at any given location in the power system, both during steady state operation and following a disturbance[5].

A REZ must comply with system strength requirements: see Appendix 7. The system strength requirements can be staged as the capacity of the generation connecting to the REZ increases over time. System strength requirements can be provided by synchronous condensers (individual or shared), synchronous generators, and/or other technologies, including appropriately designed or retro fitted inverter-based resources.

Resource adequacy

The variability of VRE resources is an important factor when considering the integration of REZ within the larger network, to reduce overall costs to consumers for additional firming supplies. When developing a REZ, dispatchable services (controllability, firmness and flexibility) should be considered. This may include firming up every MW of variable renewable generation with some ratio of firm generation. Co-developing energy storage and variable renewable generation in the same REZ, to allow the net REZ output to be more correlated with demand, may reduce the size of the network augmentation required and increase the utilisation of the REZ network.

System restoration

REZs must not inhibit the ability of AEMO and the local TNSP to restart the system under a black system event. Where technology within the REZ has capability to assist in system restart, it would be beneficial that the design of the network would be an enabler for this plant to support system restart if required.

---

[5] AEMO, System Strength, March 2020, at https://aemo.com.au/-/media/files/electricity/nem/system-strength-explained.pdf?la=en#:~:text=AEMO%20sees%20system%20strength%20as,operation%20and%20following%20a%20disturbance.&text=Unlike%20 Most%20IBR%2C%20synchronous%20Machines,coupled%20to%20the%20power%20system.

ISP REZ development

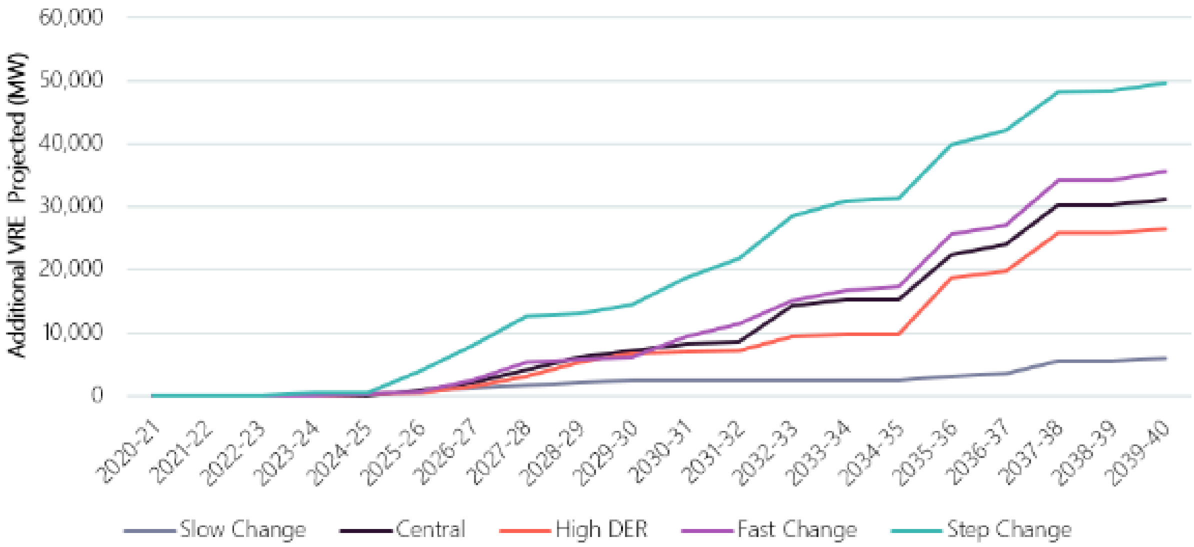
The following section presents AEMO's prioritisation and development of identified REZs within each NEM region. Factors that affect the development of a REZ include, but are not limited to:

- Energy targets, policies and scenarios.
- Resource quality.
- Existing network capacity.
- Demand correlation and correlation with other favourable REZs.
- Cost of developing or augmenting the transmission network.
- Proximity to the load centre.

Under every ISP scenario – Central, High DER, Step Change, Fast Change and Slow Change[6] – the NEM's least-cost future features large increases in VRE generation. The increases are in both large-scale wind and solar connected to the grid and distributed PV installed by households and businesses. Targeted and strategic investment in the grid is needed to balance resources across states and to unlock much-needed REZs.

During the first 10 years of the forecast horizon, modest ongoing growth in VRE generation is forecast, driven by relative cost advantages and government policies, as seen in Figure 4. From 2029-30 onwards, large growth in VRE generation is forecast, driven by the need to replace energy from retiring thermal generation.

Figure 4 Variable renewable energy developed by 2039-40 for all scenarios based on the least-cost development paths*



* Except for the Slow Change scenario, which is based on the transmission investment with the low-regret, which includes all interconnectors that are developed in every other scenario with a fixed timing.

[6] AEMO, 2019 forecasting and planning scenarios, inputs, and assumptions, at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2019/2019-20-forecasting-and-planning-scenarios-inputs-and-assumptions-report.pdf?la=en.

Each region is forecast to develop several REZs to enable the scale of VRE developments, providing an opportunity for diversely located renewable developments and storage projects to meet the needs of future customer demand. The ISP identifies the mix of REZ developments that maximises the efficient connection of these modelled ISP projects.

In this section, the ISP development opportunities for REZs are described. The sections that follow present the assessments of a REZ within these phases for each state in turn.

The REZs were assessed according to the defined criteria for assessment[7]. All VRE projections are based on the least-cost development paths, except for the Slow Change scenario. The Slow Change scenario is based on the transmission investment with the low regret, which includes all interconnectors that are developed in every other scenario with a fixed timing.

Proponents of new generation or storage should conduct their own due diligence, to understand how technical requirements might influence their connection. Engagement with traditional owners, residents, broader communities, and local governments will be essential prior to any large-scale development of a REZ. Timings presented are indicative only. It is important to note immediate actions identified in this ISP do not lock out opportunities for earlier development of any REZ, if economical in future.

A5.3.1 ISP development opportunities – REZs

REZ development can be categorised into three phases (described below), which reflect timing and drivers and should be co-ordinated with recommended augmentations of the network discussed in Appendix 3 and system strength remediation. These opportunities will take advantage of additional network capability introduced by new interconnectors where possible, as this is often the least-cost way of establishing REZs. However, some opportunities also require specific augmentations of the transmission network to unlock the REZ. There are three overlapping development phases.

Phase 1

VRE development to help meet regional energy targets, such as VRET, TRET and QRET, and other policies (such as the New South Wales Electricity Strategy and policy in respect of Central-West Orana REZ), until those schemes are complete and/or where there is good access to existing network capacity with good system strength within the current power system, good resource potential, and strong alignment with community interests.

Phase 2

VRE development to replace energy provided by retiring coal-fired generators announced to occur from the late 2020s, and/or where additional renewable development is supported by the recommended actionable ISP projects.

Phase 3

VRE development to accompany recommended future ISP projects that are being developed specifically to support them.

These REZs and their phasing are directly linked with ISP projects in the optimal development path and their timing. For actionable ISP projects with decision rules, the REZ developments and phasing assumes that the decision rules are met, and the ISP projects are delivered at the earliest timing.

[7] The criteria used for this detailed assessment of REZs are defined in Section A5.2 of this report.

Table 1 ISP REZ developments

Phases of REZ development	Region	Description
Phase 1 **Connecting renewables to support government policy**	Queensland	VRE development primarily in Darling Downs (wind and solar) and Fitzroy REZs (wind and solar) taking advantage of the existing spare network capacity to meet the QRET.
	New South Wales	VRE development in Central-West Orana REZ (wind and solar) enabled by the Central-West Orana REZ Transmission Link, forming part of the NSW Electricity Strategy.
	Victoria	VRE development in Western Victoria REZ (wind) to help meet VRET and supported by the committed Western Victoria Transmission Network Project. VRE development in South West Victoria REZ (wind) and Central North Victoria REZ (wind and solar), taking advantage of the spare network capacity to meet the VRET.
	Tasmania	The development of VRE in Midlands, North East Tasmania and North West to meet the TRET[A].
Phase 2 **Connecting renewables in areas supported by actionable ISP projects**	New South Wales	VRE development in South West NSW REZ (solar) is supported by the development of Project EnergyConnect and VNI West (via Kerang), and Wagga Wagga REZ (solar) is supported by of HumeLink. Pumped hydro generation in Tumut REZ is supported by the development of HumeLink.
	Victoria	Development of VRE in Central North Victoria REZ supported by VNI West (via Shepparton), or Murray River REZ supported by VNI West (via Kerang)[A]. VRE development in Western Victoria REZ is also supported VNI West (either via Kerang or Shepparton). Development of solar in Murray River REZ near Red Cliffs is supported by Project EnergyConnect.
	South Australia	The development of solar in the Riverland REZ enabled by Project EnergyConnect.
	Tasmania	The development of wind generation in the Midlands REZ which is supported by Marinus Link[A].
Phase 3 **Connecting renewables in areas supported by future ISP projects**	Queensland	VRE development in Darling Downs REZ (wind and solar) is supported by expansions of QNI in 2032-33 and 2035-36. Larger VRE development in Fitzroy REZ (wind and solar) and Isaac REZ (wind) are supported by future ISP projects, Gladstone Grid Reinforcement and Central to Southern Queensland transmission project. Developments in Far North Queensland REZ requires upgrades within this REZ to connect renewable generation. Additional strengthening of the 275 kV network is also required.
	New South Wales	VRE development of solar in North West NSW REZ supported by expansions of QNI in 2032-33 and 2035-36. Large developments of wind in New England would require support from a future ISP project to augment the transmission system from the REZ to provide stronger access to supply the greater Sydney region.
	South Australia	VRE development in Roxby Downs REZ (solar) and Mid-North REZ (wind) are supported by network upgrades between Davenport and Para. Development of wind in South East SA REZ requires the support of a future ISP project to connect generation within the REZ.

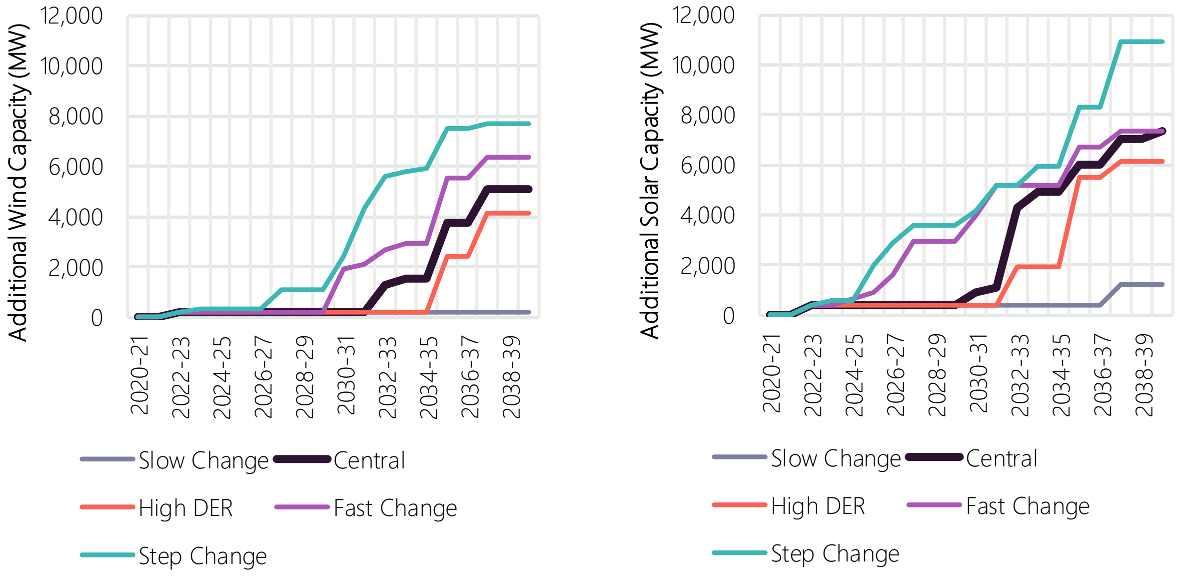
A. The REZ and timing are based on actionable ISP projects in the optimal development path satisfying decision rules and being delivered in accordance with the optimal development path.

A5.3.2 New South Wales REZ assessment

In New South Wales, with increased generation in the Snowy area and the increase in interconnection, little renewable generation development above committed generation is forecast in the first decade across the Central, High DER and Slow Change scenarios, as seen in Figure 5.

In the Step Change and the Fast Change scenarios, early development of renewable generation occurs in REZs with exiting network capacity or REZs that are supported by actionable ISP projects, namely Central-West Orana REZ Transmission Link, Project EnergyConnect, and HumeLink.

Figure 5 New South Wales projected wind (left) and solar (right) capacity build (MW) across all scenarios



AEMO assessed nine candidate REZs in New South Wales. The report card in Table 2 shows the transmission network upgrade timing and REZ phasing.

This assessment projects that it will be most efficient to:

- Increase network capacity in REZs that are aligned with identified interconnector upgrades such as:
  - The actionable ISP project, Project EnergyConnect, supporting South West New South Wales REZ.
  - The actionable ISP project HumeLink, supporting Wagga Wagga REZ.
- Undertake preparatory activities for the future QNI Medium and QNI Large upgrades to support development of the North West New South Wales REZ and New England REZ.
- Develop large-scale REZs prior to the closure of Eraring and Bayswater. The end-of-life retirement of Eraring is expected in early to mid-2030s and Bayswater in the mid-2030s.
  - Development of Central-West Orana REZ, New England and North West New South Wales REZs is required to assist meeting the energy needs of New South Wales.

From AEMO's analysis of the REZs for New South Wales, AEMO requires TransGrid to:

- Carry out preparatory activities for the New England REZ network expansions and the North West New South Wales REZ network expansion, including the publishing of a report required by 30 June 2021 (see Appendix 3).

Table 2 New South Wales REZ report card

REZ	Existing network capacity (MW)	Hosting capacity increase with new IC or future ISP projects	Priority for generation connection	Network upgrade timing				
				Central	Step	Fast	High DER	Slow
N1 – North West NSW	100	QNI Medium +1,000 MW QNI Large +2,000 MW	Phase 3	Upgrades occur with QNI Medium in 2032-33 and QNI Large in 2035-36, additional upgrades may be required:				-
				2037-38	2035-36	2035-36	2040-41	
N2 – New England	300	-	Phase 3	2035-36	2030-31	2030-31	2035-36	-
N3 – Central-West Orana NSW	3,000[A]	Actionable ISP project Central-West Orana REZ Transmission Link project	Phase 1	2024-25[B]	2024-25	2024-25	2024-25	2024-25
N4 – Southern NSW Tablelands	1,000	-	-	-	-	-	-	-
N5 – Broken Hill	-	-	-	-	-	-	-	-
N6 – South West NSW	-	Project EnergyConnect +600 MW	Phase 2	Upgrades occur with Project EnergyConnect in 2024-25				
N7 – Wagga Wagga	-	HumeLink +1,000 MW	Phase 2	Upgrades occur with HumeLink in 2025-26				
N8 – Tumut	-	HumeLink +2,040 MW (Hydro generation)	Phase 2	Upgrades occur with HumeLink in 2025-26				
N9 – Cooma-Monaro	200	-	-	2033-34	2031-32	2033-34	2037-38	-

A. This includes transmission capacity from Central-West Orana NSW REZ development with NSW Government.
B. Timed with expected completion of Central-West Orana REZ

A5.3.2.1 Central-West Orana REZ

Central-West Orana REZ, previously known as Central West REZ, has been identified by the New South Wales Government as the state's first pilot REZ[8]. The REZ is expected to provide 3,000 MW of transmission hosting capacity within the Central-West Orana region of the state by the mid-2020s.

Construction of the REZ is expected to begin in 2022. In May 2020, the New South Wales Department of Planning, Industry and Environment called for renewable energy, energy storage, and emerging energy project proponents to register their interest in being part of the first pilot REZ[9]. The registration of interest closed in the first week of June 2020, attracting 113 registrations of interest for projects, totalling approximately 27 GW[10].

[8] New South Wales Government, at https://energy.nsw.gov.au/renewables/renewable-energy-zones.

[9] New South Wales Government, at https://energy.nsw.gov.au/renewables/renewable-energy-zones.

[10] New South Wales Government, at https://energy.nsw.gov.au/renewable-energy-zone-sparking-investment-boom.

AEMO identifies the transmission augmentation Central-West Orana REZ Transmission Link as an actionable ISP project which is required to support generation with the Central-West Orana REZ. The transmission network[11] includes a 500 kV (or 330 kV) loop which traverses the Central-West region. The final transmission augmentation topology will depend on secured generator investment interest within the zone as part of a generator contracting process to be run by the New South Wales Government.

The development is expected to cost approximately $450 to $850 million. For more information please refer to Appendix 3.

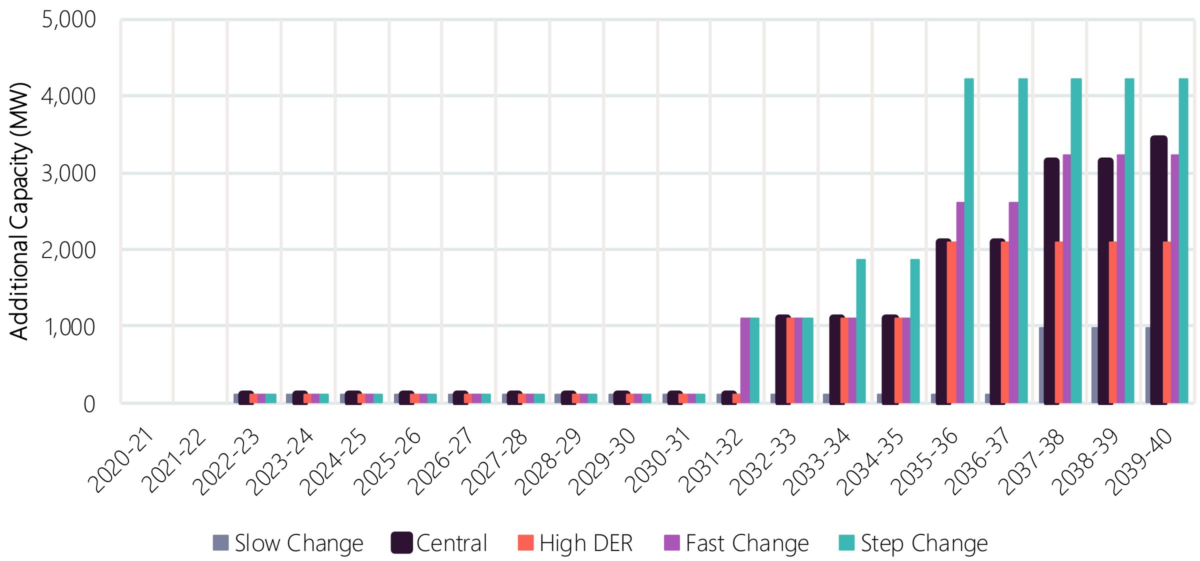
A5.3.2.2 North West New South Wales

Development in North West New South Wales is supported by QNI Medium and QNI Large upgrade proposals. The additional capacity provided by QNI is utilised immediately in the Central and High DER scenarios. Under the Step and Fast Change scenarios, the network between Boggabri and Wollar/Bayswater would need to be brought forward a year to accommodate the increase in generation projected.

As projected VRE in the North West New South Wales REZ increases beyond 2,000 MW from 2035-36, seen in Figure 6, the utilisation of storage can minimise the network build in this area. As generation further increases in North West New South Wales and New England REZs, a new 500 kV connection between the two REZs is proposed to share network capacity. North West New South Wales is predominately a solar zone, whereas New England is predominately a wind zone with interest for pumped hydro generation. The sharing of these resources across the network augmentation would allow for better transmission utilisation and reduction in transmission build. Table 3 details the proposed development for North West New South Wales.

Figure 6 shows the projected VRE in this REZ for each scenario's least-cost development path.

Figure 6 Projected capacity build (MW) for North West New South Wales REZ across all scenarios



[11] Augmentation details to be developed as part of the RIT-T.

Table 3 North West New South Wales REZ network expansion

<table>
<tr>
<td>

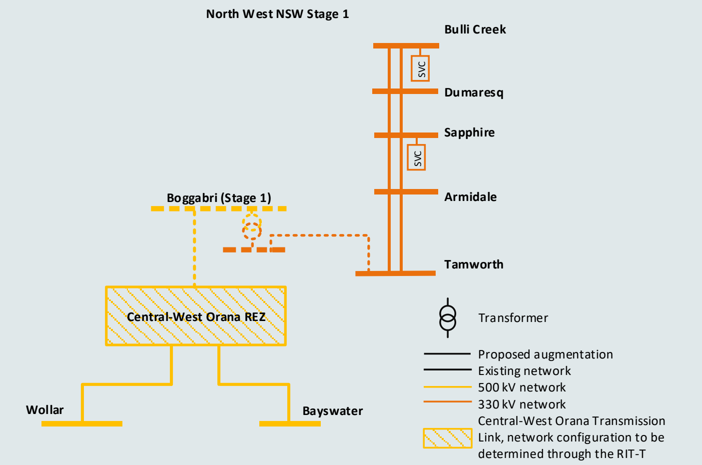
Stage 1 (Approximate capacity ~ 1,000 MW):

Bring forward QNI Medium

- Establish a new 500/330 kV substation at Boggabri
- A new single-circuit Boggabri–Tamworth 330 kV line
- A new double-circuit 500 kV line, strung one side, from this new substation via Central-West Orana to Boggabri
- 500/330 kV transformation at Boggabri

Estimated cost is ~ $320 million to $590 million

</td>
<td>



</td>
</tr>
<tr>
<td>

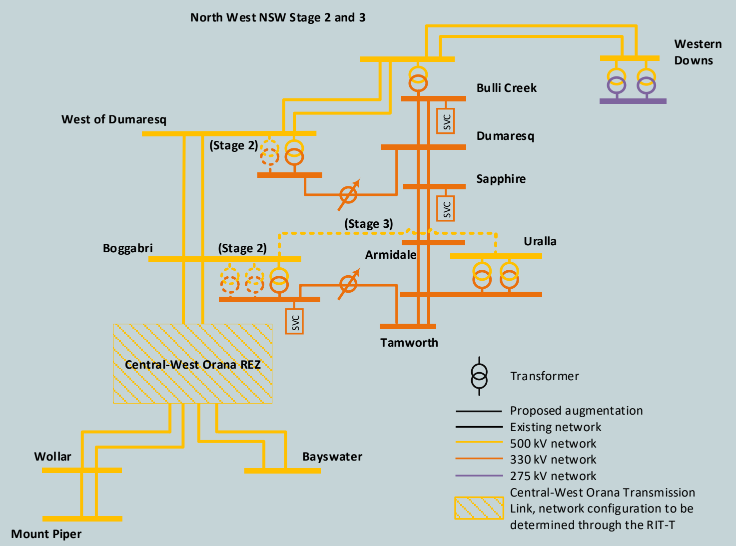
Stage 2:

This occurs after the development of QNI Medium and Large

- Establish additional 500/330 kV transformation at Boggabri
- Establish additional 500/330 kV transformation at West of Dumaresq

Estimated cost is ~ $70 million to $140 million

</td>
<td rowspan="2">



</td>
</tr>
<tr>
<td>

Stage 3 (3,000 MW including stage 2[A]):

- A new single-circuit Boggabri–Uralla 500 kV line[B]

Estimated cost is ~ $220 million to $420 million

</td>
</tr>
</table>

A. This includes parts of QNI Medium and Large that were not constructed in Stage 2.
B. Common with both New England and North West New South Wales REZs.

North West New South Wales REZ network expansion preparatory activities

The transmission infrastructure required to integrate the North West New South Wales REZ with the greater transmission network is identified as a future ISP project. This project would reduce costs, and enhance system resilience and optionality. It is not yet 'actionable' under the new ISP Rules, but is expected to be so in the future and is part of the optimal development path.

AEMO requires TransGrid to carry out preparatory activities for the North West New South Wales REZ network expansion including publishing a report on the outcome of these activities by 30 June 2021. The preparatory activities required include:

- Preliminary engineering design.
- Desktop easement assessment.
- Cost estimates based on preliminary engineering design and route selection.
- Preliminary assessment of environmental and planning approvals.
- Appropriate stakeholder engagement.

The following REZ parameters should be considered when undertaking preparatory activities.

Table 4 North West New South Wales REZ parameters

REZ design parameter	North West New South Wales
Geographical location	See North West New South Wales scorecard in section A5.4.2.
Notional REZ hosting capacity	Stage 1: 1,000 MW Stage 2: 3,000 MW (including stage 1) Stage 3: >5,000 MW (including stage 1 and 2)
Forecast expansion in the least-cost development paths	See Figure 6
Proposed connection points between the REZ and the rest of the shared network	The network between Dumaresq/West of Dumaresq and Tamworth and the network between Bayswater and Wollar.
Delivery date for the preparatory activities and report	30 June 2021
Additional matters for consideration	Consideration should be given to the possibility for the QNI interconnector to traverse through this REZ and assist with connection of generation along the path. Considerations should also be given to the possible development of New England REZ. See Appendix 3 for further details.

A5.3.2.3 New England REZ

The New South Wales Electricity Strategy[12] sets out a plan to prioritise three REZs – the New England REZ, South West New South Wales REZ, and Central-West Orana REZ – which will become a driving force to deliver affordable energy into the future.

Across all scenarios, except for Slow Change, large transmission augmentation is required to connect the projected VRE in New England to the Sydney load centre. The proposed future ISP project for the New England REZ is summarised in Table 5. Additional to the expansion noted in Table 5, as VRE within North West New South Wales, New England and Central-West Orana increases and coal retirements occur in New South Wales, network augmentation will be required between Bayswater, Newcastle and Sydney. The 500 kV network between Bayswater and Eraring would need to be linked to alleviate congestion on the 330 kV network between Tamworth, Newcastle and Sydney. Details of this required augmentation are discussed more in Appendix 3, under the ISP project Reinforcing Sydney, Newcastle and Wollongong Supply.

Table 5 New England REZ network expansion

Stage 1[A] (Approximate 3,000-4,000 MW[B]): • Uprate Armidale–Tamworth 330 kV lines 85 and 86 • Establish a new Uralla 500/330 kV substation • Turn both Armidale–Tamworth 330 kV lines 85 and 86 into Uralla • A new double-circuit Uralla–Bayswater 500 kV line • Two 500/330 kV 1,500 MVA Uralla transformers • Additional reactive support	

[12] New South Wales Government, New South Wales Electricity Strategy, at https://energy.nsw.gov.au/media/1921/download.

- Establish a new 500/300 kV substation at Walcha
- Cut Uralla–Bayswater 500 kV lines into Walcha
- Two 500/330 kV 1,500 MVA Walcha transformers
- One 500/330 kV 1,500 MVA Bayswater transformer

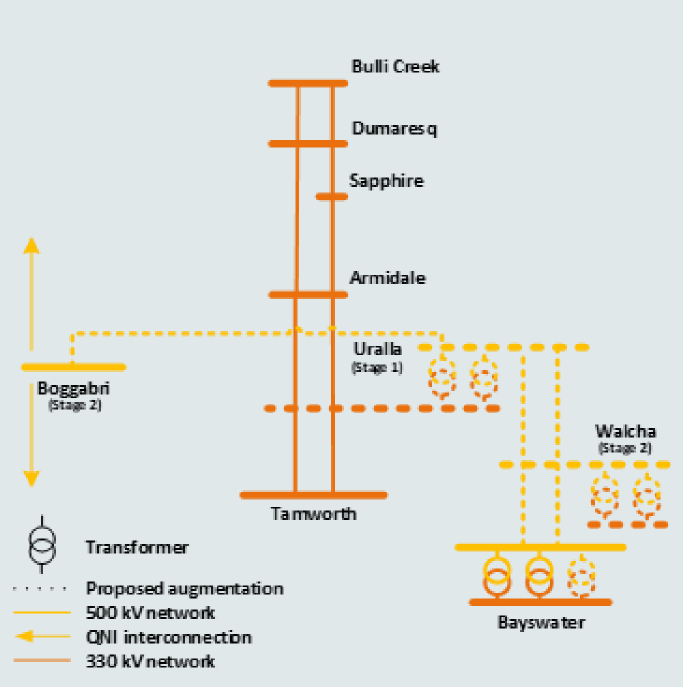
Estimated cost is ~ $720 million to $1,330 million

Stage 2:

- A new single-circuit Boggabri–Uralla 500 kV line[C]

Estimated cost is ~ $220 million to $420 million

Approximate capacity: 4,000-5,000 MW including stage 1[D]



A. In addition to the REZ expansion listed in Table 5, this assumes that the network augmentation between Bayswater, Newcastle and Sydney is in place. This augmentation is required with the increase of VRE in North West New South Wales, New England, and Central-West Orana New South Wales and due to retirement of coal generation.
B. Capacity is dependent on the development of QNI Medium and Large, resource diversity, and network upgrades between New England and the Sydney load centre. Storage is also utilised to reduce network build requirements and store excess energy.
C. Common between North West New South Wales REZ and New England REZ.
D. Capacity is dependent on development of North West New South Wales REZ and QNI flow, resource diversity, and the amount of storage to connect in this area. Storage was assumed for this zone. Options to increase this to 8,000 MW to match the target from the New South Wales Government will be explored in the preparatory activities for QNI Medium and Large, North West New South Wales REZ, and New England REZ. See Appendix 3 for further details.

The delivery of New England network expansion is required from mid-2030s in the Central, and High DER scenarios and 2030-31 in the Step and Fast change scenarios when VRE projections exceed 300 MW (see Figure 7). The timing of the New England network expansion may be accelerated by the New South Wales Government as part of its announced policy to support development of VRE in this REZ[13]. On 10 July 2020, the New South Wales Government announced a $79 million plan to develop a REZ, of 8,000 MW size, in this region. TransGrid has also announced, just before release of this ISP, a proposed approach to further accelerate the development of this REZ.

New England REZ network expansion preparatory activities

The transmission infrastructure required to integrate the New England REZ with the greater transmission network is identified as a future ISP Project (see Appendix 3). It is not yet 'actionable' under the new ISP Rules, but is expected to be so in the future and is part of the optimal development path.

AEMO requires TransGrid to carry out preparatory activities for the New England REZ network expansion including publishing a report on the outcome of these activities by 30 June 2021.

The following REZ parameters should be considered when undertaking preparatory activities.

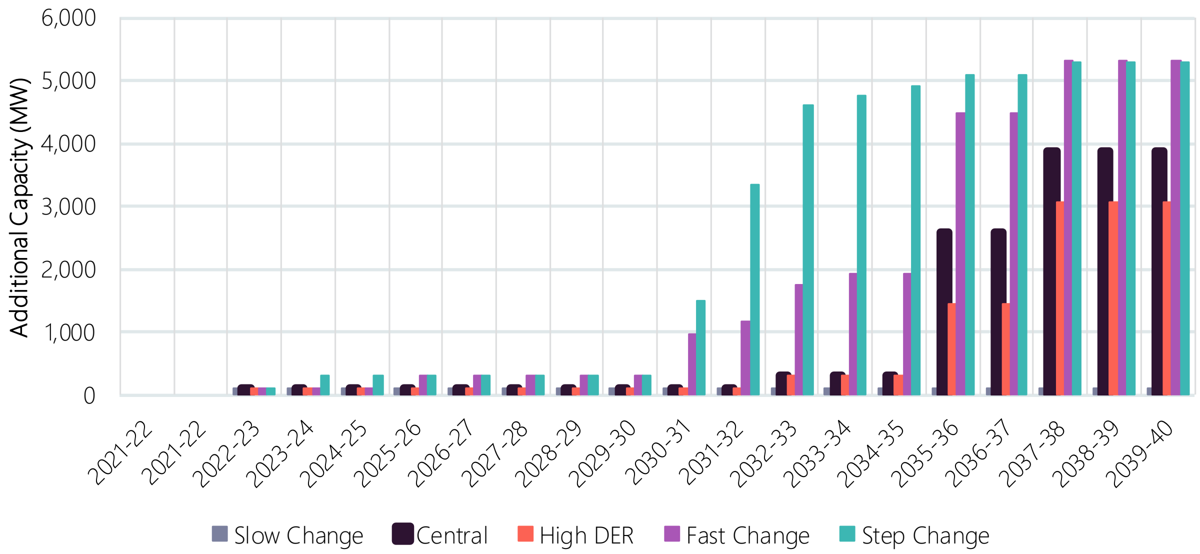
[13] NSW Government. *New England to light up with second NSW Renewable Energy Zone*, available at https://www.nsw.gov.au/media-releases/new-england-to-light-up-second-nsw-renewable-energy-zone.

Table 6 New England REZ parameters

REZ parameter	New England
Geographical location	See New England scorecard in section A5.4.2.
Notional REZ hosting capacity	Stage 1: 3,000-4,000 MW Stage 2: 8,000 MW (including stage 1)
Forecast expansion in the least-cost development paths	See Figure 7
Proposed connection points between the REZ and the rest of the shared network	The network between Sapphire and Tamworth and the network between Liddell and Bayswater.
Delivery date for the REZ design report	30 June 2021
Additional matters for consideration	Consideration should be given to the possibility for the QNI Medium and Large interconnector to traverse through this REZ and assist with connection of generation along the path. Consideration should also be given to the REZ design for North West New South Wales. See Appendix 3 for further details.

Figure 7 shows the projected VRE in this REZ for each scenario's least-cost development path.

Figure 7 Projected capacity build (MW) for New England REZ across all scenarios

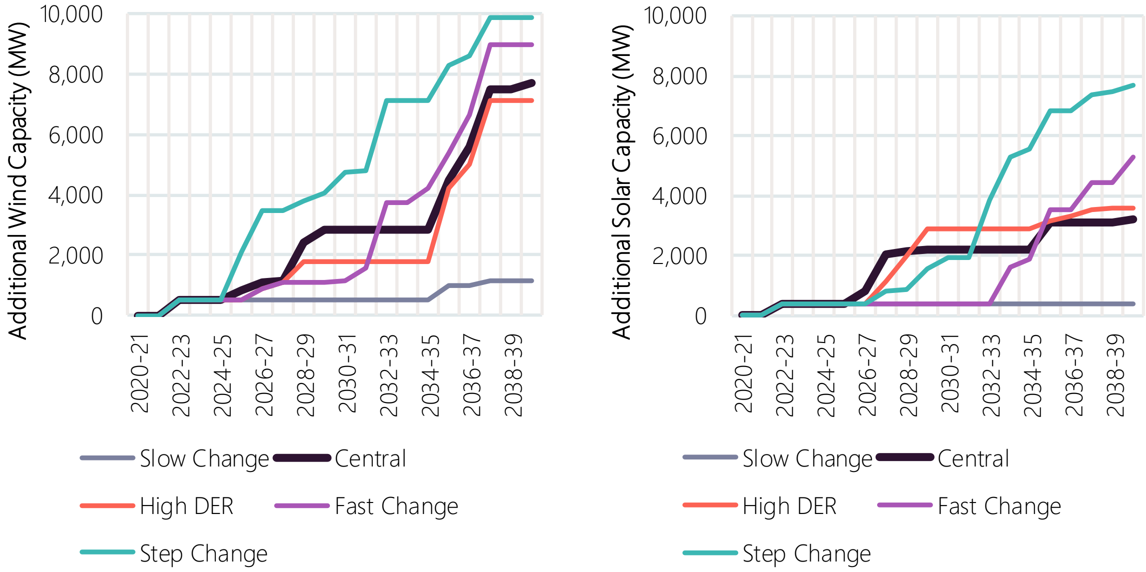


A5.3.3 Queensland REZ assessment

Renewable generator connections in Queensland in the 2020s are driven by the state-based QRET under the Central, High DER and Step Change scenarios. The Queensland Government has committed to a 50% renewable energy target by 2030. This target is measured against Queensland energy consumption, including renewable DER. Queensland generator connections, to meet the energy target, occur in REZs that have both existing network capacity and good quality resources.

After QRET, development of renewable generation connection is forecast to continue growing rapidly in all scenarios, except the Slow Change which does not consider this QRET, as seen in Figure 8.

Figure 8 Queensland's projected wind (left) and solar (right) capacity build (MW) across all scenarios



AEMO assessed eight candidate REZs in Queensland. The report card in Table 7 shows the transmission network upgrade timing and REZ phasing.

Table 7 Queensland REZ report card

REZ	Existing network capacity (MW)	Hosting capacity increase with ISP projects	Priority for generation connection	Network upgrade timing				
				Central	Step Change	Fast	High DER	Slow
Q1 – FNQ	700	Future ISP project +800-1,500 MW	Phase 3	2037-38	2030-31	2035-36	2037-38	-
Q2 – North QLD Clean Energy Hub	-	-	-	-	-	-	-	-
Q3 – Northern Queensland	Q1+Q2+Q3 < 1,800 MWA	-	-	-	-	-	-	-
Q4 – Isaac	Q1+Q2+Q3+ Q4+Q5 < 2,000 – 2,500 MW[B]	Intra-regional augmentation future ISP Gladstone project and CQ-SQ +800-900 MW	Phase 3	Early to mid-2030s	Late 2020s	Early to mid-2030s	Mid-2030s	-
Q5 – Barcaldine	-	-	-	-	-	-	-	-
Q6 – Fitzroy	Q1+Q2+Q3+ Q4+Q5+Q6 < 2,000 – 2,500[C]	Intra-regional augmentation future ISP CQ-SQ and Gladstone project +800-900 MW	Phase 1 and phase 3	Early to mid-2030s	Late 2020s	Early to mid-2030s	Mid-2030s	-
Q7 – Wide Bay	500	-	-	-	-	-	-	

REZ	Existing network capacity (MW)	Hosting capacity increase with ISP projects	Priority for generation connection	Network upgrade timing				
				Central	Step Change	Fast	High DER	Slow
Q8 – Darling Downs	3,000	Future ISP Project QNI Medium + 1,000 MW QNI Large +2,000 MW	Phase 1 and phase 3	Upgrades occur with QNI Medium in 2032-33 and QNI Large in 2035-36, additional upgrades may be required:				
				>2039-40	>2039-40	>2039-40	>2039-40	-

A. This REZ is subject to group constraint, where the sum of generation developed in Q1, Q2 and Q3 should be less than 1,800 MW.
B. This REZ is subject to group constraint, where the sum of generation developed in Q1, Q2, Q3, Q4 and Q5 should be less than 2,000-2,500 MW.
C. This REZ is subject to group constraint, where the sum of generation developed in Q1, Q2, Q3, Q4, Q5 and Q6 should be less than 2,000-2,500 MW.

AEMO's REZ analysis for Queensland projects that it will be most efficient to:

- Meet the QRET with large VRE development within Fitzroy REZ and Darling Downs REZ utilising existing spare network capacity. Smaller VRE developments are projected to be efficient in Far North Queensland REZ and Isaac REZ. The QRET of 50% VRE by 2030 is forecast to require approximately 5.1 GW of additional large scale VRE capacity, above existing and committed generation projects. The first 900 MW of this is expected to come from the announced projects Broadsound Solar Farm, Cape Yorke Solar & Storage, and Macintyre Wind Farm.
- Increase network capacity in Darling Downs REZ aligned with QNI Medium and QNI Large interconnector upgrades.
- Utilise storage to decrease the size of transmission augmentations required to transfer renewable generation from Northern Queensland to the load centres.
- Prepare for the closure of coal and gas generation in Queensland in the mid-late 2030s by developing renewable generation in Far North Queensland, Isaac, Fitzroy, Wide Bay, and Darling Downs REZs.
  - With significant projected VRE development in Far North Queensland, Isaac, and Fitzroy REZs, and the retirement of Gladstone generation, strengthening of the 275 kV network is required between Bouldercombe and Calliope River, Calvale to Larcom Creek, and on the Central to Southern Queensland cut-set.
  - Additional to the augmentation above, the projected VRE development in Far North Queensland requires strengthening of the 275 kV network between Chalumbin and Strathmore via Ross and network expansion to areas of high renewable interest.
  - AEMO requires Powerlink to carry out preparatory activities for the Gladstone Grid Reinforcements and for the Central to Southern Queensland (CQ-SQ) transmission project.

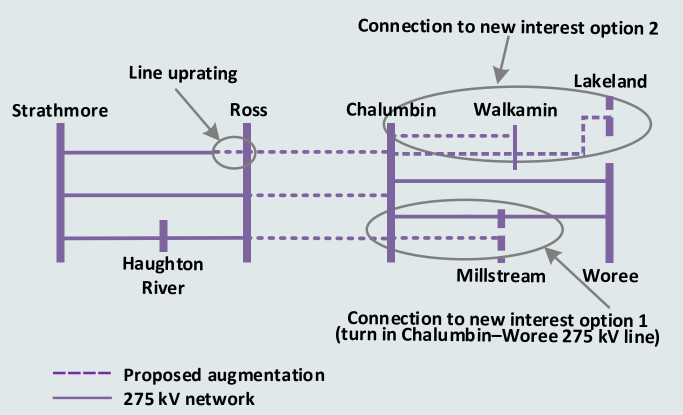
A5.3.3.1 Far North Queensland

Far North Queensland has excellent wind resources. There is some existing spare network capacity to connect utility-scale wind generation before upgrades are required. This spare capacity is location-specific within the REZ and system strength remediation is likely for connection of generation in this area.

Although the cost of upgrades is high in this REZ, it has a good capacity factor and high diversity of wind resources with other REZs. Its development is timed in the least-cost development paths in the mid to late-2030s, or as possibly as early as 2031 if the Step Change scenario. The network upgrades are required when VRE in this zone exceeds 700 MW. Table 8 shows two possible options, depending on the area within the REZ. Option 1 is to strengthen the network for wind generation in the Millstream area and Option 2 is to extend the 275 kV network towards the Lakeland area: see Appendix 3.

Table 8 Proposed network development options for Far North Queensland REZ

Backbone upgrade stages	Stage 1 (500 MW additional hosting capacity): • Rebuild Chalumbin–Ross 275 kV double-circuit line Estimated cost ~ $400 million to $740 million[A] Stage 2 (700-800 MW additional hosting capacity): • Uprating the lower rated Ross–Strathmore 275 kV line (~$10 million to $15 million) • Build 3rd 275 kV Chalumbin–Ross single-circuit line[B] Estimated cost ~ $280 million to $530 million
Network extension options	Option 1 – Development interest towards Millstream: • Build a new 275 kV substation North of Millstream • Build a new 275 kV Chalumbin–North of Millstream single-circuit line • Turn existing Chalumbin–Woree 275 kV line into Millstream Estimated cost ~ $90 million to $160 million Option 2 – Development interest towards Lakeland: • Build a new 275 kV substation at Lakeland • Build a new 275 kV double-circuit Chalumbin–Walkamin line • Build a new 275 kV Lakeland–Walkamin single-circuit line Estimated cost ~ $310 million to $570 million



A. The rebuild of the Chalumbin–Ross 275 kV line is also required for asset replacement around mid to late 2030s.
A. A possible a fourth Ross–Strathmore–Nebo 275 kV line is required under certain scenarios.

A5.3.3.2 Fitzroy and Isaac REZs

Isaac and Fitzroy REZs have good wind and solar resources. Potential pumped hydro locations have been identified near Nebo in the Isaac REZ and near Bouldercombe and Calvale in the Fitzroy REZ.

Fitzroy has stronger connection to the major load centres in Queensland than all other candidate REZs except for Darling Downs. With high VRE projected across all scenarios, except Slow Change, storage will play a key role in firming up renewable resources, maximise the utilisation of transmission network and if strategically placed can reduce the size of the transmission augmentation needed to connect the projected renewable generation to the load centre. Pumped hydro in addition to increasing the capability to host renewable generation can also assist in alleviating minimum demand issues.

The amount of new generation that can be accommodated in the Isaac and Fitzroy REZs is largely dependent on other REZs in northern Queensland and the capacity of the Central to Southern Queensland network (CQ-SQ). As more generation is developed in northern Queensland, CQ-SQ cut-set becomes restrictive together with the 275 kV network between Bouldercombe and Calliope River. However, the retirement of thermal generation within this region will allow more VRE to be accommodated within the network capacity.

Two key transmission projects, Central to Southern Queensland transmission project and Gladstone Grid Reinforcement, have been identified as being required to accommodate the projected VRE generation in Far North Queensland, Isaac, and Fitzroy REZs. AEMO requires Powerlink to carry out preparatory activities for both projects to investigate the costs and benefits of these projects. Future stages of for the Central to Southern Queensland cut-set for further capability improvements should be investigated.

Central to Southern Queensland

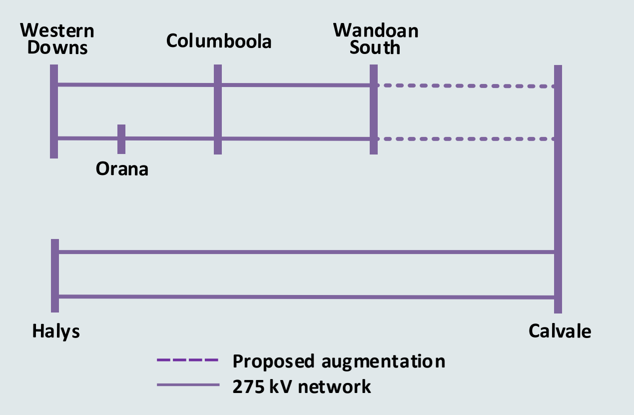
The Central to Southern Queensland cut-set is defined as the power flow on the Calvale–Halys 275 kV lines, the Calliope River–Gin Gin 275 kV lines, and the Wurdong–Teebar Creek[14] 275 kV line. Currently, power flow in the southerly direction is limited to prevent voltage and transient instability under fault conditions. These stability limits will need to be addressed to increase the transfer across the CQ-SQ cut-set. The need is realised when generation in the north of this cut-set exceeds 2,000-2,500 MW above the existing and committed generation. This network augmentation, detailed in Table 9, is projected to be required in the early to mid-2030s.

Table 9 CQ-SQ transmission project

The proposed CQ-SQ augmentation is:

- A new double-circuit Calvale – Wandoan South 275 kV line

Estimated cost[A] ~ $300 million to $560 million



A. $432 million is used for the market modelling inputs.

Gladstone Grid Reinforcement

The need for the Gladstone Grid Reinforcement is driven by various aspects which include asset renewal, retirement of Gladstone Power Station, and high renewable generation connection in northern Queensland. Upgrading the Central to Southern Queensland cut-set, detailed in Table 10, will further highlight the need for the upgrade on this network, as addressing this limitation will shift the limitations further north under high VRE output.

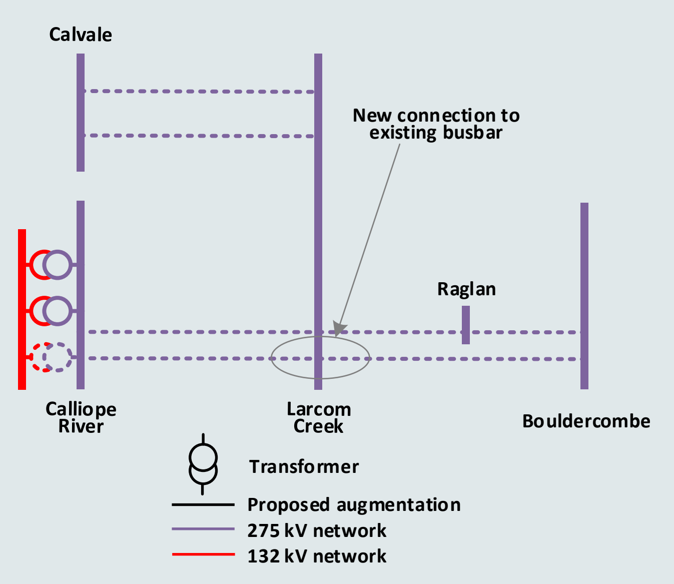
[14] Soon to be Rodds Bay – Teebar Creek around 2022-23.

Table 10 Gladstone Grid Reinforcement transmission augmentation

Gladstone proposed augmentation is as follows:

- Rebuild the Bouldercombe–Raglan–Larcom Creek–Calliope River and the Bouldercombe–Calliope River 275 kV lines as a high capacity double-circuit lines, for a gain of approximately 700-800 MW of additional hosting capacity, required in early to mid-2030s[A]
- A new double-circuit Calvale–Larcom Creek 275 kV line (required in mid-2030s)
- A third Calliope River 275/132 kV transformer (required in mid-2030s)

Estimated cost ~ $300 million to $560 million



A. For development of generation north of Bouldercombe, some scenarios require an additional line Bouldercombe–Larcom Creek 275 kV line.

A5.3.4 South Australia REZ assessment

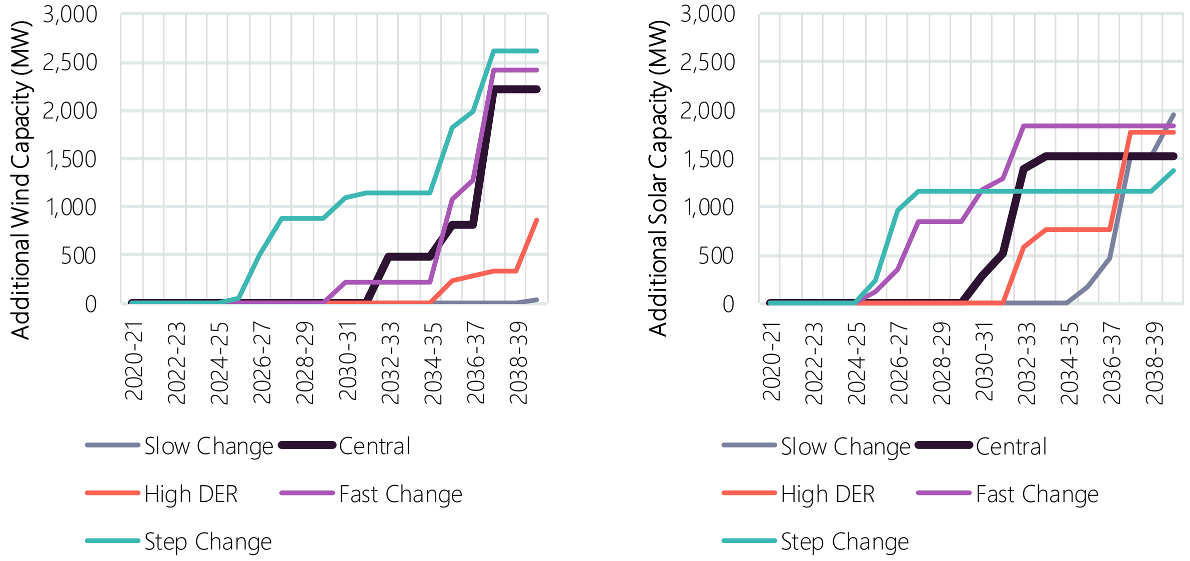
South Australia connects to Victoria via two interconnectors, Heywood and Murraylink. Over the last two years, South Australia has been a net energy exporter to Victoria[15]. This has been driven by the continued increase in wind and solar generation in South Australia and the decrease of coal-fired generation in Victoria following the closure of Hazelwood Power Station in March 2017 and outages of the remaining coal-fired generators over the 2018-19 period.

Figure 9 shows the projected new utility solar and wind development across each scenario in the next two decades. No new wind generation is projected to be efficient in South Australia until the 2030s, except in the Step Change scenario. Similarly, no new utility-scale solar is projected to be efficient in South Australia until the 2030s except in the Step and Fast Change scenarios.

- Projected solar generation sharply increases post 2030 before settling at approximately 1,500-2,000 MW in 2035-36.
- The Riverland and Roxby Down REZs have been highlighted for this solar development; development beyond approximately 1,900 MW of solar generation would require significant transmission infrastructure investment.
- Wind generation is projected to increase post 2034-35 to replace retiring generation. South Australia is forecast to feature the highest share of renewable energy of all NEM regions in the Central scenario.

[15] AEMO, 2019 South Australia Report, page 38, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/SA_Advisory/2019/2019-South-Australian-Electricity-Report.pdf.

Figure 9 South Australia's projected wind (left) and solar (right) capacity build (MW) across all scenarios



AEMO assessed nine candidate REZs in South Australia. AEMO's REZ analysis for South Australia projects that it will be most efficient to:

- Co-ordinate REZ development in areas supported by interconnector upgrade Project EnergyConnect and HumeLink.
- Co-ordinate REZ development in areas with good resource and existing network capacity.
- Strengthen the Mid-North 275 kV network to increase capacity to numerous REZs.

AEMO recommends timing VRE development with interconnector upgrade and recommends Riverland, Mid-North South Australia, South East South Australia, and Roxby Downs for medium to long-term large-scale VRE connections.

Table 11 South Australia REZ report card

REZ	Existing network capacity (MW)	Hosting capacity increase with ISP projects	Priority for generation connection	Network upgrade timing				
				Central	Step	Fast	High DER	Slow
S1 – South East SA	55	-	Phase 3	2037-38	2030-31	2037-38	2039-40	-
S2 – Riverland	200	Project EnergyConnect +800 MW[A]	Phase 2	2032-33	2026-27	2030-31	2037-38	2037-38
S3 – Mid-North SA	1,000	Future ISP project Mid-North +1,000 MW[B]	Phase 3	2035-36	2035-36	2035-36	-	-
S4 – Yorke Peninsula	-	-	-	2035-36	2037-38	2035-36	-	-
S5 – Northern SA	1,000	-	-	-	-	-	-	-
S6 – Leigh Creek	-	-	-	-	-	-	-	-

REZ	Existing network capacity (MW)	Hosting capacity increase with ISP projects	Priority for generation connection	Network upgrade timing				
				Central	Step	Fast	High DER	Slow
S7 – Roxby Downs	960[C]	Future ISP project Mid-North[D] +1,000 MW	Phase 3	2036-38	2036-38	2035-36	-	-
S8 – Eastern Eyre Peninsula	470[E]	-	-	-	-	-	-	-
S9 – Western Eyre Peninsula	-	-	-	-	-	-	-	-

A. Requires a minor transmission build over and above Project EnergyConnect to accommodate 800 MW. Timing associated with minor upgrade.
B. Mid-North increases generation capacity of 1,000 MW shared by generation connections in S3, S5, S6, S7, S8 and S9.
C. Includes capacity for new 275 kV line from Davenport to Mount Gunson South.
D. The existing network in Mid-North can accommodate up to 1,000 MW from REZ S3, S4, S5, S6, S7, S8 and S9, if the sum of the generation from these REZs exceeds 1,000 MW, expansion of Mid-North would be required (this is referred to as the "South Australia group constraint".
E. Includes the upgrades from the Eastern Eyre Electricity Supply RIT-T.

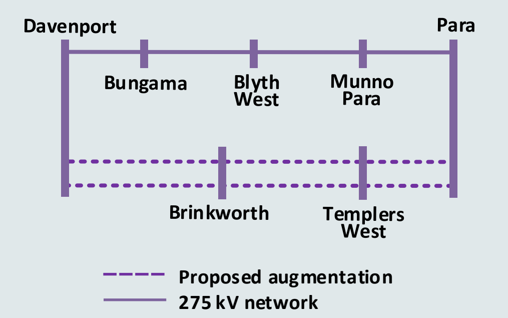
A5.3.4.1 Mid-North South Australia REZ

The Mid-North South Australia REZ has moderate wind and solar resources. Due to the nature of the South Australian network, VRE development in the north, west and south west of Davenport contributes to congestion in the Mid-North REZ along the 275 kV corridor between Davenport and Para. If this congestion is addressed, then capacity could be unlocked in all of these zones (S5, S6, S7, S8 and S9), assuming they can be connected to Davenport. The proposed future ISP project augmentation is detailed in Table 12.

Table 12 Mid-North South Australia Network Project

- Rebuild the single-circuit Davenport–Brinkworth–Templers West–Para[A] 275 kV line at a high capacity double-circuit line, and/or
- Reconfiguration of 132 kV network in the Mid-North REZ to ensure balance flows between the 275 kV and the 132 kV networks

Estimated cost ~ $420 million to $770 million[B]



A. Depending on connection interest within Mid-North, the network augmentation may not need to extend to Davenport.
B. $657 million is used for the market modelling inputs.

A5.3.4.2 South East South Australia

The South East South Australia REZ has moderate to good wind resources. This REZ lies on the major 275 kV path linking South Australia with Victoria (Heywood interconnector). The existing network can only effectively accommodate a small amount of additional generation. Beyond this 55 MW hosting capacity, transmission network expansions would be required to accommodate generation within this zone.

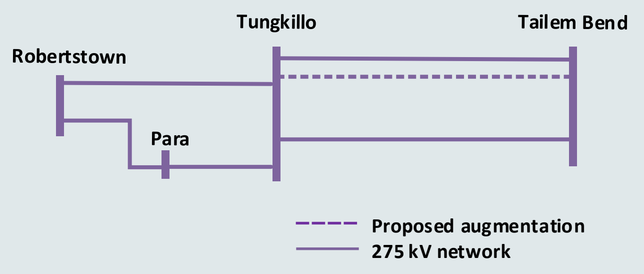
South East South Australia has been projected for VRE development greater than the current hosting capacity. This VRE development is timed in 2030-31 under the Step Change scenario and between 2037-38 and 2039-40 for the Central, Fast Change and High DER scenarios. The proposed network augmentation is highlighted in Table 13.

Table 13 South East South Australia proposed REZ development

- String the other side of the 275 kV Tailem Bend-Tungkillo line

Estimated cost is ~ $20 to $80 million[A]

- Where necessary, manage overloads with run back schemes
- Additional 275 kV transmission lines may be required between Tailem Bend and generation interest within the zone. This augmentation and costing would depend on the location of the generation.



A. Advised by ElectraNet, available in the TAPR: https://www.electranet.com.au/wp-content/uploads/2019/06/2019-ElectraNet-TAPR_WEB.pdf

A5.3.5 Tasmania REZ assessment

Tasmania became a net exporter of electricity via Basslink during 2017-18 and has exported more electricity each year to 2019-20. With increasing wind development, Tasmania is likely to continue this trend of energy surplus and is projected to continue to be a net exporter of energy.

In this ISP, the projected development of wind and hydro generation in Tasmania is driven by a TRET, expected to be legislated by the Tasmanian Government (considered in the Step Change and High DER scenarios). Figure 10 shows the impact of this 200% renewable energy target by 2040, in the High DER and Step Change scenarios. It also shows how, in the Step Change scenario, wind development in excess of the TRET target occurs after 2029-30. This is consistent with the Step Change characteristic to underpin rapid transformation across the energy sector.

Tasmania has relatively poor solar resources. As a result, limited utility-scale solar generation is projected in Tasmania over the next 20-year outlook.

AEMO assessed three candidate REZs in Tasmania. The report card in Table 14 shows the transmission network upgrade timing and REZ phasing. The assessment concludes the following:

- To meet TRET, VRE development occurs in all three REZs, with more than 80% of this generation projected in Tasmania Midlands by 2039-40. Just under 1.4 GW[16] of new large-scale VRE is expected to be required in Tasmania in order to meet the TRET, over and above what is already committed and in service.
- Under the TRET, Tasmania's VRE would be about 150% of its needs by 2029-30, unless there were significant new local energy-intensive industry developed (such as hydrogen export). The surplus energy would have to be either exported or curtailed. Marinus Link is an efficient solution to enable the export of this surplus energy.
- Marinus Link is required under all scenarios, except for Slow Change, to facilitate the sharing of renewable energy between Tasmania and the mainland. The optimal timing to develop Marinus Link varies mainly as a response to TRET, to the saturation of Basslink, and as a result of coal retirements in the mainland. If the Step Change scenario occurs, one cable would be optimal as soon as 2028-29.
- Additional network augmentation is required under the Step Change and High DER scenarios to facilitate the transfer of generation from the Midlands REZ to Basslink and Marinus Link.
  - No network augmentations, beyond those associated with Marinus Link, have been highlighted as future ISP projects in Tasmania. The ISP model projects extensive generation build in the Midlands REZ, but the North East and North West REZs are technically similar. The future ISP augmentation in Tasmania will be investigated as generation connections become more certain.

[16] 1.4 GW is the difference between what is required in the Central Scenario sensitivity with TRET and the Central scenario which does not include TRET.

Figure 10 Tasmania's projected wind (left) and solar (right) capacity build (MW) across all scenarios

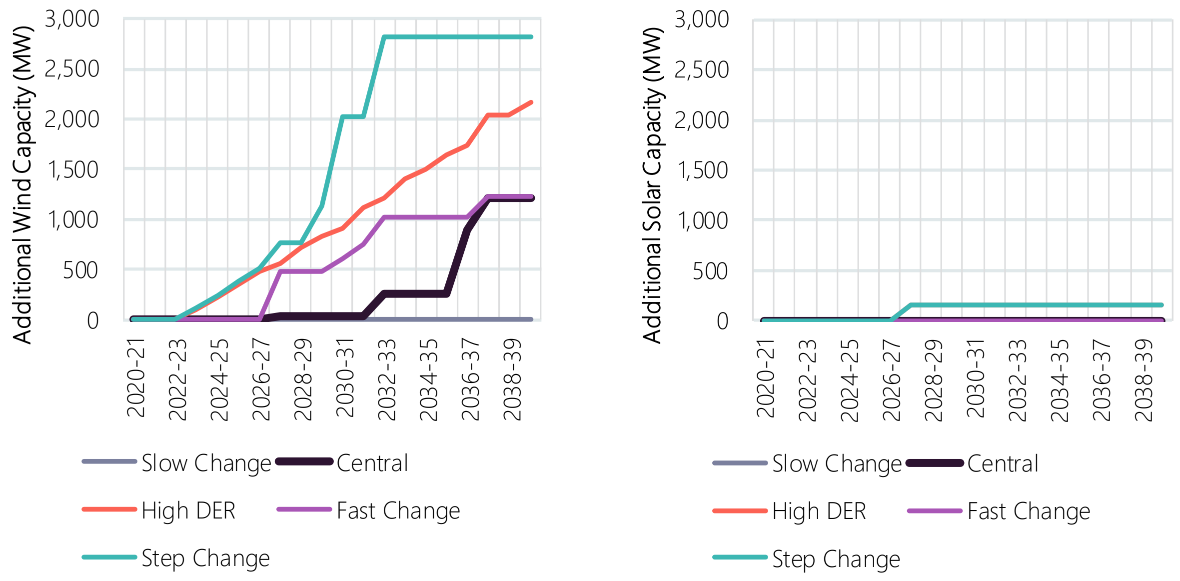


Table 14 Tasmania REZ report card

REZ	Existing network capacity (MW)	Hosting capacity increase with ISP projects	Priority for generation connection	Network upgrade timing				
				Central	Step	Fast	High DER	Slow
T1 – North East Tasmania	250	-	Phase 1[A]	-	-	-	-	-
T2 – North West Tasmania	340	Marinus Link[B] +600 MW[C] stage 2	Phase 1[A]	Timed with Marinus Link, timing varies across scenarios, however VRE projections does not utilise capacity.				
T3 – Tasmania Midlands	480	Marinus Link +540 MW[D] stage 1	Phase 1[A] and phase 2	Timed with Marinus Link, timing and stages varies across scenarios. Additional to the capacity supported by Marinus Link additional augmentation is required:				
				-	2030-31	-	2037-38	-

A. Phase 1 classification is subject to TRET becoming legislated.
B. Marinus Link stage 1 refers to the first 750 MW HVDC interconnector between Victoria and Tasmania and the 220 kV network augmentation within Tasmania to support it Stage 2 refers to the second 750 MW HVDC interconnector and the 220 kV augmentations within Tasmania to support it.
C. Increase hosting capacity in this REZ is supported by the 220 kV transmission network between Burnie – Hampshire – Staverton, as part of the Marinus Link Stage 2
D. Increase hosting capacity in this REZ supported by the 220 kV transmission network between Burnie – Sheffield – Palmerston, as part of Marinus Link stage 1.

A5.3.6 Victoria REZ assessment

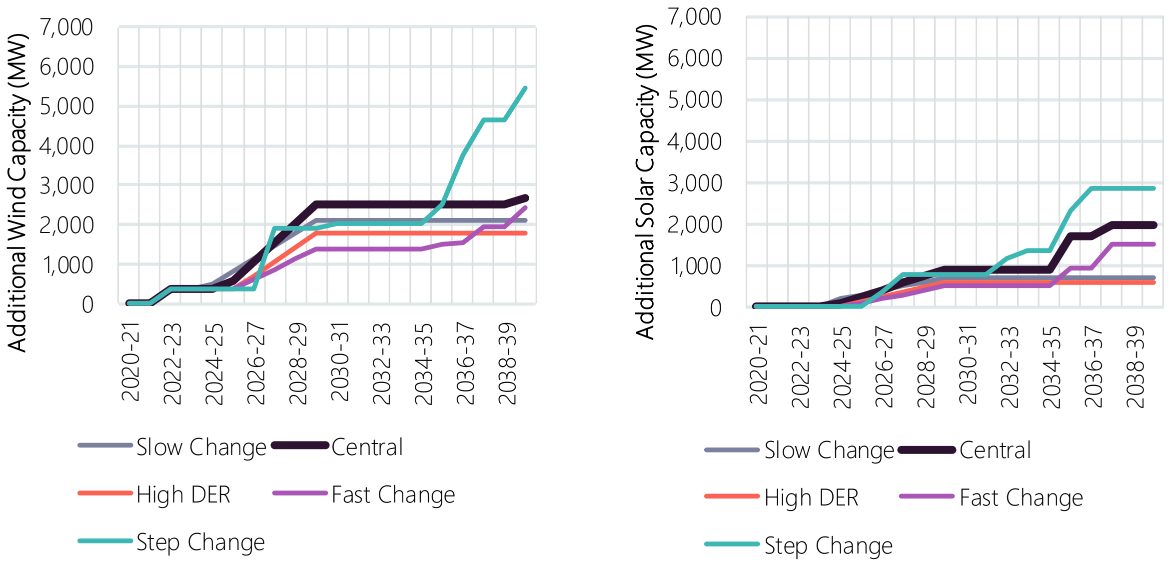
VRE connections in Victoria in the first decade are projected to be driven by high quality wind and solar resources and the state-based renewable energy target. The VRET mandates 25% of the region's generation be sourced from renewable sources by 2020, 40% by 2025 and 50% by 2030[17]. This target is measured against Victorian generation, including renewable DER.

[17] Victoria State Government, Environmental, Land, Water and Planning, Victoria Renewable Energy Target 2018-2019 Progress Report, at https://www.energy.vic.gov.au/__data/assets/pdf_file/0030/439950/Victorian-Renewable-Energy-Target-2018-19-Progress-Report.pdf.

Gippsland REZ has good hosting capacity and significant wind generation interest, including a large offshore wind farm of 2,000 MW. Development within this REZ could leverage the existing Latrobe Valley to Melbourne 500 kV and 220 kV network. The ISP does not, however, find the need to develop large quantities of wind in this REZ in the planning period. If VNI West is accelerated, then it is optimal to develop VRE in other REZs with higher quality wind resources.

In most scenarios, after 2029-30, there is little to no increase in projected renewable generation in Victorian REZ until the mid-2030s, as seen in Figure 11. The proposed VNI West interconnector, when delivered, increases capacity for additional connection of renewable generation in Victoria in Western Victoria REZ, and in the Murray River REZ or the Shepparton REZ depending on the route selection.

Figure 11 Victoria's projected wind (left) and solar (right) capacity build (MW) across all scenarios



AEMO assessed six candidate REZs in Victoria. The report card in Table 15 shows the transmission network upgrade timing and REZ phasing.

AEMO's REZ analysis for Victoria projects that it will be most efficient to meet the VRET by:

- Utilising spare network capacity with the development of renewable generation in South West Victoria and Central North Victoria REZs, and in Gippsland REZ if VNI West is not delivered by 2030.
- Utilising network capacity within the Western Victoria REZ introduced by the Western Victoria Transmission Network Project and in the Murray River REZ supported by actionable Project EnergyConnect.
- Co-ordinating further REZ development in areas supported by VNI West.

Table 15 Victoria REZ report card

REZ	Existing network capacity (MW)	Hosting capacity increase with ISP projects	Priority for generation connection	Network upgrade timing				
				Central	Step	Fast	High DER	Slow
V1 – Ovens Murray	300	-	-	-	-	-	-	-
V2 – Murray River	-	Project EnergyConnect +380 MW	Phase 2	2024-25	2024-25	2024-25	2024-25	2024-25
V3 – Western Victoria	450[A]	VNI West +1,000 MW	Phase 1 and phase 2	Timed with Western Victoria Transmission Network Project in 2025-26 and VNI West in 2027-28 or later				
V4 – South West Victoria	750	-	Phase 1	-	2036-37	2040-41	-	-
V5 – Gippsland	2,000	-	-	-	-	-	-	-
V6 – Central North Victoria	800	VNI West (Option 6) +2,000 MW	Phase 1 and phase 2	Upgrades occur with VNI West			-	-

A. Includes capacity gained after Western Victoria Transmission Network Project.

A5.3.6.1 Western Victoria REZ

Western Victoria REZ is identified for VRE development in phase 1 and phase 2, supported by the committed Western Victoria Transmission Network Project and the actionable VNI West project. Currently, generation interest within the Western Victoria REZ exceeds the capacity of the transmission network. This means generation is being constrained due to thermal and stability limitations.

The VRE development in phase 1 is the Western Victoria Transmission Network Project, which seeks to reduce the emerging constraints on the network, unlock renewable energy resources, reduce congestion, and improve the productivity of existing assets.

The Western Victoria Transmission Network Project, detailed in Table 16, is a committed project. The short-term augmentation is expected to be complete by 2020-21, and the medium-term augmentation is currently on track to be commissioned in 2025-26.

Connections in this REZ should be monitored and possibly managed with a control scheme if necessary – for example, it may be necessary in the future to implement a run back scheme.

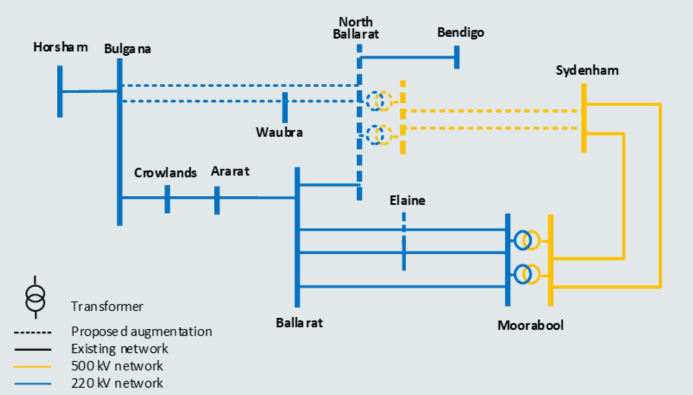
There are currently automated control schemes in the area, and their interactions need to be carefully monitored. Regular review all automated control schemes in the area may be required to ensure their operation can provide a secure network following 220 kV line contingencies as more generation connects within Western Victoria.

Table 16 Committed Western Victoria Transmission Network Project

Stage 1: The installation of wind monitoring equipment and the upgrade of station limiting transmission plant on the: • Red Cliffs–Wemen 220 kV line • Wemen–Kerang 220 kV line • Kerang–Bendigo 220 kV line • Moorabool–Terang 220 kV line • Ballarat–Terang 220 kV line	

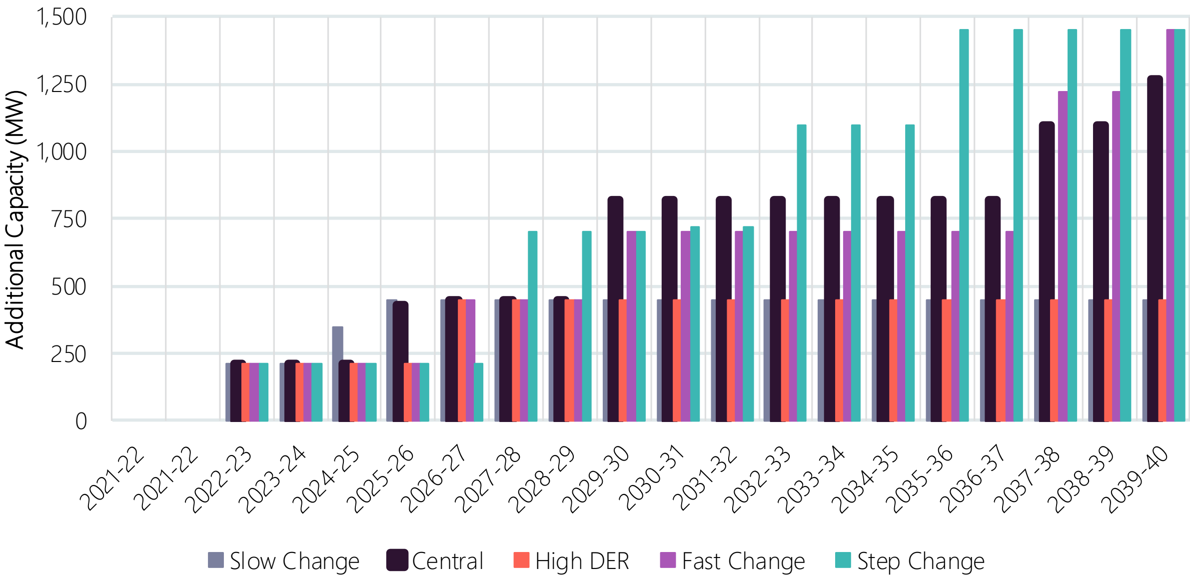
Stage 2:

- A new substation north of Ballarat[A]
- A new 500 kV double-circuit transmission line from Sydenham to the new substation north of Ballarat[A]
- A new 220 kV double-circuit transmission line from substation north of Ballarat to Bulgana (via Waubra)
- 2 x 500/220 kV transformers at the new substation north of Ballarat[A]
- Cut-in the existing Ballarat–Bendigo 220 kV line at a new substation north of Ballarat
- Moving the Waubra Terminal Station connection from the existing Ballarat–Ararat 220 kV line to a new 220 kV line connecting the substation north of Ballarat to Bulgana
- Cut-in the existing Moorabool–Ballarat No. 2 220 kV line at Elaine Terminal Station



A. New terminal station north of Ballarat which will be established through Western Victoria Transmission Network Project

Figure 12 Projected capacity build (MW) for Western Victoria REZ across all scenarios



A5.4. REZ scorecards

A5.4.1 REZ scorecard details

The REZ scorecards provide an overview of the characteristics of each REZ so an assessment can be made as the development opportunities arise. The following explains the criteria in the scorecards.

REZ Report Card Details

REZ Assessments

REZ Phases

REZs are classified into phases (see section A5.3.1). If a REZ has more than one phase, the earliest applicable phase is used. REZ phases have been colour coded:

Phase 1	Connecting renewables to support government policy
Phase 2	Connecting renewables in areas supported by actionable ISP projects
Phase 3	Connecting renewables in areas supported by future ISP projects
N/A	REZ is not listed for a REZ phased development.

Renewable Resources

Map Legend

Indicative generation is shown based on the resource availability:

Wind | Solar | Hydro | Geothermal | Battery

The green shading shows the indicative geographic area of the Renewable Energy Zone.

Resource Quality

Solar average capacity factor based on 9 reference years.

≥30%	≥28%	≥26%	≥24%	≥22%	<22%
A	B	C	D	E	F

Wind average capacity factor based on 9 reference years.

≥45%	≥40%	≥35%	≥30%	<30%
A	B	C	D	E

Correlation between demand describes whether the REZ resources are available at the same time as the regional demand, using a statistical correlation factor. A higher correlation represents that the resource is more available at regional demand.

≥0.3	≥0.15	≥0.0	≥-0.15	<-0.15

<table>
<tr><td></td><td><table><tr><td></td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr></table></td></tr>
<tr><td>Renewable Resources</td><td>Estimated potential REZ size in MW based on the geographical size and resource quality in the REZ. Social license and community support may impact the ability to deliver projects up to the renewable resource limit.</td></tr>
<tr><td colspan="2">Climate Hazard</td></tr>
<tr><td>Temperature</td><td>
<table>
<tr><td colspan="2">The REZ temperature score is based on the projected 1 in 10-year maximum temperatures[A] for the years 2030 and 2050.</td></tr>
<tr><td>Score</td><td>Description</td></tr>
<tr><td>A</td><td>Once in 10-year maximum temperature projections range between 28 and 38 degrees Celsius for the years 2030 and 2050. for the years 2030 and 2050.</td></tr>
<tr><td>B</td><td>Once in 10-year maximum temperature projections range between 30 and 44 degrees Celsius for the years 2030 and 2050.</td></tr>
<tr><td>C</td><td>Once in 10-year maximum temperature projections range between 32 and 48 degrees Celsius for the years 2030 and 2050.</td></tr>
<tr><td>D</td><td>Once in 10-year maximum temperature projections range between 34 and 50 degrees Celsius for the years 2030 and 2050.</td></tr>
<tr><td>E</td><td>Once in 10-year maximum temperature projections range between 44 and 52 degrees Celsius for the years 2030 and 2050.</td></tr>
<tr><td colspan="2">A. 1 in 10-year maximum temperature data was provided by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) for 2030 and 2050.</td></tr>
</table>
</td></tr>
<tr><td>Bushfire</td><td>
<table>
<tr><td colspan="2">The REZ bushfire score is based on the projection of annual average FFDI "high" fire danger days[B] around the years 2030 and 2050 and the probability of large bush fires occurring (a dominant input).</td></tr>
<tr><td>Score</td><td>Description</td></tr>
<tr><td>A</td><td>Model projections associate less than half the days of a year with high fire danger days and a probability of zero large fires in 20 years.</td></tr>
<tr><td>B</td><td>Model projections associate less than half the days of a year with high fire danger days and a probability of 1 large fire in 20 years.</td></tr>
<tr><td>C</td><td>Model projections associate more than half the days of a year with high fire danger days and a probability of 1 large fire in 20 years.</td></tr>
<tr><td>D</td><td>Model projections associate more than half the days of a year with high fire danger days and a probability of between 1 and 4 large fires in 20 years.</td></tr>
<tr><td>E</td><td>Model projections associate more than half the days of a year with high fire danger days and a probability of 1 large fire in 3 years.</td></tr>
<tr><td colspan="2">FFDI - Forest Fire Danger Index
B. A "high" fire danger day is defined as any day where the FFDI is greater than 12.</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th colspan="2">Variable Generation Outlook</th></tr>
<tr><td>Scenario</td><td>Long term market simulations of different scenarios named Central, Slow Change, Fast Change, Step Change and High DER.</td></tr>
<tr><td>Existing/Committed Generation</td><td>The existing and committed generation as of the 31/01/2020. Solar and wind generation is captured for existing and committed generation >10 MW.</td></tr>
<tr><td>Projected Variable Generation</td><td>Long-term market simulations projected variable generation outlook for solar and wind generation at different times intervals across all scenarios. All VRE projections are based on the least-cost development paths except for the Slow Change scenario. The Slow Change scenario is based on the transmission investment with the lowest regret, which includes all interconnectors that are developed in every other scenario with a fixed timing.</td></tr>
<tr><th colspan="2">Storage</th></tr>
<tr><td></td><td>Storage, in each dispatchable depth category: shallow, medium and deep, has been projected at a state level. The REZ scorecards' use the state level storage projections to suggest storage at a REZ level in proportions that would benefit the network taking into consideration pumped hydro interest in the REZs.</td></tr>
<tr><td>Shallow Storage</td><td>Shallow storage includes VPP battery and 2-hour large-scale batteries. The value of this category of storage is more for capacity, fast ramping, and FCAS (not included in AEMO's modelling) than it is for its energy value. For the purpose of the REZ scorecards, only 2 hour battery is captured.</td></tr>
<tr><td>Medium Storage</td><td>Medium Storage includes 4-hour batteries, 6-hour pumped hydro, 12-hour pumped hydro, and the existing pumped hydro stations, Shoalhaven and Wivenhoe. The value of this category of storage is in its intra-day shifting capability, driven by demand and solar cycles.</td></tr>
<tr><td>Deep Storage</td><td>Deep storage includes 24-hour pumped hydro and 48-hour pumped hydro, and includes Snowy 2.0 and Tumut 3. The value of this category of storage is in covering VRE 'droughts' (that is, long periods of lower-than-expected VRE availability), and seasonal smoothing of energy over weeks or months.</td></tr>
<tr><th colspan="2">Network Capability</th></tr>
<tr><td>Hosting Capacity (MW)</td><td>The approximate scale of additional generation (MW) that can be transported from the REZ to the load centre considering network limitations (excluding system strength) and REZs' current and committed generation as of the 31/01/2020. Diversity of resources and storage can affect the hosting capacity and these assumptions change between scenarios. For any REZ and interconnector augmentation options, the figure listed as the hosting capacity is the increase in hosting capacity above the current hosting capacity provided by the augmentation.</td></tr>
<tr><td>Loss Robustness Factors</td><td>The loss factor robustness is the sensitivity of Marginal Loss Factor (MLF) to additional generation inside the REZ. The current loss factor robustness is calculated for the year 2022. The future loss factor robustness is calculated in 2041 for future network augmentation unless staging requires an assessment of an earlier year. Loss robustness factors are only calculated for augmentations built in the optimal development path, improvement of MLF robustness is linked to an uncertain investment. The measure used is the additional generation (MW) that can be added before the MLF changes by -0.05:
<table>
<tr><td>≥1000</td><td>≥800</td><td>≥600</td><td>≥400</td><td>≥200</td><td><200</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td></tr>
</table></td></tr>
<tr><td>Interconnector Augmentations</td><td>Recommended interconnector augmentations of the optimal development path are presented where it may influence the REZ network hosting capacity. Where appropriate, alternative interconnector options including route variations are presented. See Appendix 3 and the Input and Assumptions Workbook[18] for more information on transmission projects.</td></tr>
</table>

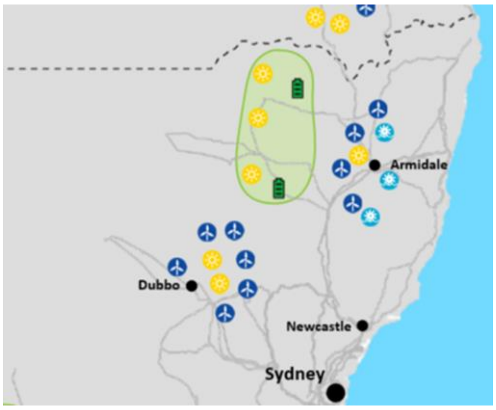
[18] AEMO. *Input and Assumptions Workbook*, available at https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2020-integrated-system-plan-isp/2019-isp-database.

Possible REZ Augmentations	Possible REZ augmentations that can increase the hosting capacity of the REZ.
ISP Development	Lists the scenarios that required the REZ augmentation to increase the hosting capacity of the REZ to accommodate projected growth in variable generation within the REZ.
System Strength	
Available Fault Level (MVA)	Captures the approximate available fault level in MVA for the Central and Step Change scenarios for 2030 and 2035 assuming minimum fault level node requirements continue to be maintained by the TNSP. Committed system strength projects have been considered for future years. The available fault level calculations have been performed in order to indicate when fault level remediation by connecting generators may be required in the REZ. A negative value indicates remediation may be required, with the approximate amount required detailed in the 'System Strength remediation' section. An assumed short circuit ratio requirement of 3 has been used for these calculations, which may be considered conservative especially for the later years. The methodology used for calculation the available fault level can be found in Appendix 7. This is only a first pass review and does not negate the need for individual impact assessments as part of standard generator connection processes. Investors and developers should conduct their own due diligence to understand how technical requirements might influence their connection.
System Strength Remediation	Approximate system strength remediation was calculated to restore the available fault level in the REZ to a positive value using synchronous condensers. Where synchronous pumped hydro has been planted in the REZ, it is expected this could form part of the system strength remediation. If alternative services, like synchronous generation is available for contract at reasonable price, it could offset the need for synchronous condensers or other forms of system strength remediation listed in this section. In the NEM, the division of responsibilities for the provision of system strength is: • AEMO is required to determine the fault level requirements across the NEM and identify whether a fault level shortfall is likely to exist now or in the future. The System Strength Requirements Methodology[19] defines the process AEMO must apply to determine the system strength requirement at each node. • The local TNSP is required to provide system strength services to meet the minimum three phase fault levels at relevant fault level nodes if AEMO has declared a shortfall. • A connecting generator is required to implement or fund system strength remediation, such that its connection (or altered connection) does not have an adverse impact on system strength, assessed in accordance with AEMO's system strength impact assessment guidelines. Investors and developers should conduct their own due diligence to understand how technical requirements might influence their connection. See Appendix 7 for more information on system strength.

[19] AEMO. *System Strength Requirements Methodology*, at http://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/System_Strength_Requirements_Methodology_PUBLISHED.pdf.

A5.4.2 New South Wales REZ scorecards

N1 – North West New South Wales

Summary	Phase 3 REZ
The North West New South Wales REZ is situated to the west of Tamworth, Armidale and Dumaresq. This REZ encompasses the 132 kV network between Armidale and Tamworth towards Inverell, Moree, Boggabri, Narrabri and Gunnedah. The existing 132 kV network is weak and would require significant network upgrades to accommodate VRE greater than the current hosting capacity of 100 MW. Since the 2018 ISP, there have been no additional committed and commissioned renewable generation projects in this REZ. The currently preferred upgrades to the Queensland – New South Wales interconnector, QNI Medium and QNI Large, increase the hosting capacity within this REZ. While this zone has high quality solar resources, the wind resource is estimated to be inadequate for wind farm development.	

REZ Assessment

Phase 3	Development of North West NSW REZ is projected in phase 3. Development in this region could be supported by QNI Medium and Large augmentations. The additional capacity provided by QNI Medium and QNI Large project is utilised immediately in the Central and High DER scenarios, and only in the late 2030s in the Slow Change scenario. Under the Step Change and Fast Change scenarios, the network between Wollar and Boggabri of QNI Medium would need to be brought forward a year to accommodate the increase in generation projected.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	A			D		
Renewable Potential (MW)	6,500			0		
Demand Correlation	2020	2030	2040	2020	2030	2040
	E	E	E	D	D	D

Climate Hazard

Temperature Score	D	Bush Fire Score	E

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	56	100	1,100	3,450	There are no existing wind generators in this REZ, and no wind projects progressed to the anticipated or committed level in last 2 years. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step		100	1,850	4,200				
Fast		100	1,100	3,250				
High DER		100	1,100	2,100				
Slow		100	100	1,000				

<table>
<tr><th colspan="6">Storage</th></tr>
<tr><td rowspan="12">ISP modelling has generally demonstrated benefits in co-locating solar generation with shallow-to-medium storages. There is a large projection of solar generation for this REZ which makes it a great candidate for storage. Locating storage within this REZ will firm up supply within the North West New South Wales REZ and reduce the scale of network augmentations required to transfer this energy to the load centres.

Storage development in this REZ can support firm energy exports to both New South Wales and Queensland load centres via the proposed development of the QNI upgrades.</td><th colspan="5">Suggested Storage for REZ (MW)</th></tr>
<tr><th rowspan="2"></th><th rowspan="2">Depth</th><th colspan="3">Projected</th></tr>
<tr><th>2029-30</th><th>2034-35</th><th>2039-40</th></tr>
<tr><td>Central</td><td rowspan="5">Shallow</td><td>0</td><td>0</td><td>50</td></tr>
<tr><td>Step</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fast</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>High DER</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Slow</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Central</td><td rowspan="5">Medium</td><td>0</td><td>200</td><td>200</td></tr>
<tr><td>Step</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fast</td><td>0</td><td>300</td><td>300</td></tr>
<tr><td>High DER</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Slow</td><td>0</td><td>0</td><td>0</td></tr>
</table>

<table>
<tr><th colspan="3">Existing Network Capability</th></tr>
<tr><th>Description</th><th>Approximate Existing Hosting Capacity</th><th>Loss Factor Robustness</th></tr>
<tr><td>The existing 132 kV network connects Armidale to Tamworth via Inverell, Moree, Narrabri, Boggabri East and Gunnedah.</td><td>100 MW</td><td>F</td></tr>
<tr><th colspan="3">Associated Interconnector Augmentations</th></tr>
<tr><th>Description</th><th>Additional Hosting Capacity</th><th>Loss Factor Robustness</th></tr>
<tr><td>QNI Medium Option 2E (Preparatory Activities Required):
A new 500 kV interconnector from Western Downs in Queensland via Boggabri to a new substation near Wollar in New South Wales.</td><td>+1,000 MW</td><td>A</td></tr>
<tr><td>QNI Large Option 3E (Preparatory Activities Required):
A second 500 kV interconnector from Western Downs in Queensland via Boggabri to the new substation near Wollar in New South Wales.</td><td>+1,000 MW</td><td>A</td></tr>
</table>

<table>
<tr><th colspan="5">Possible REZ Augmentations</th></tr>
<tr><th>Description</th><th>Additional Hosting Capacity</th><th>Upgrade Cost Estimate</th><th>ISP Development</th><th>Loss Factor Robustness</th></tr>
<tr><td>Augmentation Option 1 (Bring forward of QNI Medium):
Parts of QNI Medium are required earlier under the Step and Fast scenarios. These augmentations involve:
• Establish a new 500/330 kV at Boggabri
• A new Boggabri–Tamworth 330 kV line (for sharing capacity with New England and allowing solar generation access to possible pumped hydro)
• Establish a new substation on Bayswater–Wollar 500 kV line</td><td>+1,000 MW</td><td>Part of QNI</td><td>Fast, Step Change</td><td>-</td></tr>
</table>

• A new double-circuit 500 kV line from this new substation to Boggabri • 500/330 kV transformation at Boggabri				
Augmentation Option 2: • Establish a new 330 kV at Gunnedah • A new double-circuit Gunnedah–Tamworth 330 kV line • A new double-circuit Gunnedah–Wollar 330 kV line	+1,350 MW	$390 million to $730 million	Not identified as being required under any ISP scenario	-
Augmentation Option 3 (if augmenting before QNI): This augmentation is required to connect generation within North West New South Wales and New England, and opens for further extensions on QNI along either the west or eastern path: • Establish a new 500/330 kV substation at Uralla • Establish a new 330 kV substation just west of Gunnedah • Turn both Armidale–Tamworth 330 kV lines into Uralla • A new single-circuit 500 kV line from Uralla to Bayswater • 500/330 kV transformation at Uralla and new substation near Gunnedah • Build a new 500 kV Uralla–west of Gunnedah–Wollar single-circuit line • Build a new 330 kV Uralla–Tamworth–Liddell single-circuit line • Build a new 330 kV west of Gunnedah–Tamworth double-circuit line	+4,000 MW[A]	$1,340 million to $2,500 million	Not identified as being required under any ISP scenario	-
Augmentation Option 4: Additional to QNI Medium and Large, the following is required: • Two 500/330 kV transformers at Boggabri • 500/330 kV transformer at West of Dumaresq • Connection to New England REZ with a 500 kV line between Boggabri and Uralla[B].	+3,000 MW[C]	$300 million to $550 million	Central, High DER, Fast and Step Change scenarios (2035-36)	A

A. Additional hosting capacity gained in North West NSW and New England.
B. Timing on 500 kV line is dependent on build in both North West NSW and New England, which varies across scenarios.
C. Depends on augmentation for New England, New England REZ generation and QNI flows.

Available Fault Level (MVA)

	Scenario	Existing	2029-30	2034-35
Available fault level in this REZ is influenced by planting of solar PV from the mid-2030s.	**Central**	1,900	1,600	300
	Step	1,900	1,550	-3,550

System Strength Remediation Augmentation

	Description	Date Required	Cost
Central	Remediation not required with forecast level of VRE.	-	-
Step	Establish 2 x 250 MVAr synchronous condensers.	2033-34	$95 million to $120 million

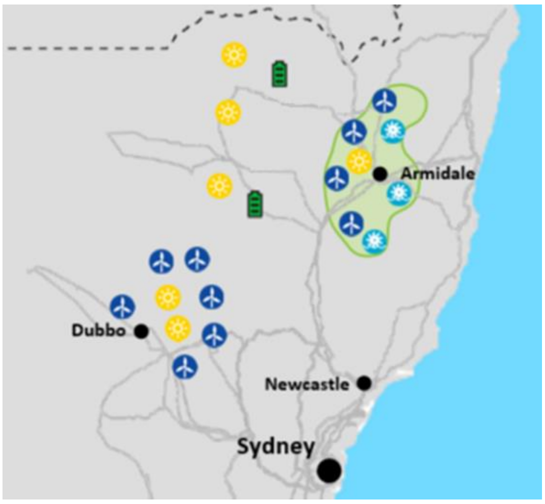
N2 – New England

Summary	Phase 3 REZ

The New England REZ, previously known as Northern New South Wales Tablelands, is identified by the New South Wales government as one of three potential priority renewable energy zones in the New South Wales Government Electricity Strategy released in 2019.

This REZ has moderate to good wind and solar resources in close proximity to the 330 kV network. Interest in the area includes large scale solar and wind generation as well as pumped hydro generation. The connection of additional generation in this zone may compete with generation from Queensland via the New South Wales – Queensland 330 kV interconnector.

Three of the larger Queensland to New South Wales interconnector options increase the capacity for the connection of renewable energy within this zone.



REZ Assessment	
Phase 3	Expansion of the New England REZ is optimally timed in Phase 3 (or earlier if the New England REZ development is accelerated through NSW government policy). This REZ is supported by a future ISP project, New England REZ network expansion, to connect the renewable generation to the load centre.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	C			C		
Renewable Potential (MW)	3,500			7,400		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	D	E	E	D	D	C

Climate Hazard

Temperature Score	C	Bush Fire Score	E

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central		100	100	100		0	200	3,750
Step		300	300	300		0	4,600	5,000
Fast	20	300	300	300	443	0	1,600	5,000
High DER		100	300	300		0	0	2,750
Slow		100	100	100		0	0	0

Storage					
Given the large projected solar and wind generation for the New England, North West New South Wales and Darling Downs REZs, there is a need for large scale storage under all scenarios except Slow Change. The development of pumped hydro and battery storage within the New England and North West New South Wales REZs could assist in not only firming up the VRE but also deferring or reducing the scale of transmission augmentation required. Storage has been suggested for this region under all scenarios except for the Slow Change scenario whereby little VRE is projected in the REZ. New England REZ has good potential for pumped hydro. The pumped hydro resources are situated close to the 330 kV network, just east of Armidale and Uralla. There are also pumped hydro resources along the Armidale–Coffs Harbour 330 kV line. In April 2020, on behalf of the Australian Government, ARENA announced that it is providing $951,000 to the Oven Mountain Pumped Hydro Project to undertake a study to analyse the benefits that 600 MW/7,200 MWh pumped hydro energy would have on the New England REZ[20].	**Suggested Storage for REZ (MW)**				
		Depth	**Projected**		
			2029-30	**2034-35**	**2039-40**
	Central	**Medium**	0	0	1,150
	Step		0	200	350
	Fast		0	0	500
	High DER		0	0	350
	Slow		0	0	0
	Central	**Deep**	0	0	0
	Step		0	0	1,100
	Fast		0	0	0
	High DER		0	0	0
	Slow		0	0	0

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
The existing 330 kV network can support around 300 MW of new connections in and around Tamworth 330 kV substation.	300 MW	A

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
QNI (Preparatory Activities Required): A second 500 kV interconnector from Western Downs in Queensland via Boggabri and Uralla, to Bayswater in New South Wales. This is an alternative option to QNI medium and large captured in North West NSW scorecard (see Appendix 3).	+2,000 MW [A]	-
A. The 2,000 MW is shared between North West NSW and the New England REZ.		

Possible REZ Augmentations				
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**	**Loss Factor Robustness**
Augmentation Option 1 **Stage 1:** For generation interest at Uralla: • Establish a new 500/330 kV substation at Uralla • Turn both Armidale–Tamworth 330 kV lines into Uralla	+4,000-5,000 MW[C]	$940 million to $1,750 million	Step and Fast Change (from 2030-31), Central and High DER (from 2035-36)[D]	A

[20] Arena, available at: https://arena.gov.au/news/pumped-hydro-plant-could-unlock-new-england-renewable-energy-zone/

• Uprate Armidale–Uralla–Tamworth 330 kV lines • A new double-circuit 500 kV line from Uralla to Bayswater • 500/330 kV 1,500 MVA transformation at Uralla **Stage 2:** For generation interest in and around the Walcha area: • Establish a new 500/330 kV substation near Walcha • Turn both Bayswater–Uralla lines into Walcha • 500/330 kV 1,500 MVA transformation at Walcha • A new Bayswater 500/330 kV 1,500 MVA transformer • A new Uralla–Boggabri 500 kV single-circuit line[B]				
Augmentation Option 2 (If augmented before QNI): This augmentation is to connect generation within North West New South Wales and New England, and opens for further extensions on QNI along either the west or eastern path: • Establish a new 500/330 kV substation at Uralla • Establish a new 330 kV substation just west of Gunnedah • Turn both Armidale–Tamworth 330 kV lines into Uralla • A new single-circuit 500 kV line from Uralla to Bayswater • 500/330 kV transformation at Uralla and new substation near Gunnedah • Build a new 500 kV Uralla–west of Gunnedah–Wollar single-circuit line • Build a new 330 kV Uralla–Tamworth–Liddell single-circuit line • Build a new 330 kV west of Gunnedah–Tamworth double-circuit line	+4,000 MW	$1,340 million to $2,500 million	Larger build required in the ISP	-
Augmentation Option 3: • Establish a new Uralla 500/330 kV substation • Uprate and turn Armidale–Tamworth 330 kV lines 85 and 86 into Uralla • Build a new 500 kV Bayswater–Uralla single-circuit line • 500/330 kV transformation at Uralla	+1,000 MW	$460 million to $860 million	Larger build required in ISP scenarios	-

B. Timing is dependent on the growth in both North West NSW and New England REZ which varies across scenarios.
C. Capacity gained depend of resources, location of storage and QNI transfers within this REZ. It assumes QNI Medium and Large in place. Options to increase this to 8,000 MW to match the target from NSW Government will be explored in the preparatory activities for QNI Medium and Large, North West NSW REZ and New England REZ. See Appendix 5. for further details.
D. Additional network augmentation may be required with large VRE build in North West New South Wales, Central West NSW and New England, and coal retirement in NSW to strengthen the network between Bayswater, New Castle and Sydney.

Available Fault Level (MVA)

	Scenario	Existing	2029-30	2034-35
Pumped hydro from the late 2030s is expected to form part of the system strength solution for this (and surrounding) REZs.	**Central**	550	550	550
	Step	550	1,200	-10,950

System Strength Remediation Augmentation			
	Description	**Date Required**	**Cost**
Central	Remediation not required with forecast level of VRE.	-	-
Step	Establish 4 x 250 MVAr synchronous condensers.	2031-32	$180 million to $230 million

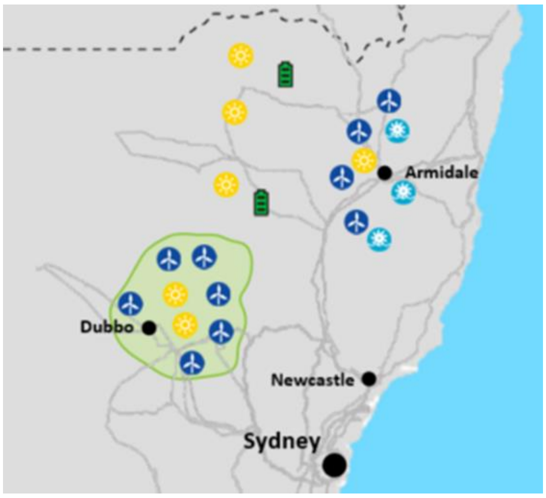
N3 – Central-West Orana

Summary

The Central–West Orana REZ is electrically close to the Sydney load centre and has moderate wind and solar resources. Currently there is more than 700 MW of commissioned and committed generation within Central–West Orana REZ, most of this generation is derived from solar energy.

With significant existing investment and investor interest, the Central–West Orana REZ has been identified by the New South Wales Government as the state's first pilot REZ – expected to unlock 3,000 MW of transmission hosting capacity by the mid–2020s[21]. Construction of the pilot REZ is expected in begin in 2022. In May, the NSW Department of Planning, Industry and Environment called for renewable energy, energy storage and emerging energy project proponents to register their interest in being part of the first pilot REZ. The registration of interest closed the first week of June.

Phase 1 REZ



REZ Assessment

Phase 1 REZ	Central–West Orana REZ has development in phase 1. Generation development within the Central–West Orana REZ is facilitated by the actionable Central–West Orana REZ Transmission Link project.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	C			C		
Renewable Potential (MW)	7,200			3,000		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	E	F	F	E	D	D

Climate Hazard

Temperature Score	C	Bush Fire Score	E

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	520	150	2,150	2,200	251	0	800	800
Step		1,550	2,200	4,800		750	800	2,200
Fast		950	2,200	2,200		0	800	800
High DER		150	150	2,100		0	0	900
Slow		150	150	150		0	0	0

[21] New South Wales Government, Renewable Energy Zones, at https://energy.nsw.gov.au/renewables/renewable-energy-zones

Storage

Central-West Orana has high quality solar and moderate quality wind resources. The Central-West Orana REZ has good pumped hydro resources which could be used to firm solar and wind generation. Potential storage sites are situated predominately to the east of the Wellington–Mount Piper 330 kV line. Developing pumped hydro or battery storage in this zone would increase the hosting capacity of solar generation within the network by smoothing and firming the profile of energy production across the REZ.

Due to the large VRE projection within Central-West Orana REZ, storage has been suggested an efficient solution to firm energy production in the Step and Fast Change scenarios.

Suggested Storage for REZ (MW)				
	Depth	Projected		
		2029-30	2034-35	2039-40
Central	**Medium**	0	0	0
Step		0	200	350
Fast		0	0	500
High DER		0	0	0
Slow		0	0	0
Central	**Deep**	0	0	0
Step		0	0	100
Fast		0	0	0
High DER		0	0	0
Slow		0	0	0

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
The Central–West Orana REZ is connected via a 330 kV circuit between Wellington–Wollar and Mount Piper–Wellington. A 132 kV network connects Wellington, Mount Piper and Yass. A 132 kV network further extends from Wellington to Dubbo area.	3,000 MW	A

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
There are no associated interconnector augmentations with this REZ.		

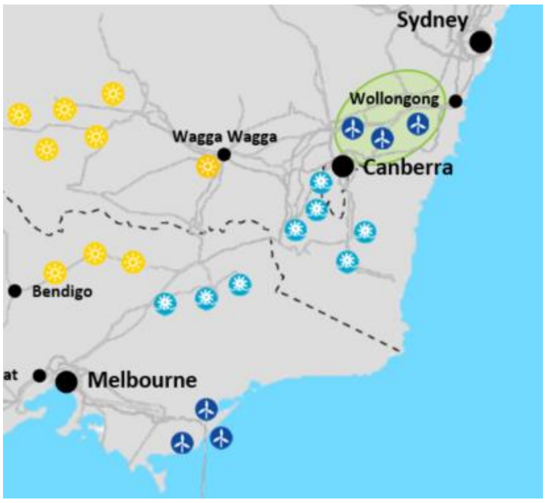
Possible REZ Augmentations

Description	Additional Hosting Capacity	Upgrade Cost Estimate	ISP Development	Loss Factor Robustness
Augmentation Option 1: • A 500 kV (or 330kV) loop which traverses the Central-West region	+3,000 MW	$450 million to $850 million	Central, Step, Fast, Slow and High DER	A
Augmentation Option 2: Develop a Central West hub: • A new Central West Hub 330 kV substation • A new double-circuit Wollar–Central Hub 330 kV line • A new Central West Hub–Wellington 330 kV line • 500/330 kV Wollar transformer	+1,000 MW	$390 million to $720 million	Larger build required in the ISP	-

Available Fault Level (MVA)				
Available fault level in this REZ is influenced by planting of wind and solar PV from the late 2020s.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	1,200	1,300	-700
	Step	1,200	-5,650	-5,600

System Strength Remediation Augmentation			
	Description	**Date Required**	**Cost**
Central	Establish 1 x 250 MVAr synchronous condenser.	2032-33	$45 million to $60 million
Step	Establish 2 x 250 MVAr synchronous condensers.	2027-28	$95 million to $120 million

N4 – Southern New South Wales Tablelands

Summary	
The Southern New South Wales Tablelands REZ has excellent wind resources. There is currently just over 640 MW of renewable generation installed within this zone – over 630 MW of which is wind generation. Southern New South Wales Tablelands has one of the highest wind capacity factors within New South Wales. However, there has been significant opposition from the community within this area for the connection of any additional wind generation, and the proposed extension of Crookwell 3 Wind Farm was rejected by the New South Wales Independent Planning Commission[22].	

REZ Assessment	
N/A	Southern NSW Tablelands REZ does not have REZ phase development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	D			B		
Renewable Potential (MW)	–			–		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	E	E	F	C	C	C

Climate Hazard

Temperature Score	C	Bush Fire Score	E

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	10	The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.			635	250	250	250
Step						250	250	250
Fast						250	250	250
High DER						250	250	250
Slow						250	250	250

[22] New South Wales Independent Planning Commission, Statement of reasons for decisions Crookwell 3 wind farm (SSD 6695) available at, https://www.ipcn.nsw.gov.au/resources/pac/media/files/pac/projects/2015/02/crookwell-iii-wind-farm/determination/crookwell-3-wind-farm-ssd-6695--statement-of-reasons.pdf

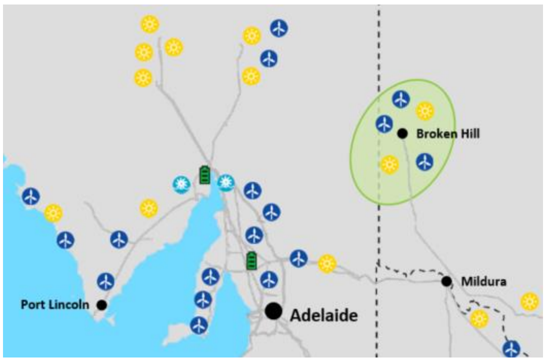
<table>
<tr><th colspan="5">Storage</th></tr>
<tr><td colspan="2" rowspan="2">Southern NSW Tablelands has identified pumped hydro locations close to the 330 kV network between Marulan and Dapto. With more than 2,000 MW of storage developed in the Tumut REZ and little projections of VRE in the Southern NSW Tablelands area, no storage has been suggested in the region.</td><td colspan="3">Suggested Storage for REZ (MW)</td></tr>
<tr><td colspan="3">Southern NSW Tablelands has not been suggested for storage across any scenario in the 2020 ISP.</td></tr>
<tr><th colspan="5">Existing Network Capability</th></tr>
<tr><td colspan="2">Description</td><td colspan="2">Approximate Existing Hosting Capacity</td><td>Loss Factor Robustness</td></tr>
<tr><td colspan="2">This REZ is close to four 330 kV transmission lines and two 500 kV transmission lines supporting Sydney. The existing network could support approximately 1,000 MW of new connections.</td><td colspan="2">1,000 MW</td><td>A</td></tr>
<tr><th colspan="5">Associated Interconnector Augmentations</th></tr>
<tr><td colspan="2">Description</td><td colspan="2">Additional Hosting Capacity</td><td>Loss Factor Robustness</td></tr>
<tr><td colspan="5">There are no associated interconnector augmentations with this REZ.</td></tr>
<tr><th colspan="5">Available Fault Level (MVA)</th></tr>
<tr><td rowspan="3">Available fault level in this REZ is influenced by planting of wind from the mid-2020s.</td><td>Scenario</td><td>Existing</td><td>2029-30</td><td>2034-35</td></tr>
<tr><td>Central</td><td>2,700</td><td>1,300</td><td>1,350</td></tr>
<tr><td>Step</td><td>2,700</td><td>2,650</td><td>2,250</td></tr>
<tr><th colspan="5">System Strength Remediation Augmentation</th></tr>
<tr><td colspan="5">Remediation not required with forecast level of VRE in the Central and Step Change scenarios.</td></tr>
</table>

N5 – Broken Hill

Summary

Broken Hill REZ has excellent solar resources. It is connected to the New South Wales grid via a 220 kV line from Buronga with an approximate length of 270 km. The current capacity of this 220 kV line is utilised by the existing solar, wind and gas generation in the area.

With little local load and the long distance to the load centres, the MLF robustness for this REZ is one of the worst in the NEM. Significant development of VRE in this REZ could prove costly as it would require significant transmission network augmentation due to the distance of the REZ from the main transmission paths of the shared network. For this reason, the ISP has prioritised other REZ for development ahead of this REZ.



REZ Assessment

N/A	Broken Hill REZ does not have any projected development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	A			C		
Renewable Potential (MW)	8,000			5,100		
Demand Correlation	2020	2030	2040	2020	2030	2040
	E	F	F	E	E	E

Climate Hazard

Temperature Score	E	**Bush Fire Score**	C

Variable Renewable Energy Outlook

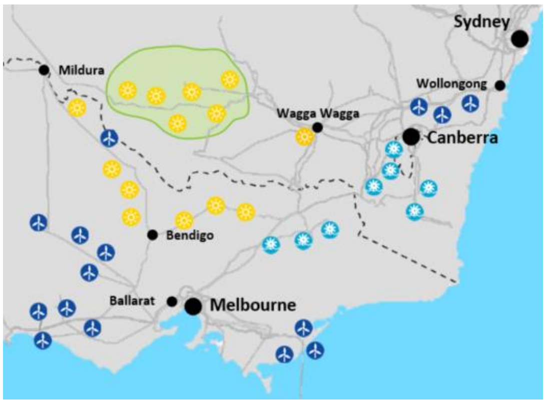
	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	54	The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.			199	The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.		
Step								
Fast								
High DER								
Slow								

Storage

	Suggested Storage for REZ (MW)
Broken Hill REZ has not been identified as having significant potential pumped hydro capability. Furthermore, no VRE is projected for this REZ, in any scenario, due to the large costs required to extend additional transmission infrastructure to this zone. For these reasons, no storage has been suggested for this zone.	Broken Hill has not been suggested for storage across any scenario in the 2020 ISP.

Existing Network Capability				
Description		**Approximate Existing Hosting Capacity**		**Loss Factor Robustness**
Broken Hill REZ is connected via a 270 km 220 kV line from Buronga to Broken Hill. With 253 MW of generation already connected within this zone, there is no additional spare hosting capacity available.		–		F
Associated Interconnector Augmentations				
Description		**Additional Hosting Capacity**		**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.				
Possible REZ Augmentations				
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**	**Loss Factor Robustness**
Due to the location of this REZ and distance of network augmentation required, it is difficult to meet the REZ design principles economically. Possible future consideration should include options to connect to Central-West Orana REZ/QNI Medium and Large.				
Available Fault Level (MVA)				
	Scenario	**Existing**	**2029-30**	**2034-35**
Available fault level in this REZ is influenced by development of nearby REZs.	**Central**	At limit[A]	-300	-300
	Step	At limit[A]	-250	-300
A. Existing system strength limits in this area are already requiring remediation by connecting generation.				
System Strength Remediation Augmentation				
Remediation requirements shown for this REZ are due to expansion of VRE in neighbouring REZs, and are met through a joint solution reported in REZ N6.				

N6 – South West New South Wales

Summary	Phase 2 REZ
In the 2018 ISP, the South West New South Wales REZ formed part of the Murry River REZ which covered the western part of New South Wales and Victoria. The New South Wales portion of the Murray River REZ now forms the South West New South Wales REZ. This zone has over 1,000 MW of generation currently in service and committed, all of which is solar generation. For any further large scale renewable generation to connect in this area, additional transmission infrastructure would be required to get the generation from this REZ to the Sydney load centre. The capacity within this REZ and ability to transfer energy from the REZ to the main load centres in the greater Sydney area will be improved by the proposed New South Wales and South Australia interconnector, Project EnergyConnect, together with HumeLink. One option for VNI West (Kerang route) would further increase the hosting capacity of this REZ.	

REZ Assessment

Phase 2 REZ	South West NSW REZ has development in phase 2. The full commissioning of the Project EnergyConnect expected by 2024-25, will increase the hosting capacity within this REZ. The additional capacity released through Project EnergyConnect is fully utilised in all scenarios except for the Slow Change scenario. In the Fast Change and Step Change scenario the capacity is utilised in the mid–late 2020s. In the Central and High DER scenarios, it is utilised in the mid-late 2030s.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	B			D		
Renewable Potential (MW)	4,000			4,300		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	E	F	F	D	D	D

Climate Hazard

Temperature Score	E	Bush Fire Score	D

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	1,034	0	600	600	There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step		600	600	600				
Fast		600	600	600				
High DER		0	0	600				
Slow		0	0	0				

Storage

South West New South Wales REZ has not been identified as having significant potential pumped hydro capability. For this reason, no pumped hydro has been suggested for this region.

With over 1,000 MW of solar generation in service and committed within this zone, and another 600 MW projected, this REZ would be a good location for storage. Medium storage is suggested for South West New South Wales in the Central and Fast Change scenarios.

Suggested Storage for REZ (MW)				
	Depth	Projected		
		2029-30	2034-35	2039-40
Central	**Medium**	0	150	150
Step		0	0	0
Fast		0	200	200
High DER		0	0	0
Slow		0	0	0

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
The 220 kV network within this REZ is weak and currently has no spare hosting capacity to connect large scale renewable energy.	–	E

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
Project EnergyConnect (Actionable ISP project): A new 330 kV interconnector between Robertstown in South Australia and Wagga Wagga in New South Wales, via Buronga.	+600 MW	A
VNI West (Actionable ISP Project): A new 500 kV interconnector between Victoria and NSW. There are multiple alternative corridors for VNI West of which one option, via Kerang, opens capacity within this REZ: see Appendix 3.	+1,000 MW	-

Possible REZ Augmentations

Description	Additional Hosting Capacity	Upgrade Cost Estimate	ISP Development
Augmentation Option 1[A]: • Build a new double/single-circuit Darlington Point–Wagga 330 kV line • Establish 330 kV substation at Hay[B] • Build a double-circuit 330 kV line from Darlington Point to Hay substation[B] • Install 1,500 MVA, 500/330 kV transformation at Wagga	+1,400 MW	$450 million to $840 million	Not identified as being required under any ISP scenario

A. Assumes HumeLink is built.
B. Only if significant interest lies around Hay.

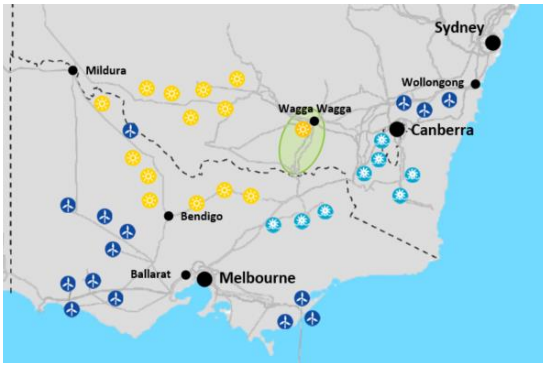
Available Fault Level (MVA)				
Available fault level in this REZ is influenced by planting of solar PV from the mid-2030s.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	At limit[C]	-1,150	-950
	Step	At limit[C]	-1,000	-1,000

C. Existing system strength limits in this area are already requiring remediation by connecting generation.

System Strength Remediation Augmentation

	Description	Date Required	Cost
Central	Establish 1 x 250 MVAr synchronous condenser.	2033-34	$45 million to $60 million
Step	Establish 1 x 250 MVAr synchronous condenser.	2028-27	$45 million to $60 million

N7 – Wagga Wagga

Summary	Phase 2 REZ
The Wagga Wagga REZ is a new addition to the New South Wales REZ candidates for the 2020 ISP. The need to identify this area as a candidate REZ has been driven by interest in the area. This REZ extends north of Wagga Wagga and south past Hume. This REZ has moderate wind and solar resources. Bomen Solar Farm, 100 MW, is committed and will connect to the network north of Wagga Wagga.	

REZ Assessment

Phase 2 REZ	Wagga Wagga REZ has development in phase 2. The commissioning of HumeLink will increase the hosting capacity within this REZ by approximately 1,000 MW in 2025-26. The additional hosting capacity provided by HumeLink is fully utilised in all scenarios except the Slow Scenario; the Step and Fast Change scenarios make full use of the additional capacity from the late 2020s and the Central scenario from 2032-33. The High DER scenario develop Wagga Wagga REZ in 2032-33, but only maximises the capacity available into the 2040s.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	C			E		
Renewable Potential (MW)	1,100			1,100		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	E	F	F	D	D	D

Climate Hazard

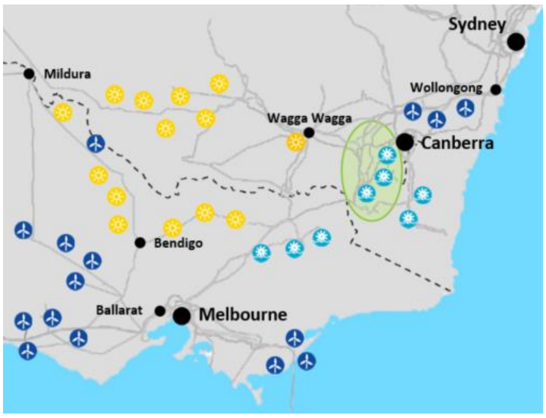
Temperature Score	D	Bush Fire Score	D

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	100	0	1,000	1,000	There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step		1,000	1,000	1,000				
Fast		1,000	1,000	1,000				
High DER		0	400	1,000				
Slow		0	0	0				

<table>
<tr><th colspan="5">Storage</th></tr>
<tr><td rowspan="2" colspan="2">Wagga Wagga REZ has not been identified as having significant potential pumped hydro capability. Across all scenarios, moderate to high levels of solar generation is projected to grow in this REZ. However, no storage is suggested for this REZ due to it being located electrically close to the storage in the snowy region.</td><td colspan="3">Suggested Storage for REZ (MW)</td></tr>
<tr><td colspan="3">Wagga Wagga REZ has not been suggested for storage across any scenario in the 2020 ISP.</td></tr>
<tr><th colspan="5">Existing Network Capability</th></tr>
<tr><td colspan="2">Description</td><td colspan="2">Approximate Existing Hosting Capacity</td><td>Loss Factor Robustness</td></tr>
<tr><td colspan="2">The 330 kV and the 132 kV network around Wagga Wagga has no additional spare hosting capacity available.</td><td colspan="2">–</td><td>C</td></tr>
<tr><th colspan="5">Associated Interconnector Augmentations</th></tr>
<tr><td colspan="2">Description</td><td colspan="2">Additional Hosting Capacity</td><td>Loss Factor Robustness</td></tr>
<tr><td colspan="2">HumeLink (Actionable ISP project):
A new 500 kV transmission line connection between Wagga, Maragle in the Snowy area and Bannaby.</td><td colspan="2">+1,000 MW</td><td>A</td></tr>
<tr><th colspan="5">Possible REZ Augmentations</th></tr>
<tr><td colspan="2">Description</td><td>Additional Hosting Capacity</td><td>Upgrade Cost Estimate</td><td>ISP Development</td></tr>
<tr><td colspan="2">Augmentation Option 1:
• Build a new 500 kV substation at Wagga
• Build a new 500 kV Bannaby–Wagga single-circuit line
• Install 1,500 MVA of 500/330 kV transformation at Wagga</td><td>+1,000 MW</td><td>$480 million to $890 million</td><td>Not identified as being required under any ISP scenario</td></tr>
<tr><th colspan="5">Available Fault Level (MVA)</th></tr>
<tr><td rowspan="3">Available fault level in this REZ is influenced by planting of solar PV from the mid-2030s.</td><td>Scenario</td><td>Existing</td><td>2029-30</td><td>2034-35</td></tr>
<tr><td>Central</td><td>At limit[A]</td><td>1,350</td><td>300</td></tr>
<tr><td>Step</td><td>At limit[A]</td><td>1,400</td><td>800</td></tr>
<tr><td colspan="5">A. Existing system strength limits in this area are already requiring remediation by connecting generation.</td></tr>
<tr><th colspan="5">System Strength Remediation Augmentation</th></tr>
<tr><td colspan="5">Remediation not required with forecast level of VRE in the Central and Step Change scenarios.</td></tr>
</table>

N8 – Tumut

Summary	Phase 2
The Tumut REZ has been identified due to the potential for additional pumped hydro generation. The proposed HumeLink, an actionable ISP project currently undergoing a RIT–T, will enable the connection of just over 2,000 MW of pumped hydro generation (Snowy 2.0) in this area. On the 31st of January 2020, the New South Wales and Commonwealth governments signed a memorandum of understanding (MOU) that sets out a clear, long–term path to help the state meet its targets of net zero emissions by 2050[23]. Key initiatives of this MOU include improving transmission interconnections and network access including accelerating and delivering the HumeLink project to unlock existing and future generation from the Snowy area within the Tumut REZ.	

REZ Assessment	
Phase 2	Tumut REZ does not have any VRE projected. The actionable ISP project HumeLink is expected to unlock existing and future generation from Snowy Hydro.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	C			B		
Renewable Potential (MW)	–			–		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	E	E	F	C	C	C

Climate Hazard

Temperature Score	C	Bush Fire Score	E

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation for this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step								
Fast								
High DER								
Slow								

[23] New South Wales Government Memorandum of Understanding, at https://energy.nsw.gov.au/government-and-regulation/electricity-strategy/memorandum-understanding

Storage					
Tumut REZ has excellent pumped hydro resources. Snowy 2.0[24], has been considered committed, across all scenarios, with the timing in 2025. The HumeLink RIT–T, which is currently underway, will unlock existing and future generation within this area. This project proposes the addition of 500 kV transmission between Wagga Wagga, the Tumut area and Bannaby. In late February 2019, the Commonwealth Government approved Snowy 2.0 as part of its plan to support renewable energy transformation delivering affordable, reliable power[25].	**Suggested Storage for REZ (MW)**				
		Depth	**Projected**		
			2029-30	**2034-35**	**2039-40**
	Central	**Committed Snowy 2.0 (Deep)**	2,040	2,040	2,040
	Step		2,040	2,040	2,040
	Fast		2,040	2,040	2,040
	High DER		2,040	2,040	2,040
	Slow		2,040	2,040	2,040

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
Currently the 330 kV transmission network around Lower and Upper Tumut is congested during peak demand periods. A careful balance of generation from the existing hydro units and flow between Victoria and New South Wales is required to prevent overloads within this area.	–	N/A

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
HumeLink (Actionable ISP project): A new 500 kV transmission line connection between Wagga, Maragle in the Snowy area and Bannaby.	+2,040 MW[26]	N/A

Available Fault Level (MVA)				
Available fault level in this REZ is influenced by development of nearby REZs.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	At limit	1,700	300
	Step	At limit	1,750	800

System Strength Remediation Augmentation
Remediation not required with forecast level of VRE in the Central and Step Change scenarios.

[24] About Snowy Hydro, available at https://www.snowyhydro.com.au/snowy-20/about/

[25] Prime Minister of Australia, media release 26 February 2019, available at https://www.pm.gov.au/media/historic-snowy-20-plan-approved

[26] Unlocking new generation capacity of 2,040 MW for Snowy 2.0

N9 – Cooma-Monaro

Summary

The Cooma-Monaro REZ has been identified for its pumped hydro potential. This REZ has moderate to good quality wind resources with one wind farm, Boco Rock Wind Farm (113 MW), connecting within this REZ since the 2018 ISP.

REZ Assessment

N/A	Cooma-Monaro REZ does not have any REZ phase development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	D			C		
Renewable Potential (MW)	–			300		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	E	E	F	C	C	C

Climate Hazard

Temperature Score	B	Bush Fire Score	E

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				113	0	300	300
Step						100	300	300
Fast						0	300	300
High DER						0	0	300
Slow						0	0	0

Storage		
Cooma-Monaro REZ was identified due to its pumped hydro capacity. The network connection at Cooma-Monaro is weak, to accommodate any large scale pumped hydro this network would need to be augmented.	**Suggested Storage for REZ (MW)**	
	Cooma-Monaro has not been suggested for storage across any scenario in the 2020 ISP.	

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
The existing 132 kV network connecting Cooma-Monaro REZ to Canberra, Williamsdale and Munyang can accommodate approximately 200 MW of generation.	200 MW	F

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

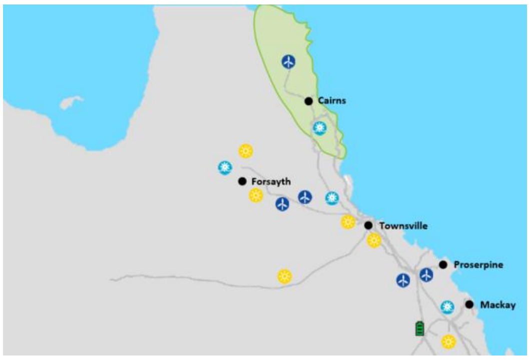
Possible REZ Augmentations				
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**	**Loss Factor Robustness**
Augmentation Option 1: • Build new 132 kV REZ substation • Build a new single-circuit 132 kV Canberra/Williamsdale to a new substation located near generation interest	+200 MW	$90 million to $160 million	Step Change (2031-32) Central and Fast Change (2033-34) High DER (2037-38)	F

Available Fault Level (MVA)				
Available fault level in this REZ is influenced by planting of wind from the mid-2030s.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	At limit	200	-700
	Step	At limit	-100	-700

System Strength Remediation Augmentation			
	Description	**Date Required**	**Cost**
Central	Establish 1 x 125 MVAr synchronous condenser.	2031-32	$40 million to $55 million
Step	Establish 1 x 125 MVAr synchronous condenser.	2031-32	$40 million to $55 million

A5.4.3 Queensland REZ scorecards

Q1 – Far North Queensland

Summary	Phase 3 REZ
Far North Queensland REZ is at the most northerly section of Powerlink's network. It has excellent wind and moderate solar resources. This REZ contains two hydro power stations, Barron Gorge and Kareeya, with a combined capacity of 152 MW. Two renewable generation projects have been commissioned since the 2018 ISP: Lakeland Solar and Storage (12 MW) and Mt Emerald Wind Farm (180 MW). Far North Queensland has a moderate 275 kV network connection capacity, however, its distance makes it prone to losses with the addition of generation. AEMO recommends the installation of dedicated wind monitoring equipment or partnering with interested parties to measure the wind potential and quantify its potential in greater detail to inform future assessment.	

REZ Assessment

Phase 3	Far North Queensland has development in phase 3. In the mid to late 2030s the future ISP transmission augmentation project will be required to support the VRE projected for this zone.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	C			A		
Renewable Potential (MW)	1,100			2,400		
Demand Correlation	**2020**	**2030**	**2040**	**2020**	**2030**	**2040**
	F	F	F	E	D	D

Climate Hazard

Temperature Score	B	**Bush Fire Score**	A

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	**Projected**			**Existing/ committed**	**Projected**		
		2029-30	**2034-35**	**2039-40**		**2029-30**	**2034-35**	**2039-40**
Central	10	50	50	50	193	650	650	1,600
Step		50	50	50		650	1,100	2,400
Fast		50	50	50		600	650	1,900
High DER		50	50	50		650	650	1,950
Slow		50	50	50		0	0	650

Storage	
Far North Queensland has good potential pumped hydro locations just north of Cairns, towards the north east around Desailly and around Tully. The transmission network near this location is weak and upgrades would be required to accommodate large scale pumped hydro generation. There are also potential pumped hydro locations near Herberton within proximity of the Chalumbin–Walkamin/Woree 275 kV lines. Far North Queensland has good wind resource capacity that has a diverse correlation compared to other REZs.	**Suggested Storage for REZ (MW)** Far North Queensland has not been suggested for storage across any scenario in the 2020 ISP.

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
Far North Queensland REZ connection is to the 275 kV network connecting Woree to Ross via Chalumbin and Walkamin.	700 MW	E

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations				
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**	**Loss Factor Robustness**
Augmentation Option 1: To connect generation in the northern part of Far North Queensland REZ: • Establish a new 275 kV substation in the Lakeland area • Build a 275 kV line from Walkamin to the new substation • Build a new 275 kV Chalumbin–Walkamin single-circuit line To increase capacity on the 275 kV transmission backbone towards Townsville: • Rebuild the double-circuit Chalumbin–Ross 275 kV line at a higher capacity (possibly timed with asset replacement)	+500 MW	$280 million to $520 million[A]	Not identified as required in any ISP scenario	-
Augmentation Option 2: To connect generation in the Ravenshoe, Evelyn and Tumoulin area: • Establish a new 275 kV substation north of Millstream • Build a 275 kV single-circuit line from Chalumbin to Millstream • Turn Chalumbin–Woree 275 kV line into Millstream To increase capacity on the 275 kV transmission backbone towards Townsville: • Rebuild the double-circuit Chalumbin–Ross 275 kV line at a higher capacity (possibly timed with asset replacement)	+500 MW	$90 million to $160 million[A]	Not identified as required in any ISP scenario	-

Augmentation Option 3[B]: To connect generation in the Ravenshoe, Evelyn and Tumoulin area: • Establish a new 275 kV substation north of Millstream • Build a 275 kV single/double-circuit line from Chalumbin to Millstream • Turn Chalumbin–Woree 275 kV line into Millstream To increase capacity on the 275 kV transmission backbone towards Townsville: • Rebuild the double-circuit Chalumbin–Ross 275 kV line at a higher capacity (possibly timed with asset replacement) • Build an additional Chalumbin–Ross 275 kV single-circuit line	+1,200 – 1,300 MW	$360 million to $660 million[A]	Central (2037-38), High DER (2037-38), Fast (2035-36)	E
Augmentation Option 4[B]: To connect generation in the Ravenshoe, Evelyn and Tumoulin area: • Establish a new 275 kV substation north of Millstream • Build a 275 kV double-circuit line from Chalumbin to Millstream • Turn Chalumbin–Woree 275 kV line into Millstream To connect generation in the northern part of Far North Queensland REZ: • Establish a new 275 kV substation near Lakeland • Build a 275 kV line from Walkamin to the new substation • Build a new Chalumbin–Walkamin 275 kV line To increase capacity on the 275 kV transmission backbone towards Townsville: • Rebuild the double-circuit Chalumbin–Ross 275 kV line at a higher capacity (possibly timed with asset replacement) • Build an additional double-circuit Chalumbin–Ross 275 kV line	+1,800 – 2,000 MW	$710 million to $1,310 million[A]	Step (2030-31)[C]	-

A. The rebuild of the Chalumbin–Ross 275 kV line is required for asset replacement around mid to late 2030s, therefore the cost of the augmentation was not included.
B. Please refer to North Queensland REZ for additional augmentation required to transfer generation to load areas, south of Townsville.
C. A staged approach to have the full build by 2038.

Available Fault Level (MVA)

	Scenario	Existing	2029-30	2034-35
Available fault level in this REZ is influenced by planting of wind from the late 2020s.	**Central**	At limits[D]	-800	-750
	Step	At limits[D]	-400	-900

D. Powerlink is currently finalising mitigation to meet the declared system strength shortfall at Ross, and this may offset some of the later shortfalls shown

System Strength Remediation Augmentation

	Description	Date Required	Cost
Central	Establish 1 x 250 MVAr synchronous condenser.	2027-28	$45 million to $60 million
Step	Establish 1 x 250 MVAr synchronous condenser.	2025-26	$45 million to $60 million

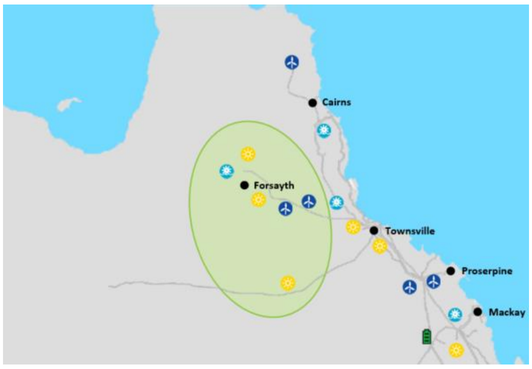
Q2 – North Queensland Clean Energy Hub

Summary

North Queensland Clean Energy Hub is in north Queensland. It has excellent solar and wind resources. The existing 132 kV line to the North Queensland Clean Energy Hub from Ross cannot accommodate large-scale generation developments.

Significant transmission infrastructure would be required to connect large-scale generation in this area which would include building a 200 km double/single-circuit line.

One renewable generation project has been commissioned since the 2018 ISP – Kidston Solar Project Phase 1 (50 MW), and two additional projects have been committed: Hughenden Sun Farm (18 MW) and Kennedy Energy Park Phase 1 (60 MW). In addition, there is interest of more than 1,200 MW consisting of wind, solar and pumped hydro within this REZ.



REZ Assessment

N/A	North Queensland Clean Energy Hub REZ does not have any projected development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	A			A		
Renewable Potential (MW)	8,000			18,600		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	E	D	D

Climate Hazard

Temperature Score	D	Bush Fire Score	C

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	83	The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.			43	The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.		
Step								
Fast								
High DER								
Slow								

Storage

	Suggested Storage for REZ (MW)
North Queensland Clean Energy Hub REZ has not been identified as having significant potential pumped hydro capability. There is interest to develop a 250 MW pumped hydro scheme at Kidston; converting the Kidston Gold mine upper and lower reservoirs into a pumped hydro scheme[27]. Additional transmission infrastructure would be required to connect pumped hydro in this area. This zone has not been identified for storage in the ISP, since the VRE outlook does not project wind or solar within this REZ.	North Queensland Clean Energy Hub has not been suggested for storage across any scenario in the 2020 ISP.

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
This REZ's connection is via a single 132 kV line from Ross–Kidston–George Town.	–	F

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations

Description	Additional Hosting Capacity	Upgrade Cost Estimate	ISP Development
Augmentation Option 1: For generation interest near Kidston: • Establish a new 275 kV substation mid–point Chalumbin–Ross 275 kV line • Turn in both Chalumbin–Ross 275 kV lines into the new substation • Establish a new 275 kV substation near Kidston or area with high renewable energy interest • Build a new double-circuit 275 kV line from the substation near Kidston to the substation mid–point Ross and Chalumbin • Upgrades between the new mid-point substation and Ross would be required if Q1 REZ is also developed	+800 MW	$310 million to $580 million[A]	Not identified as required in any scenario
Augmentation Option 2: For generation interest near Kidston and Hughenden • Establish a new 275 kV substation mid–point Chalumbin–Ross 275 kV line • Turn in both Chalumbin–Ross 275 kV lines into the new substation • Build a new 275 kV substation near Kidston • Build a new 275 kV substation near Hughenden • Build a new single-circuit from mid–point Ross and Chalumbin to Kidston, to Hughenden and back to Ross/Strathmore • Including relevant reactive power support equipment	+900-1,000 MW	$880 million to $1,630 million[A]	Not identified as required in any scenario

[27] Genex Power Limited Kidston pumped storage hydro project available at: https://www.genexpower.com.au/250 Mw-kidston-pumped-storage-hydro-project.html

<table>
<tr><td colspan="2">

- Upgrades between the new mid-point substation and Ross would be required if Q1 REZ is also developed</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">

Augmentation Option 3:

- Build a new 275 kV substation near Kidston
- Build a new 275 kV substation near Hughenden
- Establish a new 275 kV substation mid–point between Kidston and Hughenden
- Build a new double-circuit from mid–point Kidston and Hughenden to Ross
- Build a new single-circuit from mid–point substation to Kidston
- Build a new single-circuit from mid–point substation to Hughenden
- Reactive power support equipment</td><td>+1,000 MW</td><td>$670 million to $1,250 million[A]</td><td>Not identified as required in any scenario</td></tr>
<tr><td colspan="5">A. The rebuild of the Chalumbin–Ross 275 kV line is required for asset replacement around mid to late 2030s, therefore the cost of the augmentation was not included.</td></tr>
<tr><td colspan="5">Available Fault Level (MVA)</td></tr>
<tr><td rowspan="3">Available fault level in this REZ is influenced by VRE development and remediation of nearby REZs.</td><td>Scenario</td><td>Existing</td><td>2029-30</td><td>2034-35</td></tr>
<tr><td>Central</td><td rowspan="2">At limits[B]</td><td>-800</td><td>-750</td></tr>
<tr><td>Step</td><td>-400</td><td>-550</td></tr>
<tr><td colspan="5">B. Powerlink is currently finalising mitigation to meet the declared system strength shortfall at Ross, and this may offset some of the later shortfalls shown</td></tr>
<tr><td colspan="5">System Strength Remediation Augmentation</td></tr>
<tr><td colspan="5">The system strength remediation augmentation proposed for nearby REZ Q1 would also resolve the remediation requirements, assuming no further VRE development in this REZ.</td></tr>
</table>

Q3 – Northern Queensland

Summary

The North Queensland REZ encompasses Townsville and the surrounding area. It has good quality solar and wind resources and is situated close to the 275 kV corridor. Clare Solar Farm (100 MW), Haughton Solar Farm (100 MW), Ross River Solar Farm (116 MW), and Sun Metals Solar Farm (107 MW) are operational.

The existing 275 kV network has good capacity, but this is shared with the REZs in North and Central Queensland. Even though there is good network capacity, the MLF will decline sharply due to the distance from major load centres. Further connections of inverter-based resources in this area is likely to require system strength remediation.

REZ Assessment

N/A	Northern Queensland REZ does not have any projected development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	A			B		
Renewable Potential (MW)	3,400			–		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	D	C	C

Climate Hazard

Temperature Score	C	Bush Fire Score	E

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	423	The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.			There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step								
Fast								
High DER								
Slow								

Storage	
Northern Queensland has good potential pumped hydro locations to the north east (near the Chalumbin–Ross 275 kV lines) and just east of Townsville. There is no projected VRE for this zone and for this reason, no storage has been suggested.	**Suggested Storage for REZ (MW)** Northern Queensland REZ has not been suggested for storage across any scenario in the 2020 ISP.

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
The current network connects to Far North QLD via two Ross–Chalumbin 275 kV lines and to Strathmore via three Ross–Strathmore 275 kV lines. The current spare hosting capacity of approximately 1,800 MW is for all the generation to be located within REZs Q1, Q2 and Q3.	1,800 MW	D

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations

Description	Additional Hosting Capacity	Upgrade Cost Estimate	ISP Development	Loss Factor Robustness
Augmentation Option 1: • Upgrade lower rated Ross–Strathmore 275 kV line	+400 - 600 MW	$10 million to $15 million[A]	Central, High DER and Fast (2037-38) Step (2035-36)[B]	D
Augmentation Option 2: • Build an additional 275 kV line between Ross and Nebo via Strathmore	+700 - 800 MW	$360 million to $670 million	Step (2035-36)[B]	-

A. Cost provided by Powerlink
B. Augmentation required for the increase in VRE in Far North Queensland.

Available Fault Level (MVA)

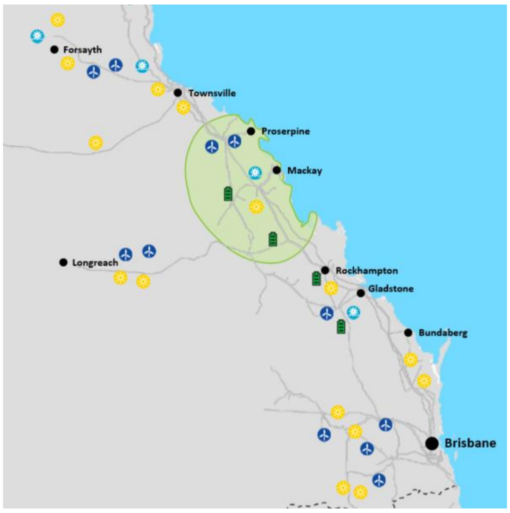
	Scenario	Existing	2029-30	2034-35
Available fault level in this REZ is influenced by VRE development and remediation of nearby REZs.	**Central**	At limits[C]	-800	-750
	Step		-400	-550

C. Powerlink is currently finalising mitigation to meet the declared system strength shortfall at Ross, and this may offset some of the later shortfalls shown

System Strength Remediation Augmentation

The system strength remediation augmentation proposed for nearby REZ Q1 would also resolve the remediation requirements, assuming no further VRE development in this REZ.

Q4 – Isaac

Summary	Phase 3
The Isaac REZ has good wind and solar resources covering Collinsville and Mackay. Daydream Solar Farm (150 MW), Hayman Solar Farm (50 MW), Collinsville PV (41 MW), Clermont Solar Farm (75 MW), Emerald Solar Farm (72 MW), Hamilton Solar Farm (57 MW), Lilyvale Solar Farm (100 MW), Rugby Run (65 MW) and Whitsunday Solar Farm (57.5 MW) are operational. The existing 275 kV network has spare capacity, but this is shared with the REZs in North and Central Queensland.	

REZ Assessment

Phase 3	Isaac REZ has development in phase 3. For large scale VRE development in this region, upgrades are required to transmission network between Central to Southern Queensland and between Bouldercombe and Calliope River. The future ISP projects, Central to Southern Queensland transmission project and Gladstone Reinforcement, will facilitate development of this REZ.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	B			B		
Renewable Potential (MW)	6,900			3,800		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	B	B

Climate Hazard

Temperature Score	C	Bush Fire Score	C

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	666	450	450	450	There is no existing or committed wind generation in this REZ.	0	0	1,000
Step		350	350	350		1,000	1,000	1,000
Fast		350	350	350		0	1,000	1,000
High DER		350	350	350		0	0	1,000
Slow		350	350	350		0	0	0

Storage					
	Suggested Storage for REZ (MW)				
		Depth	**Projected**		
			2029-30	**2034-35**	**2039-40**
There are numerous potential pumped hydro locations to the north east and south east of Nebo. This REZ has a good diversity of resources - wind, solar and storage. Locating storage in this zone could maximise transmission utilisation. Pumped hydro, if synchronous, could also further improve system strength within the area when in service. The Isaac REZ is well located, close to other REZs in North and Central Queensland with high projected VRE. Strategic development of large scale storage could defer some costly transmission network augmentations. Shallow, medium and deep storage has been suggested for this zone.	**Central**	**Shallow**	0	0	850
	Step		50	50	50
	Fast		0	0	200
	High DER		0	0	0
	Slow		0	0	150
	Central	**Medium**	0	250	250
	Step		600	1,100	1,100
	Fast		0	200	250
	High DER		0	0	0
	Slow		0	0	0
	Central	**Deep**	0	0	0
	Step		0	50	450
	Fast		0	0	500
	High DER		0	0	150
	Slow		0	0	0

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
275 kV and 132 kV circuits pass through this REZ. The hosting capacity along this corridor is approximately 2,000 to 2,500 MW which includes any generation that connects in Q1, Q2, Q3, Q4 and Q5.	2,000 MW – 2,500 MW	B

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations				
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**	**Loss Factor Robustness**
Augmentation Option 1: • Rebuild the Bouldercombe–Calliope River and the Bouldercombe–Raglan–Larcom Creek–Calliope River 275 kV lines as a high capacity double-circuit lines (may be possible to bring forward the end of life condition replacement)[A] • A new double-circuit Calvale–Larcom Creek 275 kV line • 275/132 kV Calliope River transformer	+700 MW - 800 MW	$300 to $560 million	Central, Step, Slow, Fast and High DER (early to mid-2030s)	A
Augmentation Option 2: • Build an additional 275 kV line between Bouldercombe and Calliope River	+1,000 MW	$130 million to $240 million	Central, Step, Slow, Fast and High DER (mid to late-2030s)	-
Augmentation Option 3: • Build an additional Bouldercombe – Nebo 275 kV single-circuit line	+700 MW - 800 MW	$320 million to $600 million	Step, Fast, High DER (mid to late-2030s)	-
A. Cost assumes full cost of the full rebuild (and not the cost of the bring forward)				

Available Fault Level (MVA)				
Available fault level in this REZ is dominated by planting of solar PV from the mid-2019-20s and influenced by VRE development and remediation of nearby REZs.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	At limit	-800	-850
	Step		-500	-800

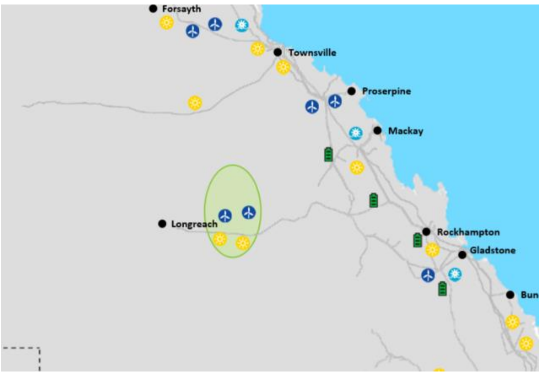
System Strength Remediation Augmentation
The system strength remediation augmentation proposed for nearby REZ Q1 would also resolve the remediation requirements.

Q5 – Barcaldine

Summary

The Barcaldine REZ is situated in Central Queensland. This REZ has excellent solar resources and moderate wind resources. The existing 350 km 132 kV line to Barcaldine from Lilyvale, via Clermont, cannot support any large–scale generation developments. A possible investment option is to build a double-circuit 275 kV line from the main backbone at Lilyvale extending inland to Barcaldine.

Even after this upgrade, the MLFs will decline sharply because the generation is located a significant distance from load.



REZ Assessment

N/A	Barcaldine REZ does not have any projected development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	A			C		
Renewable Potential (MW)	8,000			3,900		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	E	D	C

Climate Hazard

Temperature Score	D	**Bush Fire Score**	C

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	34	The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.			There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step								
Fast								
High DER								
Slow								

<table>
<tr><th colspan="5">Storage</th></tr>
<tr><td colspan="2" rowspan="2">Barcaldine REZ has not been identified as having significant potential pumped hydro capability. ISP modelling does not project any VRE for this REZ due to the large cost required to augment this network. For this reason, no storage is suggested within this zone.</td><td colspan="3">Suggested Storage for REZ (MW)</td></tr>
<tr><td colspan="3">Barcaldine REZ has not been suggested for storage across any scenario in the 2020 ISP.</td></tr>
<tr><th colspan="5">Existing Network Capability</th></tr>
<tr><td colspan="2">Description</td><td colspan="2">Approximate Existing Hosting Capacity</td><td>Loss Factor Robustness</td></tr>
<tr><td colspan="2">This REZ is connected with a Lilyvale–Clermont–Barcaldine 132 kV line. The total line length is approximately 350 km.</td><td colspan="2">–</td><td>F</td></tr>
<tr><th colspan="5">Associated Interconnector Augmentations</th></tr>
<tr><td colspan="2">Description</td><td colspan="2">Additional Hosting Capacity</td><td>Loss Factor Robustness</td></tr>
<tr><td colspan="5">There are no associated interconnector augmentations with this REZ.</td></tr>
<tr><th colspan="5">Possible REZ Augmentations</th></tr>
<tr><td>Description</td><td>Additional Hosting Capacity</td><td>Upgrade Cost Estimate</td><td colspan="2">ISP Development</td></tr>
<tr><td>Augmentation Option 1:
To connect generation within Barcaldine REZ:
• Establish a new 275 kV substation within Barcaldine REZ, location to be determined by interest in the area
• A new double-circuit 275 kV line connecting the new substation to Lilyvale</td><td>+700 – 900 MW</td><td>$490 million to $910 million</td><td colspan="2">Not identified as required in any scenario</td></tr>
<tr><th colspan="5">Available Fault Level (MVA)</th></tr>
<tr><td rowspan="3">Available fault level in this REZ is influenced by development of nearby REZs.</td><td>Scenario</td><td>Existing</td><td>2029-30</td><td>2034-35</td></tr>
<tr><td>Central</td><td>600</td><td>350</td><td>350</td></tr>
<tr><td>Step</td><td>600</td><td>400</td><td>-50</td></tr>
<tr><th colspan="5">System Strength Remediation Augmentation</th></tr>
<tr><td colspan="5">Remediation not required with forecast level of VRE in the Central and Step Change scenarios.</td></tr>
</table>

Q6 – Fitzroy

Summary	Phase 1 and phase 3 REZ
The Fitzroy REZ is in Central Queensland and covers a strong part of the network where Gladstone and Callide generators are connected. This REZ has good solar and wind resources. There is no wind or solar generation in service or committed in this REZ. Currently the limitation for connection within this REZ and REZ Q1 to Q4 is due to voltage and transient stability along the cut-set CQ–SQ (Central Queensland to Southern Queensland). This is projected to limit optimal generation expansion connected north of this cut-set to 2,000 to 2,500 MW. This limit could be increased by the exit of Callide B (expected in the late 2020s) and Gladstone (in the mid–late 2030s). See Appendix 3 for more information on the Central to Southern Queensland network expansion project.	

REZ Assessment

Phase 1 and phase 3 REZ	Fitzroy REZ has development in phase 1 and phase 3. The development in Fitzroy in phase 1 occurs to meet the QRET. Further development in this region is facilitated by upgrades to the Central to Southern Queensland (CQ–SQ) cut-set and the Gladstone Grid Reinforcement.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	B			B		
Renewable Potential (MW)	7,700			3,500		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	B	B

Climate Hazard

Temperature Score	C	Bush Fire Score	B

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ.	1,350	1,350	1,350	There is no existing or committed wind generation in this REZ.	800	800	900
Step		0	0	0		500	900	900
Fast		0	0	0		0	900	900
High DER		800	800	800		650	650	900
Slow		0	0	0		0	0	0

Storage

Potential pumped hydro locations have been identified near Bouldercombe and Calvale. There is a significant projection in solar and wind generation north of the CQ–SQ cut-set. Significant transmission build would be required to accommodate such a large projection of VRE generation. Having storage located within this REZ would assist in reducing the capacity required for the transmission augmentation to connect the VRE in northern and central Queensland, to the load in southern Queensland. Storage would also assist in firming up the VRE generation.

Storage, of all depth classes, including batteries and pumped hydro, has been suggested for this zone, except for High DER.

Suggested Storage for REZ (MW)				
	Depth	Projected		
		2029-30	2034-35	2039-40
Central	**Shallow**	0	0	1,250
Step		50	50	50
Fast		0	0	300
High DER		0	0	0
Slow		0	0	200
Central	**Medium**	0	400	400
Step		250	550	550
Fast		0	50	50
High DER		0	0	0
Slow		0	0	0
Central	**Deep**	0	0	0
Step		0	50	450
Fast		0	0	0
High DER		0	0	0
Slow		0	0	0

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
This REZ is connected via a meshed 275 kV network ranging between Bouldercombe, Gladstone and Callide/Calvale. The spare hosting capacity of approximately 2,000 - 2,500 MW includes any generation that would connect to Q1, Q2, Q3, Q4, Q5 and Q6.	2,000 MW - 2,500 MW	A

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations				
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**	**Loss Factor Robustness**
Augmentation Option 1: Central to Southern Queensland minor augmentation (increasing the transient stability limit +300 MW) • Establish a new 275 kV Auburn River substation mid–point between Calvale and Halys • Turn both Calvale–Halys 275 kV lines into the Auburn River substation	+300 MW	$30 million to $60 million	Not identified as being required under any ISP scenario	-
Augmentation Option 2: Central to Southern Queensland augmentation • Build a double-circuit 275 kV line from Calvale to Wandoan South	+900 MW	$300 million to $560 million	Central, High DER, Fast and Step change (early to mid2030s)	A

Available Fault Level (MVA)				
Available fault level in this REZ is dominated by planting of wind and solar PV from the late 2020s. Pumped hydro in the step change scenario is expected to form part of the system strength remediation.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	600	-400	-200
	Step	600	400	200

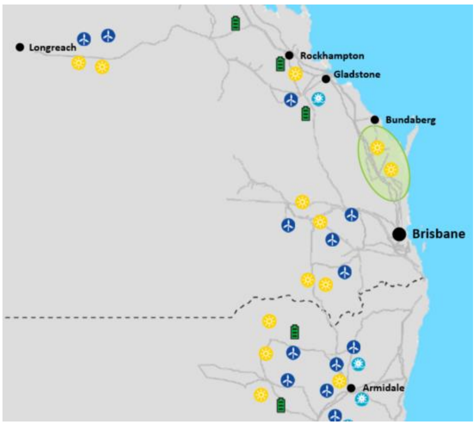
System Strength Remediation Augmentation			
	Description	**Date Required**	**Cost**
Central	Establish 1 x 125 MVAr synchronous condenser.	2027-28	$40 million to $55 million
Step	Remediation not required with forecast level of VRE in the Step Change scenario.	-	-

Q7 – Wide Bay

Summary

Due to interest in and around the wide bay area, this new Wide Bay REZ candidate has been included for the 2020 ISP. This new REZ expands across the 275 kV network around Woolooga and Teebar Creek. It also includes the 132 kV network around Maryborough, Isis and Aramara.

The Wide Bay area has moderate solar resources with Childers (56 MW) and Susan River Solar Farm (75 MW) operational within this zone.



REZ Assessment

N/A	Wide Bay REZ does not have projected REZ phase development. Development of renewable generation in this REZ occur in the mid-2029-30s within the spare network capacity.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	C			D		
Renewable Potential (MW)	2,200			1,100		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	B	B

Climate Hazard

Temperature Score	B	Bush Fire Score	E

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	131	0	0	200	There is no existing or committed wind generation in this REZ.	0	0	300
Step		0	200	200		300	300	300
Fast		0	500	500		0	0	0
High DER		0	0	200		0	0	300
Slow		0	0	0		0	0	0

Storage

	Suggested Storage for REZ (MW)
Wide Bay REZ has not been identified as having significant potential pumped hydro capability. No storage is suggested for this REZ in the ISP.	Wide Bay REZ has not been suggested for storage across any scenario in the 2020 ISP.

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
The Wide Bay REZ is connected via 275 kV lines between Woolooga, South Pine, Teebar Creek and Gin Gin.	500 MW	A

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations

Description	Additional Hosting Capacity	Upgrade Cost Estimate	ISP Development
Augmentation Option 1: • Rebuild Woolooga–Palmwoods–South Pine as a double-circuit 275 kV line	+900 MW	$270 million to $510 million	Not identified as being required under any ISP scenario
Augmentation Option 2: • Rebuild Woolooga–South Pine as a double-circuit 275 kV line	+900 MW	$250 million to $470 million	Not identified as being required under any ISP scenario

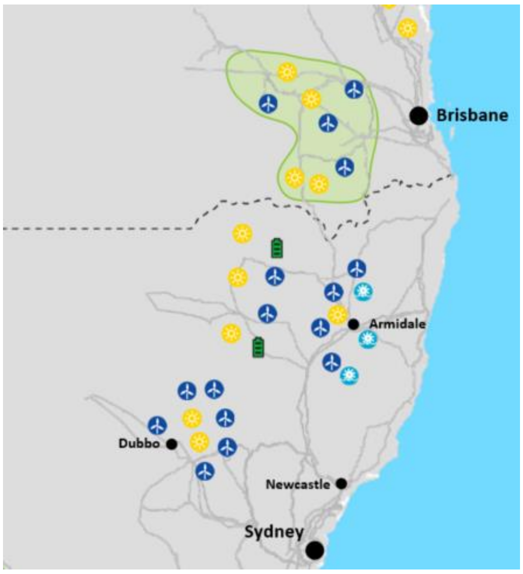
Available Fault Level (MVA)

	Scenario	Existing	2029-30	2034-35
Available fault level in this REZ is influenced by development of nearby REZs.	**Central**	1,000	900	950
	Step	1,000	1,600	850

System Strength Remediation Augmentation

Remediation not required with forecast level of VRE in the Central and Step Change.

Q8 – Darling Downs

Summary	Phase 1 and phase 3 REZ
The Darling Downs REZ covers a wide area in Southern Queensland. This REZ not only has good solar and wind resources, it also has a strong network with good potential to connect renewable generation. Currently this REZ has approximately 840 MW of generation connected or committed, almost evenly split between wind and solar. The Darling Downs REZ is situated close to the Brisbane load centre and has good access to the New South Wales – Queensland interconnector. Upgrades to the New South Wales – Queensland interconnector, such as QNI Medium and QNI Large would further improve this REZ's ability to connect renewable generation.	

REZ Assessment

Phase 1 and phase 3 REZ	Darling Downs REZ has development in phase 1 and phase 3. The development in Darling Downs in phase 1 occurs to meet the QRET, utilising existing network capacity. Further development in this region is supported by QNI Medium and QNI Large.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	B			B		
Renewable Potential (MW)	7,700			5,600		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	B

Climate Hazard

Temperature Score	C	Bush Fire Score	E

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central		350	350	1,150		1,400	1,400	3,950
Step		1,150	4,950	7,100		1,650	3,850	5,300
Fast	399	0	1,000	4,400	440	500	1,650	5,150
High DER		1,700	1,700	2,200		500	500	2,950
Slow		0	0	0		500	500	500

<table>
<tr><th colspan="6">Storage</th></tr>
<tr><td rowspan="13">Large-scale solar and wind generation is projected in the Darling Downs area. Darling Downs has good network access to the Brisbane load centre as well as the load in New South Wales via the Queensland to New South Wales interconnector.

Storage in this location would be beneficial to help firm the solar generation projected for this REZ.

No storage is suggested under the Slow Change and High DER scenarios for Darling Downs, under the Slow Change no storage is projected for Queensland and very limited storage is projected for High DER.</td><th colspan="5">Suggested Storage for REZ (MW)</th></tr>
<tr><th rowspan="2"></th><th rowspan="2">Depth</th><th colspan="3">Projected</th></tr>
<tr><th>2029-30</th><th>2034-35</th><th>2039-40</th></tr>
<tr><td>Central</td><td rowspan="5">Medium</td><td>0</td><td>0</td><td>550</td></tr>
<tr><td>Step</td><td>250</td><td>300</td><td>300</td></tr>
<tr><td>Fast</td><td>0</td><td>500</td><td>600</td></tr>
<tr><td>High DER</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Slow</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Central</td><td rowspan="5">Deep</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Step</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fast</td><td>0</td><td>0</td><td>500</td></tr>
<tr><td>High DER</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Slow</td><td>0</td><td>0</td><td>0</td></tr>
</table>

<table>
<tr><th colspan="3">Existing Network Capability</th></tr>
<tr><th>Description</th><th>Approximate Existing Hosting Capacity</th><th>Loss Factor Robustness</th></tr>
<tr><td>This is the only REZ in Queensland that has access to the transmission network at 330 kV. The Darling Downs REZ also connects to the Brisbane load centre via three 275 kV lines: one from Middle Ridge to Greenbank, one from Tarong to Blackwall and one from Tarong to South Pine.</td><td>3,000 MW</td><td>A</td></tr>
<tr><th colspan="3">Associated Interconnector Augmentations</th></tr>
<tr><th>Description</th><th>Additional Hosting Capacity</th><th>Loss Factor Robustness</th></tr>
<tr><td>QNI Medium Option 2E (Preparatory Activities Required):
A new 500 kV interconnector from Western Downs in Queensland via Boggabri to a new substation near Wollar in New South Wales.</td><td>+1,000 MW</td><td>A</td></tr>
<tr><td>QNI Large Option 3E (Preparatory Activities Required):
A second 500 kV interconnector from Western Downs in Queensland via Boggabri to the Wollar area in New South Wales.</td><td>+1,000 MW</td><td>A</td></tr>
</table>

<table>
<tr><th colspan="4">Possible REZ Augmentations</th></tr>
<tr><th>Description</th><th>Additional Hosting Capacity</th><th>Upgrade Cost Estimate</th><th>ISP Development</th></tr>
<tr><td>Augmentation Option 1:
• 3rd 330/275 kV transformer at Middle Ridge</td><td>+1,000 - 1,300 MW</td><td>$180 million to $340 million</td><td>Not identified as required under any 2020 ISP scenario</td></tr>
</table>

• Bulli Creek–Millmerran–Middle Ridge 330 kV line			

Available Fault Level (MVA)				
Available fault level in this REZ is dominated by planting of wind and solar PV from the late 2020s. Pumped hydro in the step is expected to form part of the system strength solution for this REZ.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	1,650	-200	1,650
	Step	1,650	1,100	-5,350

System Strength Remediation Augmentation

	Description	Date Required	Cost
Central	Remediation not required with forecast level of VRE in the Central scenario.	-	-
Step	Establish 4 x 250 MVAr synchronous condensers.	2032-33	$180 million to $230 million

A5.4.4 South Australia REZ scorecards

S1 – South East SA

Summary	Phase 3 REZ
The South East South Australia REZ has moderate to good quality wind resources. Over 300 MW of wind farms at Canunda and Lake Bonney are in service. This REZ lies on the major 275 kV route of the South Australia-Victoria Heywood interconnector. The existing network can only effectively accommodate a small amount of additional generation. Beyond this 55 MW hosting capacity, transmission network expansions would be required to accommodate generation within this zone. Network augmentations would be smaller if generation is located relatively close to Adelaide, and larger if located further south towards Mount Gambier. The MLF is sensitive to additional generation because the REZ is not close to any major load centres.	

REZ Assessment	
Phase 3 REZ	South East SA has development in phase 3. A future grid project within the South East REZ will need to be developed to facilitate the VRE development projected within this zone.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	D			C		
Renewable Potential (MW)	100			3,200		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	C

Climate Hazard

Temperature Score	D	Bush Fire Score	D

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	95	The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.			325	0	0	800
Step						50	300	800
Fast						0	50	800
High DER						0	0	600
Slow						0	0	0

Storage	
South East SA REZ is not considered to have potential for significant pumped hydro generation, for this reason no pumped hydro has been suggested for this region. This REZ is projected for medium scale wind development, however no other storage has been suggested for this REZ.	**Suggested Storage for REZ (MW)** South East SA has not been suggested for storage in any scenario in the 2020 ISP.

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
Presently the network capacity is limited. Any additional generation would compete with the flows on the Heywood interconnector.	55 MW	-

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
There is no interconnector augmentation on the optimal development path associated with this REZ.		

Possible REZ Augmentations

Description	Additional Hosting Capacity	Upgrade Cost Estimate	ISP Development	Loss Factor Robustness
Augmentation Option 1[A]: To strengthen connection to Adelaide: • Install an additional 275 kV line by stringing the vacant circuit on Tailem Bend–Tungkillo, including any additional reactive support • Where necessary manage generation with control schemes such as runback schemes.	+400 to 600 MW	$20 million to $80 million	Central (2037-38), Step Change (2030-31), Fast Change (2037-38), High DER (2039-40)	-

A. Additional 275 kV transmission lines may be required between Tailem Bend and generation interest within the zone. This augmentation and costing would depend on the location of the generation.

Available Fault Level (MVA)

Available fault level in this REZ is influenced by development of nearby REZs.

Remediation of S1, S2, S3 and S4 can be addressed by joint solutions.

Scenario	Existing	2029-30	2034-35
Central	At limits[B]	150	-1,000
Step	At limits[B]	-1,650	-2,450

B. Shortfalls in this area are managed by directions of synchronous units and constraints to existing VRE generation.

System Strength Remediation Augmentation

Remediation requirements shown for this REZ are due to expansion of VRE in neighbouring REZs and are met through a joint solution reported in REZ S2.

S2 – Riverland

Summary	Phase 2 REZ
The Riverland REZ is on the South Australian side of the proposed Project EnergyConnect route. It has good solar quality resources. There is minimal existing renewable generation in the zone. Prior to Project EnergyConnect, approximately 200 MW can be connected in this REZ. Once Project EnergyConnect is commissioned (2024-25), approximately 800 MW can be accommodated. Additional generation beyond 1,000 MW is not practical without extensive further network upgrades between Riverland and South Australia's neighbouring states.	

REZ Assessment

Phase 2 REZ	Riverland REZ has development in phase 2. VRE development in this REZ is supported by the commissioning of Project EnergyConnect by 2024-25, an actionable ISP project.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	B			E		
Renewable Potential (MW)	4,000			1,400		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	C

Climate Hazard

Temperature Score	E	Bush Fire Score	C

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ.	0	1,000	1,000	There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step		1,000	1,000	1,000				
Fast		0	1,000	1,000				
High DER		0	0	1,000				
Slow		0	0	1,000				

Storage

ISP modelling has generally demonstrated benefits in co-locating solar generation with shallow-to-medium storages. There is a large projection of solar generation for this REZ which makes it a great candidate for storage. Locating storage within this REZ will firm up supply within the area and reduce the scale of network augmentations required to transfer this energy to the load centres.

Since this REZ does not have significant potential for pumped hydro, battery storage of shallow and medium depth has been suggested, for this REZ across all scenarios except for High DER. Under the High DER scenario, no storage is projected for South Australia.

Suggested Storage for REZ (MW)				
	Depth	Projected		
		2029-30	2034-35	2039-40
Central	Shallow	0	100	150
Step		0	0	0
Fast		0	0	100
High DER		0	0	0
Slow		0	0	150
Central	Medium	0	0	150
Step		0	0	50
Fast		0	0	150
High DER		0	0	0
Slow		0	0	200

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
Presently the network capacity is limited, any additional generation would effectively be competing with the flows on the Murraylink interconnector.	200 MW	F

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
Project EnergyConnect (Actionable ISP project): A new 330 kV interconnector between Robertstown in South Australia and Wagga Wagga in New South Wales, via Buronga.	+800 MW	A

Possible REZ Augmentations

Description	Additional Hosting Capacity	Upgrade Cost Estimate	ISP Development	Loss Factor Robustness
Augmentation Option 1A: Assumes new interconnector Project EnergyConnect in service: • Establish a new substation in the Riverland REZ close to the new interconnector • Turn both Robertstown–Bundey–Buronga 330 kV lines into the new substation • Install necessary transformation	+800 MW	$60 million to $110 million	Central (2032-33), Step Change (2026-27), Fast Change (2030-31), High DER and Slow Change (2037-38)	A

A. Control schemes may be required to manage network conditions after a contingency.

Available Fault Level (MVA)				
Available fault level in this REZ is influenced by planting of solar PV from the mid-2030s. Remediation of S1, S2, S3 and S4 can be addressed by joint solutions.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	At limits[A]	250	-1,250
	Step	At limits[A]	-1,650	-1,600

A. Shortfalls in this area are managed by directions of synchronous units and constraints to existing VRE generation.

System Strength Remediation Augmentation

	Description	Date Required	Cost
Central	Remediation not required with forecast level of VRE in the Central scenario.	-	-
Step	Establish 2x 125 MVAr synchronous condensers	2026-27	$85 million to $110 million

S3 – Mid–North SA

Summary

The Mid–North SA REZ has moderate quality wind and solar resources. There are several major wind farms in service in this REZ, totalling 952 MW, including Hallett, Hornsdale, Starfish Hill, Waterloo and Willogoleche.

Four 275 kV circuits pass through the REZ, and about 1,000 MW of additional generation can be accommodated through this corridor. However due to the network configuration, any generation north and west of this REZ contributes to this 1,000 MW limit. For this reason, an aggregate limit for South Australia of 1,000 MW applying to S3, S5, S6, S7, S8 and S9 has been set (see section A5.3.4).

Due to the VRE projection in Roxby Downs and Mid-North, transmission augmentation is required to strengthen the network between Davenport and Para. This transmission augmentation has been identified as a future ISP project, no further action is required until the 2022 ISP.

Phase 3 REZ

REZ Assessment

Phase 3 REZ	Mid–North REZ has development in phase 3. Transmission augmentation strengthening 275 kV network between Davenport and Para is required to support the VRE projection in the Mid-North REZ and Roxby Downs REZ. This augmentation assists in transferring the power from these REZs to the load centres, to Victoria via the Heywood and Murraylink interconnectors, and to New South Wales via Project EnergyConnect.

Renewable Resources

Resource	**Solar**			**Wind**		
Resource Quality	C			C		
Renewable Potential (MW)	1,300			4,600		
Demand Correlation	**2019-20**	**2029-30**	**2039-40**	**2019-20**	**2029-30**	**2039-40**
	F	F	F	C	C	C

Climate Hazard

Temperature Score	D	**Bush Fire Score**	D

Variable Renewable Energy Outlook

	Solar PV (MW)				**Wind (MW)**			
	Existing/ committed	**Projected**			**Existing/ committed**	**Projected**		
		2029-30	**2034-35**	**2039-40**		**2029-30**	**2034-35**	**2039-40**
Central	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				952	0	500	800
Step						850	850	1,200
Fast						0	150	1,200
High DER						0	0	250
Slow						0	0	50

Storage	
Mid–North SA has moderate wind projections across all ISP scenarios. Mid-North does not have significant potential for pumped hydro generation. There is on operational battery in the Mid-North REZ – Hornsdale (100 MW/129 MWh).	**Suggested Storage for REZ (MW)** Mid–North SA has not been suggested for storage in any scenario in the 2020 ISP.

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
The present network is limited by the 275 kV lines which supply the Adelaide load centre and provides a transfer path to the Heywood interconnector and the future Project EnergyConnect interconnector. The current spare network capacity of approximately 1,000 MW is for all the generation connecting in S3, S5, S6, S7, S8 and S9.	1,000 MW	A

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations				
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**	**Loss Factor Robustness**
Augmentation Option 1: Mid–North SA 275 kV network connects REZs S3, S5, S6, S7, S8 and S9 to the Adelaide load centre as well as provides a path to both the Heywood and Project EnergyConnect interconnectors. When the combination of generation in these REZs exceeds 1,000 MW the following upgrade is required: • Rebuild Davenport–Brinkworth–Templers West–Para 275 kV line as a high capacity double-circuit line • Reconfigure the 132 kV network in the Mid–North region to balance flows	+1,000 MW	$420 million to $770 million	Central, Step and Fast (2036-2038)	A

Available Fault Level (MVA)				
Available fault level in this REZ is influenced by projected development utility solar from the mid-2030s and wind from the late-2020s in the step. Remediation of S1, S2, S3 and S4 can be addressed by joint solutions.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	At limits[A]	-550	-1,000
	Step	At limits[A]	-1,650	-2,450

A. Shortfalls in this area are managed by directions of synchronous units and constraints to existing VRE generation.

System Strength Remediation Augmentation			
	Description	**Date Required**	**Cost**
Central	Establish 3 x 125 MVAr synchronous condensers.	2032-33	$130 million to $165 million
Step	Establish 2 x 125 MVAr synchronous condensers.	2027-28	$85 million to $110 million

S4 – Yorke Peninsula

Summary

The Yorke Peninsula REZ has good quality wind resources. The Wattle Point (90 MW) wind farm lies within this REZ.

A single 132 kV line extends from Hummocks to Wattle Point (towards the end of Yorke Peninsula). Transmission augmentation would be required to connect any significant additional generation in this REZ.

This REZ is part of the South Australia group constraint (see section A5.3.4).

REZ Assessment

N/A	The VRE development in Yorke Peninsula REZ has not been identified in any REZ phase development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	C			C		
Renewable Potential (MW)	–			1,400		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	C

Climate Hazard

Temperature Score	D	Bush Fire Score	C

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				460[A]	0	0	600
Step						0	0	600
Fast						0	0	400
High DER						0	0	0
Slow						0	0	0

A. Includes Snowtown wind farm which lies just outside this REZ

Storage	
Yorke Peninsula does not have potential for significant pumped hydro generation. Small to medium scale wind development occurs within this zone and hence no storage has been suggested for this REZ in the ISP.	**Suggested Storage for REZ (MW)** Yorke Peninsula has not been suggested for storage under any scenario for the 2020 ISP.

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
The REZ connection is via the 132 kV circuit from Hummocks. Currently, there is no spare capacity available on this network.	–	F

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations

Description	Additional Hosting Capacity	Upgrade Cost Estimate	ISP Development	Loss Factor Robustness
Augmentation Option 1: Increase capacity to Yorke Peninsula: • Establish a 275 kV substation near connection interest in Yorke Peninsula • Build a double-circuit 275 kV line from Blythe West into Yorke Peninsula (location would be dependent on wind connection interest)	+800 - 1,000 MW	$190 million to $350 million[B]	Central and Fast Change[C] (2035-36), Step Change (2037-38)	C
Augmentation Option 2: Increase capacity to Yorke Peninsula: • Establish a 132 kV substation at Blythe West • Establish a new 132 kV substation near generation interest within Yorke Peninsula (location would be dependent on wind connection interest) • Build a double-circuit 132 kV Blythe West to the new substation	+400 - 450 MW	$160 million to $300 million[B]	Not identified as being required under any ISP scenario	-

B. Cost dependant on the location of the wind generation interest.
C. Fast Change Scenario only requires a single-circuit line.

Available Fault Level (MVA)

Available fault level in this REZ is influenced by planting of wind in the step from the late 2020s.

Remediation of S1, S2, S3 and S4 can be addressed by joint solutions.

Scenario	Existing	2029-30	2034-35
Central	At limits[D]	-150	-1,250
Step	At limits[D]	-1,550	-1,550

D. Shortfalls in this area are managed by directions of synchronous units and constraints to existing VRE generation.

System Strength Remediation Augmentation

Remediation requirements shown for this REZ are due to expansion of VRE in neighbouring REZs, and are met through a joint solution reported in REZ S3.

S5 – Northern SA

Summary

The Northern SA REZ has good solar and moderate wind resources. Over 1,100 MW of new generation has been proposed, with a diverse mix of solar thermal, wind, solar PV, and pumped hydro.

About 1,000 MW of additional generation can be accommodated in this REZ. The capability of this zone to accommodate new generation is also subject to the Mid-North group constraints. This REZ is part of the South Australia group constraint (see section A5.3.4).The REZ is close to the major load centre at Adelaide and the MLFs are robust to increases in generation.

REZ Assessment

N/A	Northern SA REZ does not have any projected development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	B			C		
Renewable Potential (MW)	3,000			200		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	C

Climate Hazard

Temperature Score	E	Bush Fire Score	D

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	220	The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.			212	The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.		
Step								
Fast								
High DER								
Slow								

Storage					
	Suggested Storage for REZ (MW)				
		Depth	Projected		
			2029-30	2034-35	2039-40
Northern SA and Leigh Creek are the only REZs in SA with substantial pumped hydro resources. South Australia does not have any pumped hydro storage projected across any scenario. Despite no projection of wind or solar generation growth, this REZ is favourably located with respect to other REZs and the management of the Mid–North group limit. As a result, this REZ is an ideal candidate for storage and is suggested for storage in all scenarios except for the High DER scenario, (no storage is projected in South Australia for the High DER scenario).	**Central**	**Shallow**	0	150	250
	Step		0	0	0
	Fast		0	0	150
	High DER		0	0	0
	Slow		0	0	200
	Central	**Medium**	0	0	250
	Step		0	0	100
	Fast		0	0	250
	High DER		0	0	0
	Slow		0	0	250

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
The current 275 kV network around Davenport and Cultana can accommodate approximately 1,000 MW.	1,000 MW[A]	C

A. This assumes minor network augmentation and appropriate control schemes will be in place

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations			
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**
Augmentation Option 1[A]: For generation interest around Cultana: • Uprate the existing 275 kV lines between Cultana and Davenport	+200 MW	$35 million[A]	Not identified as being required under any ISP scenario
Augmentation Option 2[B]: • Build a new 275 kV Davenport–Cultana double-circuit line	+1,200 MW	$110 million to $200 million	Not identified as being required under any ISP scenario
Augmentation Option 3[A]: • Build a new 275 kV Davenport–Cultana single-circuit line	+600 MW	$90 million to 170 million	Not identified as being required under any ISP scenario

A. Advised by ElectraNet.
B. Additional augmentation is required in Mid-North when the combination of generation in S3, S5, S6, S7, S8 and S9 >1,000 MW.

Available Fault Level (MVA)

	Scenario	Existing	2029-30	2034-35
Available fault level in this REZ is influenced by development of nearby REZs.	**Central**	At limits[C]	-750	-1,950
	Step	At limits[C]	-1,400	-1,700

C. Shortfalls in this area are managed by directions of synchronous units and constraints to existing VRE generation.

System Strength Remediation Augmentation

Remediation not required with forecast level of VRE in the Central and Step Change scenarios.

S6 – Leigh Creek

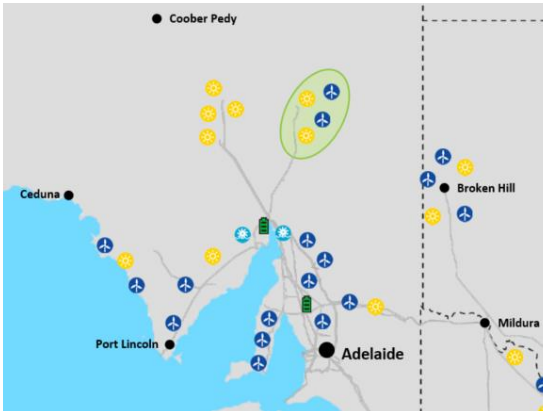
Summary

The Leigh Creek REZ is located between 150 and 350 km north east of Davenport. It has excellent solar resources and good wind resources. There has also been high-level consideration of the potential for geothermal in this REZ.

This REZ is currently supplied with a single 132 kV line that does not have material spare capacity. A possible augmentation could involve extending the 275 kV network from Davenport to this REZ.

The MLF would still decline rapidly with new generation, due to the distance from any major load centre.

This REZ is part of the South Australia group constraint (see section A5.3.4).



REZ Assessment

N/A	Leigh Creek REZ does not have any projected development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	A			B		
Renewable Potential (MW)	6,500			2,400		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	D

Climate Hazard

Temperature Score	D	Bush Fire Score	C

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central Step Fast High DER Slow	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			

Storage

	Suggested Storage for REZ (MW)
Leigh Creek REZ has potential for pumped hydro generation. The network however is weak and cannot accommodate large scale developments without significant transmission augmentation. There is also no VRE projected for Leigh Creek, for these reasons no storage has been suggested.	Leigh Creek has not been suggested for storage under any scenario for the 2020 ISP.

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
Leigh Creek REZ is connected via a single-circuit 132 kV line from Davenport. There is no spare capacity available on this network.	–	F

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

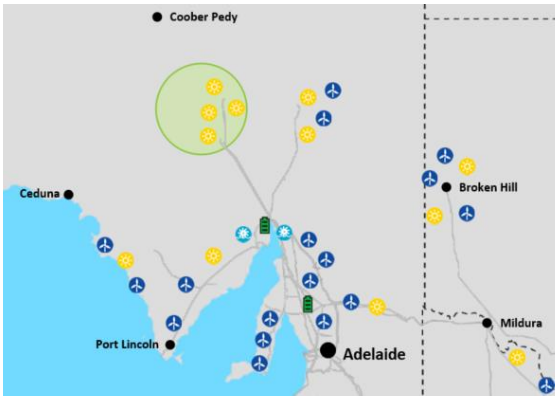
Possible REZ Augmentations			
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**
Augmentation Option 1[A]: • Build a new 275 kV substation at Leigh Creek • Build a new 275 kV Davenport/Wilmington–Leigh Creek double-circuit line	+1,000 MW	$340 million to $630 million	Not identified as being required under any ISP scenario
Augmentation Option 2: • Build a new 275 kV substation at Leigh Creek • Build a new 275 kV Davenport/Wilmington–Leigh Creek single-circuit line	+500 MW	$280 million to $510 million	Not identified as being required under any ISP scenario

A. Additional augmentation is required in Mid-North when the combination of generation in S3, S5, S6, S7, S8 and S9 >1,000 MW.

Available Fault Level (MVA)				
Available fault level in this REZ is influenced by development of nearby REZs. Remediation of S6, S7, S8 and S9 can be addressed by joint solutions.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	At limit	-750	-1,950
	Step	At limit	-700	-1,400

System Strength Remediation Augmentation
Remediation not required with forecast level of VRE in the Central and Step Change scenarios.

S7 – Roxby Downs

Summary	Phase 3 REZ
The Roxby Downs REZ is located a few hundred kilometres north west of Davenport. It has excellent solar resources. The only significant load in the area is the Olympic Dam and Carrapateena mines. This REZ is currently connected with a 132 kV line and privately owned 275 kV line from Davenport. ElectraNet is in the process extending the 275 kV system to develop a new 275/132 kV connection point at Mount Gunson South to service OZ Minerals' new and existing mines in the area. Once new generation exceeds the major size of the load in the area, the MLF in this area is likely to decline rapidly due to the distance from any major load. This REZ also forms part of the South Australia group constraint (see section A5.3.4).	

REZ Assessment

Phase 3 REZ	Roxby Downs REZ has development in phase 3. Transmission augmentation strengthening 275 kV network between Davenport and Para is required to support the VRE projection in the Mid-North REZ and Roxby Downs REZ.

Renewable Resources

Resource	**Solar**			**Wind**		
Resource Quality	A			D		
Renewable Potential (MW)	3,400			–		
Demand Correlation	**2019-20**	**2029-30**	**2039-40**	**2019-20**	**2029-30**	**2039-40**
	F	F	F	C	C	C

Climate Hazard

Temperature Score	E	**Bush Fire Score**	C

Variable Renewable Energy Outlook

	Solar PV (MW)				**Wind (MW)**			
	Existing/ committed	**Projected**			**Existing/ committed**	**Projected**		
		2029-30	**2034-35**	**2039-40**		**2029-30**	**2034-35**	**2039-40**
Central	There is no existing or committed solar generation in this REZ.	0	500	500	There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step		150	150	350				
Fast		850	850	850				
High DER		0	750	750				
Slow		0	0	950				

Storage	
Roxby Downs REZ is not considered to have potential for significant pumped hydro generation. Roxby Downs is projected to have moderate solar generation growth across all ISP scenarios. No storage has been suggested for this REZ, storage has been projected nearby in the Northern SA REZ.	**Suggested Storage for REZ (MW)** Roxby Downs REZ has not been suggested for storage across any scenario in the 2020 ISP.

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
The existing network together with a new 275 kV line between Davenport and Mount Gunson South, has a hosting capacity of 960 MW.	960 MW	E

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations			
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**
Augmentation Option 1: • Build a new 275 kV substation near generation interest in Roxby Downs • Build a new 275 kV Davenport–Roxby Downs double-circuit line	+1,000 MW	$400 million to $740 million	Not identified as being required under any ISP scenario
Augmentation Option 2: Following the above augmentation when the combination of generation in S3, S5, S6, S7, S8 and S9 >1,000 MW the following upgrade is required: • Rebuild Davenport–Brinkworth–Templers West–Para 275 kV line as a high capacity double-circuit line. • Reconfigure the 132 kV network in the mid north region to balance network loading.	+1,000 MW	$420 million to $770 million	Central, Step and Fast (2036-2038)

Available Fault Level (MVA)				
Available fault level in this REZ is influenced by planting of solar PV from the mid-2030s. Remediation of S6, S7, S8 and S9 can be addressed by joint solutions.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	At limit	-750	-1,950
	Step	At limit	-1,400	-1,700

System Strength Remediation Augmentation			
	Description	**Date Required**	**Cost**
Central	Establish 2 x 125 MVAr synchronous condensers.	2030-31	$85 million to $110 million
Step	Establish 2 x 125 MVAr synchronous condensers.	2030-31	$85 million to $110 million

S8 – Eastern Eyre Peninsula

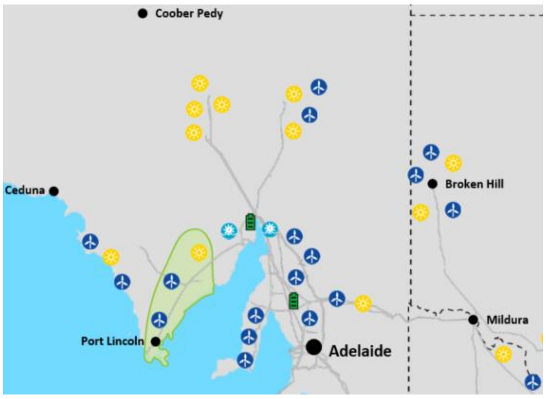
Summary

The Eastern Eyre Peninsula REZ has moderate to good quality wind resources. Wind farms in service include Cathedral Rocks (66 MW) and Mt Millar (70 MW) wind farms. ElectraNet has completed the Eyre Peninsula Electricity Supply RIT–T for transmission development to support this area. The AER has determined that the preferred option satisfies the requirements of the RIT–T.

The REZ is currently supplied by a single 132 kV line extending 250 km south of Cultana. Following the successful conclusion of the Eyre Peninsula Electricity Supply RIT–T in 2019, ElectraNet plans to replace the existing Cultana–Yadnarie–Port Lincoln 132 kV single-circuit line with a new double-circuit 132 kV line built at 275 kV for the Cultana to Yadnarie section.

The MLF is likely to decline rapidly with any additional generation. Even with upgrading the network halfway along the Peninsula to 275 kV and augmenting the remaining 132 kV lines, the MLF does not improve much.

This REZ is part of the South Australia group constraint (see section A5.3.4).



REZ Assessment

N/A	Eastern Eyre Peninsula does not have any projected development.

Renewable Resources

Resource	**Solar**			**Wind**		
Resource Quality	C			C		
Renewable Potential (MW)	5,000			2,300		
Demand Correlation	**2019-20**	**2029-30**	**2039-40**	**2019-20**	**2029-30**	**2039-40**
	F	F	F	C	C	C

Climate Hazard

Temperature Score	D	**Bush Fire Score**	D

Variable Renewable Energy Outlook

	Solar PV (MW)				**Wind (MW)**			
	Existing/ committed	**Projected**			**Existing/ committed**	**Projected**		
		2029-30	**2034-35**	**2039-40**		**2029-30**	**2034-35**	**2039-40**
Central	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				136	The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.		
Step								
Fast								
High DER								
Slow								

Storage	
This REZ is not considered to have potential for significant pumped hydro generation. Since no VRE is projected for this zone, no storage has been suggested for this REZ.	**Suggested Storage for REZ (MW)** Eastern Eyre Peninsula REZ has not been suggested for storage across any scenario in the 2020 ISP.

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
This REZ is connected via the 132 kV network from Cultana to Port Lincoln. The spare hosting capacity includes the committed rebuild of the 132 kV line from Cultana–Yadnarie–Port Lincoln as a double-circuit line.	470 MW	D

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations			
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**
Augmentation Option 1: Operate the Cultana–Yadnarie 132 kV line (built at 275 kV) at 275 kV by: • Establishing a 275 kV substation at Yadnarie • 275/132 kV transformation	+300 MW	$45 million to $85 million	Not identified as being required under any ISP scenario

Available Fault Level (MVA)				
Available fault level in this REZ is influenced by development of nearby REZs. Remediation of S6, S7, S8 and S9 can be addressed by joint solutions.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	At limits[A]	-750	-1,950
	Step	At limits[A]	-750	-1,400

A. Shortfalls in this area are managed by directions of synchronous units and constraints to existing VRE generation.

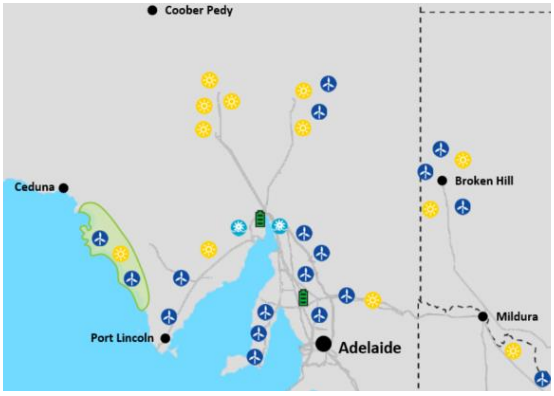
System Strength Remediation Augmentation
Remediation requirements shown for this REZ are due to expansion of VRE in neighbouring REZs, and are met through a joint solution reported in REZ S7.

S9 – Western Eyre Peninsula

Summary

The Western Eyre Peninsula REZ shares the same supply as the Eastern Eyre Peninsula. It has good solar and moderate wind resources. There are no generators currently connected or committed within this REZ.

This REZ is part of the South Australia group constraint (see section A5.3.4).



REZ Assessment

N/A	Western Eyre Peninsula does not have any projected development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	B			C		
Renewable Potential (MW)	4,000			1,500		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	C

Climate Hazard

Temperature Score	D	Bush Fire Score	C

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step								
Fast								
High DER								
Slow								

Storage

	Suggested Storage for REZ (MW)
This REZ is not considered to have potential for significant pumped hydro generation and since no VRE is projected for this zone, no storage has been suggested for this REZ.	Western Eyre Peninsula REZ has not been suggested for storage across any scenario in the 2020 ISP.

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
There is no transmission network built to this REZ.	–	N/A

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations			
Description	**Additional Hosting Capacity**[A]	**Upgrade Cost Estimate**	**ISP Development**
Augmentation Option 1: Establish REZ by establishing 275 kV network from Cultana/Corraberra Hill: • Build a new 275 kV substation at Elliston • Build a new 275 kV Cultana/Corraberra Hill–Elliston double-circuit line	+1,050 MW	$380 million to $700 million	Not identified as being required under any ISP scenario
Augmentation Option 2: Establish the REZ by establishing 275 kV network from Yadnarie: • Build a new 275 kV substation at Elliston • Build a new 275 kV Elliston–Yadnarie single-circuit line	+300-500 MW	$250 million to $460 million[B]	Not identified as being required under any ISP scenario
Augmentation Option 3: Establish REZ by establishing diverse routes from the 275 kV network: • Build a new 275 kV substation at Elliston • Build a new 275 kV Cultana/Corraberra Hill–Elliston single-circuit line • Build a new 275 kV Elliston–Yadnarie single-circuit line	+1,200 MW	$560 million to $1,040 million[B]	Not identified as being required under any ISP scenario

A. Augmentation hosting capacity dependant on generation within Eastern Eyre Peninsula, additional augmentation may be required between Yadnarie and Cultana.
B. Includes the cost for the upgrade of Cultana–Yadnarie 132 kV line to 275 kV.

Available Fault Level (MVA)

Available fault level in this REZ is influenced by development of nearby REZs.

Remediation of S6, S7, S8 and S9 can be addressed by joint solutions.

Scenario	Existing	2029-30	2034-35
Central	At limits[C]	-750	-1,950
Step	At limits[C]	-750	-1,400

C. Shortfalls in this area are managed by directions of synchronous units and constraints to existing VRE generation.

System Strength Remediation Augmentation

Remediation requirements shown for this REZ are due to expansion of VRE in neighbouring REZs, and are met through a joint solution reported in REZ S7.

A5.4.5 Tasmania REZ scorecards

T1 – North East Tasmania

Summary	Phase 1 REZ
The North East Tasmania REZ has one wind farm of 168 MW (Musselroe Wind Farm) in service. After consultation, this REZ has been extended in the 2020 ISP to encompass George Town. A sufficient three phase fault level must be maintained to ensure stable operation of the Basslink HVDC interconnector. In November 2019, AEMO declared a fault level shortfall for Tasmania, including George Town in this shortfall. The fault level at George Town is likely to deteriorate as more inverter-based resources connect within this area.	

REZ Assessment	
Phase 1 REZ	Subject to TRET becoming legislated, the development of VRE in North East Tasmania REZ has been highlighted in phase 1. VRE development utilises the spare network capacity in this REZ and is driven by TRET which is considered in the Step and High DER scenarios. Under the TRET, Tasmania's VRE would be about 150% of its needs by 2030, unless significant new local energy-intensive industry was developed. The surplus would have to be either exported or curtailed.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	D			B		
Renewable Potential (MW)	–			1,400		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	C

Climate Hazard

Temperature Score	A	Bush Fire Score	B

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				168	0	0	0
Step						0	250	250
Fast						0	0	0
High DER						0	250	250
Slow						0	0	0

Storage	
This REZ is not considered to have potential for significant pumped hydro generation. As a result, no storage has been suggested in this REZ, as only deep storage was projected for Tasmania and only under the Step Change scenario.	**Suggested Storage for REZ (MW)** North East Tasmania REZ has not been suggested for storage across any scenario in the 2020 ISP.

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
Approximately 250 MW of hosting capacity remains in and around the 220 kV network at George Town.	250 MW	A[A]

A. Loss factor robustness has been calculated at the 220 kV connection near George Town as there is currently no capacity left of the 110 kV network.

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations			
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**
Augmentation Option 1: To increase capacity within the North East Tasmania REZ the following is proposed: • Establish a new 220 kV substation in an area with generation interest to the north east • Connect the new substation to George Town with a double-circuit 220 kV line	+800 MW	$130 million to $230 million	Not identified as being required under any ISP scenario

Available Fault Level (MVA)				
Available fault level in this REZ is influenced by development of nearby REZs. Remediation of T1, T2 and T3 can be addressed by joint solution.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	At limits[A]	350	-350
	Step	At limits[A]	700	-400

A. Shortfalls in this area are managed by system strength services procured by TasNetworks.

System Strength Remediation Augmentation
Remediation requirements shown for this REZ are due to expansion of VRE in neighbouring REZs, and are met through a joint solution reported in REZ T3.

T2 – North West Tasmania

Summary	Phase 1 REZ

Summary

The North West REZ covers the north west and west coast of Tasmania. With good quality wind resources, a significant portion of the projected new wind development in Tasmania is located within the North West REZ.

In this ISP, this REZ has been extended to encompass Sheffield. The REZ has two load centres, one at Burnie and one at Sheffield. Additional to the good quality wind resources, this REZ is a good location for pumped hydro development.

The North West Tasmania REZ is a favourable connection point for Marinus Link, with the connection point proposed near Burnie.

Phase 1 REZ

REZ Assessment	
Phase 1	Subject to TRET becoming legislated, the VRE development in North West Tasmania REZ has been highlighted in phase 1. VRE development in this REZ, utilising the spare network capacity, is driven by TRET which is considered in the Step Change and high DER scenarios. Under the TRET, Tasmania's VRE would be about 150% of its needs by 2030, unless significant new local energy-intensive industry was developed. The surplus would have to be either exported or constrained off.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	E			A		
Renewable Potential (MW)	150			5,000		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	C

Climate Hazard

Temperature Score	A	Bush Fire Score	A

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ.	0	0	0	252	The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.		
Step		150	150	150				
Fast		0	0	0				
High DER		150	150	150				
Slow		0	0	0				

Storage					
North West Tasmania REZ has high potential to host pumped hydro storage. Hydro Tasmania has announced the most promising sites for the development of pumped hydro. All three sites are located within the North West REZ, two connecting around Sheffield and the third around Farrell. The only storage projected for Tasmania is deep storage under the Step Change scenario, of which all is assumed to connect within this REZ.	**Suggested Storage for REZ (MW)**				
		Depth	**Projected**		
			2029-30	**2034-35**	**2039-40**
	Central	**Deep**	0	0	0
	Step		0	200	350
	Fast		0	0	0
	High DER		0	0	0
	Slow		0	0	0

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
There is currently no spare capacity available on the 110 kV circuits west of Burnie. There is still approximately 340 MW of spare capacity on the 220 kV network from Sheffield.	340 MW	A (Solar) / D (Wind)[A]

A. The loss factor robustness for this REZ has two values due to the different connection points for wind and solar. Connection of solar is assumed around Sheffield, and wind around Farrell.

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
Marinus Link Stage 1 (Early Works): A new 750 MW HVDC interconnector between the Burnie area in Tasmania and the Latrobe Valley in Victoria. Marinus Link Stage 1 does not increase the REZ hosting capacity within this REZ, as it does not extend the current 220 kV transmission network towards Hampshire or Montague	-	-
Marinus Link Stage 2 (Early Works): A new second 750 MW HVDC interconnector between the Burnie area in Tasmania and the Latrobe Valley in Victoria.	+600 MW	A (Solar) / D (Wind)[B]

B. The loss factor robustness for this REZ has two values due to the different connection points for wind and solar. Connection of solar is assumed around Sheffield, and wind around Farrell.

Possible REZ Augmentations			
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**
Augmentation Option 1: To allow for the connection of generation in the Hampshire area, the following is proposed: • Rebuild Burnie–Sheffield 220 kV line as a double-circuit • Establish a new 220 kV substation at Hampshire • A new double-circuit Burnie–Hampshire 220 kV line	+800 MW	$150 million to $280 million	This is built as part of Marinus Link in Step Change and High DER scenarios

Augmentation Option 2: To allow for the connection of generation in the West Montague area, the following is proposed: • Rebuild Burnie–Sheffield 220 kV line as a double-circuit • Establish a new 220 kV substation at West Montague • A new double-circuit Burnie–West Montague 220 kV line	+800 MW	$210 million to $400 million	Not identified as being required under any ISP scenario

Available Fault Level (MVA)

	Scenario	**Existing**	**2029-30**	**2034-35**
Available fault level in this REZ is influenced by development of nearby REZs. Remediation of T1, T2 and T3 can be addressed by joint solution.	**Central**	At limits[C]	-50	-750
	Step	At limits[C]	50	-1,800

C. Shortfalls in this area are managed by system strength services procured by TasNetworks.

System Strength Remediation Augmentation

Remediation requirements for this REZ are due to expansion of VRE in neighbouring REZs, and are met through a joint solution reported in REZ T3.

T3 – Tasmania Midlands

Summary

The Tasmania Midlands REZ has one of the best wind capacities within the NEM and has good pumped hydro resources. It is located close to major load centres at Hobart.

The double-circuit Palmerston–Waddamana–Liapootah and Waddamana–Lindisfarne 220 kV lines pass through this REZ. Cattle Hill wind farm (144 MW) is the only committed variable generation within this zone.

Additional to transmission network limitations within Tasmania, as more generation connects, export to the mainland becomes a limiting factor.

Phase 1 and phase 2

REZ Assessment

Phase 1 and phase 2	Subject to TRET becoming legislated, Midlands is identified for development in phase 1. VRE development in this REZ exceeds the existing spare network capacity before 2030. Under the TRET, Tasmania's VRE would be about 150% of its needs by 2030, unless significant new local energy-intensive industry was developed. The surplus would have to be either exported or curtailed. The development of this REZ in phase 2 is further supported by Marinus Link which increases the hosting capacity of this REZ by 540 MW in each stage. VRE development occurs in all scenarios including those without TRET, except for the Slow Change scenario.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	E			A		
Renewable Potential (MW)	–			3,400		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	C

Climate Hazard

Temperature Score	A	Bush Fire Score	D

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				144	50	250	1,200
Step						1,150	2,550	2,550
Fast						500	1,000	1,200
High DER						850	1,250	1,900
Slow						0	0	0

Storage	
The Tasmania Midlands REZ has potential to host pumped hydro storage. Hydro Tasmania has not included any pumped hydro options in the Midlands REZ in its latest review of promising pumped hydro sites. The only storage projected for Tasmania is deep storage under the Step Change scenario which is assumed to connect in the North West Tasmania REZ.	**Suggested Storage for REZ (MW)** Tasmania Midlands REZ has not been suggested for storage across any scenario in the 2020 ISP.

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
The existing 220 kV network which extends from Palmerston to Waddamana to Liapootah and from Waddamana to Lindisfarne has a hosting capacity of approximately 480 MW.	480 MW	A

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
Marinus Link Stage 1 (Early Works): A new 750 MW HVDC interconnector between the Burnie area in Tasmania and the Latrobe Valley in Victoria.	+540 MW	A
Marinus Link Stage 2 (Early Works): A new second 750 MW HVDC interconnector between the Burnie area in Tasmania and the Latrobe Valley in Victoria.	-	A

Possible REZ Augmentations

Description	Additional Hosting Capacity	Upgrade Cost Estimate	ISP Development	Loss Factor Robustness
Augmentation Option 1: To increase capacity within the Tasmania Midlands REZ the following is proposed: • A new double-circuit Palmerston–Sheffield 220 kV line	+800 MW	$110 million to $200 million	Built as part of Marinus Link in Central and Fast Change. Brough forward Fast Change and High DER (2027-28/ 2028-29)	A
Augmentation Option 2: To increase capacity to generation connection over and above the build of Palmerston-Sheffield 220 kV line: • A new double-circuit Palmerston–Waddamana 220 kV line	-	$60 million to $120 million	Depends on the location of generation interest within this zone	-

Available Fault Level (MVA)

Description	Scenario	Existing	2029-30	2034-35
Available fault level in this REZ is influenced by planting of wind from the late 2020s. Remediation of T1, T2 and T3 can be addressed by joint solution.	**Central**	At limits[A]	-150	-800
	Step	At limits[A]	150	-3,750

A. Shortfalls in this area are managed by system strength services procured by TasNetworks.

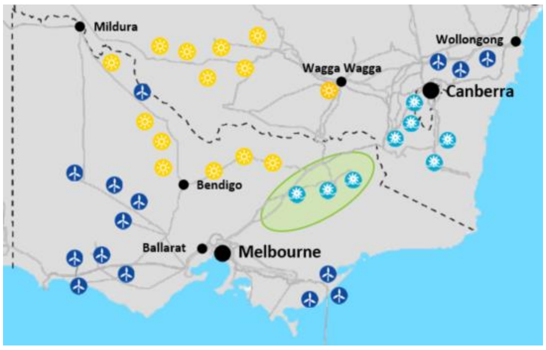
System Strength Remediation Augmentation			
	Description	**Date Required**	**Cost**
Central	Establish 1 x 125 MVAr synchronous condenser.	2030-31	$40 million to $55 million
Step	Establish 4 x 125 MVAr synchronous condensers.	2030-31	$175 million to $220 million
	Establish additional 3 x 125 MVAr synchronous condensers.	2032-33	$130 million to $165 million

A5.4.6 Victoria REZ scorecards

V1 – Ovens Murray

Summary

The Ovens Murray REZ has been identified as a candidate REZ due to this REZ having good pumped hydro resources. There is currently 770 MW of installed hydro generation within this zone. Good potential pumped hydro locations within this zone and the proximity of this REZ to good solar resources, makes Ovens Murray REZ a good candidate for meeting some of the pumped hydro needs in Victoria.



REZ Assessment

N/A	Ovens Murray REZ does not have any projected VRE development. It has not been highlighted for any REZ phase development.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	D			B		
Renewable Potential (MW)	–			–		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	C	C	C

Climate Hazard

Temperature Score	B	Bush Fire Score	E

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step								
Fast								
High DER								
Slow								

Storage					
Ovens Murray has been highlighted as having significant potential for pumped hydro generation within Victoria. Ovens Murray is connected to the Victoria load centre via two 330 kV lines from Dederang to South Morang. It also lies on the interconnector flow path between New South Wales and Victoria. No storage has been projected in Victoria in the Central, Fast Change and the High VRE scenarios before 2040. Storage, due to this zone's pumped hydro potential, has been suggested for the Step Change scenario. Ovens Murray is close to both the Melbourne load centre and the solar generation projected for Central North Victoria and has thus been suggested for storage under this scenario.	**Suggested Storage for REZ (MW)**				
		Depth	**Projected**		
			2029-30	**2034-35**	**2039-40**
	Central	**Medium**	0	0	0
	Step		100	100	300
	Fast		0	0	0
	High DER		0	0	0
	Slow		0	0	0

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
Ovens Murray REZ lies along the path of the existing Victoria - New South Wales interconnector.	300 MW	N/A

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations on the optimal development path with this REZ.		

Available Fault Level (MVA)				
Available fault level in this REZ is influenced by pumped hydro in the step from the late 2020s.	**Scenario**	**Existing**	**2029-30**	**2034-35**
	Central	900	950	950
	Step	900	2,050	2,150

System Strength Remediation Augmentation
Remediation not required with forecast level of VRE in the Central and Step Change scenarios.

V2 – Murray River

Summary	Phase 2 REZ
The Murray River REZ has solar resources. Despite being remote and electrically weak, this REZ has attracted significant investment in solar generation with more than 640 MW of generation installed and committed. The existing 220 kV network between Bendigo and Red Cliffs is electrically weak, with MLFs declining sharply as new generators connect. Voltage stability and thermal limits currently restrict the output of generators within this REZ. The VNI West project is recommended to upgrade transfer capability between Victoria and New South Wales via either Kerang or Shepparton. The development of VNI West via Kerang would significantly increase the ability for renewable generation to connect in this zone. The proposed new interconnector between New South Wales and South Australia (Project EnergyConnect) will facilitate a small improvement in capacity within Murray River REZ.	 Note: In the 2018 ISP, the Murray River candidate REZ spanned over North West Victoria and South West New South Wales towards Darlington Point. In the 2020 ISP, the 2018 Murray River candidate REZ has been split into two REZs, one in New South Wales and one in Victoria.

REZ Assessment

Phase 2 REZ	Murray River REZ has development in phase 2. Phase 2 VRE development is supported by Project EnergyConnect, an actionable ISP project. Project EnergyConnect facilitates a small increase in generation hosting capacity in the Red Cliffs area. VNI West (Kerang route) will further support VRE development within this zone.

Renewable Resources

Resource	**Solar**			**Wind**		
Resource Quality	C			D		
Renewable Potential (MW)	4,700			–		
Demand Correlation	**2019-20**	**2029-30**	**2039-40**	**2019-20**	**2029-30**	**2039-40**
	F	F	F	D	C	C

Climate Hazard

Temperature Score	E	**Bush Fire Score**	C

Variable Renewable Energy Outlook

	Solar PV (MW)				**Wind (MW)**			
	Existing/ committed	**Projected**			**Existing/ committed**	**Projected**		
		2029-30	**2034-35**	**2039-40**		**2029-30**	**2034-35**	**2039-40**
Central	641	400	400	400	There is no existing or committed wind generation in this REZ. The modelling outcomes, for all scenarios, did not project additional wind generation for this REZ.			
Step		400	600	600				
Fast		400	400	400				
High DER		400	400	400				
Slow		400	400	400				

<table>
<tr><th colspan="6">Storage</th></tr>
<tr><td rowspan="13">Murray River REZ is not considered to have potential for significant pumped hydro generation. Due to this lack of potential pumped hydro generation, shallow and medium storage has been suggested for this REZ.</td><td colspan="5">Suggested Storage for REZ (MW)</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">Depth</td><td colspan="3">Projected</td></tr>
<tr><td>2029-30</td><td>2034-35</td><td>2039-40</td></tr>
<tr><td>Central</td><td rowspan="5">Shallow</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Step</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fast</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>High DER</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Slow</td><td>0</td><td>100</td><td>100</td></tr>
<tr><td>Central</td><td rowspan="5">Medium</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Step</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fast</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>High DER</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Slow</td><td>0</td><td>0</td><td>150</td></tr>
</table>

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
Murray River REZ, which has no additional hosting capacity, is connected via a weak 220 kV line from Bendigo to Red Cliffs via Kerang and Wemen.	–	E

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
Project EnergyConnect (Actionable ISP project): A new 330 kV interconnector between Robertstown in South Australia and Wagga Wagga in New South Wales, via Buronga.	+380 MW	C
VNI West (Actionable ISP Project): A new 500 kV interconnector between Victoria and NSW. There are multiple credible corridors for VNI West of which one option, via Kerang, opens capacity within this REZ (see Appendix 3).	+2,000 MW	-

Possible REZ Augmentations			
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**

Augmentation Option 1: Extend Murray River REZ by augmenting the 220 kV network: • Build a new double-circuit 220 kV Kerang–Red Cliffs 220 kV line, via Wemen • Build a new double-circuit Bendigo–Kerang 220 kV line • Build a new double-circuit Bendigo–Ballarat[A] 220 kV line • A new Ballarat[A] 500/220 kV 1,000 MVA transformer	+1,200 MW	$600 million to $1,120 million	Not identified as being required under any ISP scenario
Augmentation Option 2: Extend Murray River REZ if VNI West (Shepparton route) is developed and interest for Murray River REZ is around Kerang: • Establish a new 500 kV substation at Bendigo • Turn both Ballarat[A]–Shepparton 500 kV lines into Bendigo • Build a double-circuit Bendigo–Kerang 500 kV line • Establish 2 x 500/220 kV transformers at Kerang	+1,500 – 2,000 MW[B]	$360 million to $680 million	Not identified as being required under any ISP scenario

A. A new terminal substation north of Ballarat which will be established through Western Victoria Transmission Network Project
B. Augmentation hosting capacity dependant on generation within Western Victoria, Central North Victoria, and South West Victoria.

Available Fault Level (MVA)

	Scenario	Existing	2029-30	2034-35
Available fault level in this REZ is influenced by planting of solar PV from the late 2020s.	**Central**	At limit[B]	200	-300
	Step	At limit[B]	-250	-1,650

C. Existing system strength limits in this area already requiring remediation by connecting generation. Shortfall already declared for Red Cliffs.

System Strength Remediation Augmentation

	Description	Date Required	Cost
Central	Remediation not required with forecast level of VRE in the Central scenario.	-	-
Step	Establish 1 x 250 MVAr synchronous condenser.	2033-34	$45 million to $60 million

V3 – Western Victoria

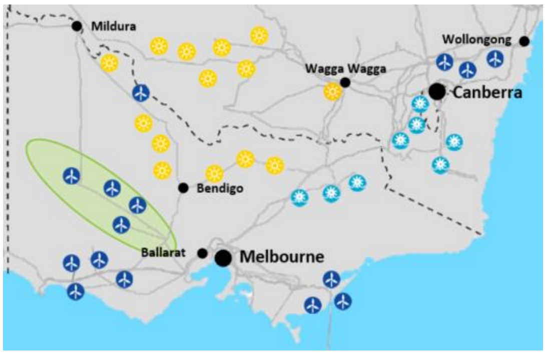
Summary

The Western Victoria REZ has good to excellent quality wind resources. The existing and committed renewable generation within this REZ exceeds 1 GW, all of which is from wind generation. The current network is constrained and cannot support any further connection of renewable generation without transmission augmentation.

The Western Victoria Transmission Network Project is a committed ISP project, with the preferred option to expand generation within this zone as follows:

- A new substation north of Ballarat
- A new 220 kV double-circuit line from Bulgana to the new substation north of Ballarat (Via Waubra)
- A new 500 kV double-circuit line from a new substation north of Ballarat to Sydenham
- 2 x 500/220 kV 1,000 MVA transformers at the new substation north of Ballarat

Phase 1 and phase 2 REZ



REZ Assessment

Phase 1 and phase 2 REZ	This REZ has development in phase 1 and phase 2. Early development of generation in Western Victoria is supported by the committed Western Victoria Transmission Network Project. The phase 1 development is driven in this REZ to help meet VRET. Phase 2 development is supported by VNI West.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	D			B		
Renewable Potential (MW)	400			2,800		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	D	C	C

Climate Hazard

Temperature Score	D	Bush Fire Score	D

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ.	100	100	400	1,631	700	700	850
Step		0	400	400		700	700	1,050
Fast		0	0	400		700	700	1,050
High DER		0	0	0		450	450	450
Slow		0	0	0		450	450	450

Storage					
	Suggested Storage for REZ (MW)				
		Depth	Projected		
			2029-30	2034-35	2039-40
Western Victoria REZ is not considered to have potential for significant pumped hydro generation. Due to this lack of potential pumped hydro generation, shallow and medium storage has been recommended for this REZ.	**Central**	**Shallow**	0	0	0
	Step		0	0	0
	Fast		0	0	0
	High DER		0	0	0
	Slow		0	100	100
	Central	**Medium**	0	0	0
	Step		0	0	0
	Fast		0	0	0
	High DER		0	0	0
	Slow		0	0	150

Existing Network Capability		
Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
The hosting capacity within Western Victoria REZ will be approximately 450 MW after completion of the committed Western Victoria Transmission Network Project.	450 MW	A

Associated Interconnector Augmentations		
Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
VNI West (Actionable ISP Project): A new 500 kV interconnector between Victoria and NSW. There are multiple credible corridors for VNI West of which two options, one via Kerang and one via Shepparton, increases capacity within this REZ. See Appendix 3 for more information.	+1,000 MW	A

Possible REZ Augmentations			
Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**
Augmentation Option 1: Extend Western Victoria REZ by augmenting the 500 kV network: • Build a new single-circuit 500 kV line from Tarrone/Mortlake to the new 500 kV substation north of Ballarat[A]. • Build new 500/132 kV substations between Tarrone/Mortlake and the Ballarat area. • 500/132 kV transformation	1,500 MW	$490 million to $920 million	Not identified as being required under any ISP scenario

Augmentation Option 2: Extend Western Victoria REZ by augmenting the 220 kV network: • Build a new double-circuit 220 kV line from new substation North of Ballarat[A] to Bulgana turning one circuit into Ararat and Crowlands • Build new single-circuit 220 kV line between the existing Ballarat substation and the new substation north of Ballarat[A]. • Install a series reactor on the Crowlands–Ararat–Ballarat 220 kV line • 500/220 kV transformer at the new substation north of Ballarat[A]	+1,000 MW	$170 million to $320 million	Not identified as being required under any ISP scenario

A. A new terminal substation north of Ballarat which will be established through Western Victoria Transmission Network Project

Available Fault Level (MVA)

	Scenario	Existing	2029-30	2034-35
Available fault level in this REZ is influenced by planting of wind from the late 2020s.	**Central**	At limit[B]	-1,350	-250
	Step	At limit[B]	-250	-1,650

B. Existing system strength limits in this area are already requiring remediation by connecting generation. Shortfall already declared for Red Cliffs

System Strength Remediation Augmentation

Description		**Date Required**	**Cost**
Central	Establish 1 x 250 MVAr synchronous condenser.	2025-26	$45 million to $60 million
Step	Establish 1 x 250 MVAr synchronous condenser.	2027-28	$45 million to $60 million

V4 – South West Victoria

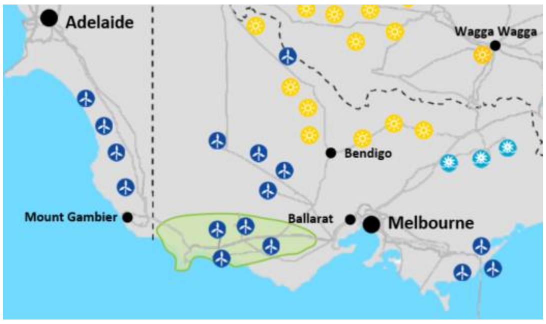
Summary

The South West Victoria REZ has moderate to good quality wind resource in close proximity to the 500 kV and the 220 kV networks in the area.

Currently the 220 kV network is congested, however there is still approximately 750 MW of hosting capacity remaining on the 500 kV network.

There are several large wind farms already in service including Macarthur (420 MW) and Portland (149 MW). The total committed and in service wind generation in the area exceeds 1.7 GW.

Phase 1 REZ



REZ Assessment	
Phase 1 REZ	South West Victoria REZ has development in phase 1. The development in this REZ in phase 1 uses the existing network capacity to help meet the VRET.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	E			C		
Renewable Potential (MW)	–			3,900		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	E	F	F	C	C	C

Climate Hazard

Temperature Score	C	Bush Fire Score	D

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				1,739	750	750	750
Step						750	850	2,600
Fast						300	300	1,000
High DER						750	750	750
Slow						750	750	750

Storage

<table>
<tr><td rowspan="13">The South West Victoria REZ is not considered to have potential for significant pumped hydro generation. Due to this lack of potential pumped hydro generation, shallow and medium storage has been suggested for this REZ.</td><td colspan="5">Suggested Storage for REZ (MW)</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">Depth</td><td colspan="3">Projected</td></tr>
<tr><td>2029-30</td><td>2034-35</td><td>2039-40</td></tr>
<tr><td>Central</td><td rowspan="5">Shallow</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Step</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fast</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>High DER</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Slow</td><td>0</td><td>100</td><td>100</td></tr>
<tr><td>Central</td><td rowspan="5">Medium</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Step</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Fast</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>High DER</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Slow</td><td>0</td><td>0</td><td>150</td></tr>
</table>

Existing Network Capability

Description	**Approximate Existing Hosting Capacity**	**Loss Factor Robustness**
The current hosting capacity of 750 MW within this REZ is on the 500 kV network between Moorabool and Heywood. The 220 kV and 66 kV network between Moorabool and Terang is currently congested.	750 MW	A[A]

A. Loss factor robustness has been calculated on the 500 kV network.

Associated Interconnector Augmentations

Description	**Additional Hosting Capacity**	**Loss Factor Robustness**
There are no associated interconnector augmentations with this REZ.		

Possible REZ Augmentations

Description	**Additional Hosting Capacity**	**Upgrade Cost Estimate**	**ISP Development**	**Loss Factor Robustness**
Augmentation Option 1: Extend South West Victoria REZ by augmenting the 500 kV network: • Build a new 500 kV Mortlake–Moorabool–Sydenham single-circuit line	+3,000 MW	\$360 million to \$660 million	Not identified as being required under any ISP scenario	-
Augmentation Option 2: Extend South West Victoria REZ by augmenting the 500 kV network to a new substation north of Ballarat: • Build a new 500 kV single-circuit line from Mortlake to a new substation north of Ballarat • Turn Tyrone – Hunter Gully into Mortlake substation	+2,500 MW[B]	\$270 million to \$510 million	Step (2036-37), Fast (2040-41)	-

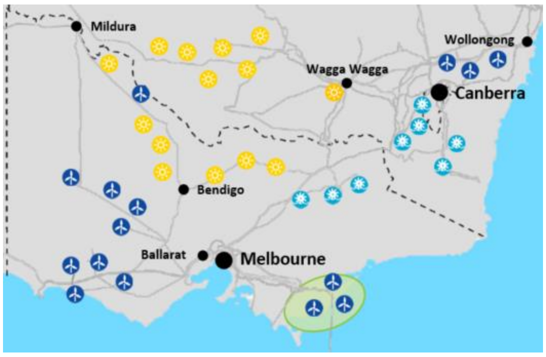
B. Additional hosting capacity depend on the development of VNI West and generation development within Western Victoria.					
Available Fault Level (MVA)					
Available fault level in this REZ is influenced by planting of wind from the late 2020s.		**Scenario**	**Existing**	**2029-30**	**2034-35**
		Central	At limits	-1,900	-1,500
		Step	At limits	-250	-2,550
System Strength Remediation Augmentation					
	Description		**Date Required**	**Cost**	
Central	Establish 1 x 250 MVAr synchronous condenser.		2026-27	$45 million to $60 million	
Step	Establish 1 x 250 MVAr synchronous condenser.		2030-31	$45 million to $60 million	

V5 – Gippsland

Summary

Two wind farms are in service in the Gippsland REZ: Bald Hill Wind Farm (106 MW) and Wonthaggi Wind Farm (12 MW). There is currently significant wind generation interest in this area, including a large offshore wind farm of 2,000 MW.

Due to the strong network in this REZ (with multiple 500kV and 220kV lines from Latrobe Valley to Melbourne designed to transport energy from major Victorian brown coal power stations), significant generation can be accommodated with the retirements of coal fired generation in this area.



REZ Assessment

N/A	Wind development is projected in Gippsland REZ if VNI West is not developed by 2030. Development in this REZ could makes use of existing network capacity to help meet the VRET.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	D			D (on–shore) B (off–shore)		
Renewable Potential (MW)	–			2,000 (on–shore) 4,000 (off–shore)		
Demand Correlation	**2019-20**	**2029-30**	**2039-40**	**2019-20**	**2029-30**	**2039-40**
	E	F	F	C	C	C

Climate Hazard

Temperature Score	C	**Bush Fire Score**	D

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	**Projected**			**Existing/ committed**	**Projected**		
		2029-30	**2034-35**	**2039-40**		**2029-30**	**2034-35**	**2039-40**
Central	There is no existing or committed solar generation in this REZ. The modelling outcomes, for all scenarios, did not project additional solar generation for this REZ.				119	650	650	650
Step						50	50	1,150
Fast						0	0	0
High DER						200	200	200
Slow						900	900	900

Storage

Gippsland REZ has a strong 500 kV network connecting coal fired power stations to the Melbourne load centre as well as interconnection to Tasmania via Basslink. Due to the high network capacity, Gippsland REZ is a good candidate for storage.

Storage has been projected in this REZ for the Step Change and Slow Change scenario.

Suggested Storage for REZ (MW)				
	Depth	Projected		
		2029-30	2034-35	2039-40
Central	**Shallow**	0	0	0
Step		0	0	0
Fast		0	0	0
High DER		0	0	0
Slow		0	100	100
Central	**Medium**	0	0	0
Step		100	100	550
Fast		0	0	0
High DER		0	0	0
Slow		0	0	150

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
There is significant 500 kV and 220 kV network connecting the Gippsland REZ to the Melbourne load centre.	2,000 MW	A[A]

A. Loss factor robustness has been projected for connection at 500 kV.

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
There are no associated interconnector augmentations with this REZ.		

Available Fault Level (MVA)

Available fault level in this REZ is influenced by planting of wind from the late 2020s.

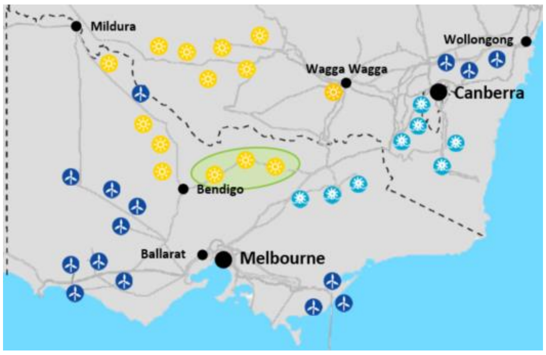
Pumped hydro in the step is expected to form part of the system strength solution for this REZ.

Scenario	Existing	2029-30	2034-35
Central	4,850	2,950	3,850
Step	4,850	5,200	1,950

System Strength Remediation Augmentation

Remediation not required with forecast level of VRE in the Central and Step Change scenarios.

V6 – Central North Victoria

Summary	Phase 1 and phase 2
The Central North Victoria REZ, after careful assessment and consultation, was included in the 2020 ISP as a new REZ candidate. This REZ has moderate quality wind and solar resources. In addition to the currently in service and committed solar farms, Numurkah (100 MW) and Winton Solar Farm (85 MW), the solar generation applications exceed 200 MW whilst the enquiries within this zone exceeds 2.5 GW. The VNI West project is recommended to upgrade transfer capability between Victoria and New South Wales via either Kerang or Shepparton. The development of VNI West via Shepparton would significantly increase the ability for renewable generation to connect in this zone.	

REZ Assessment	
Phase 1 and phase 2	Central North Victoria REZ has development in phase 1 and phase 2. The development in this REZ in phase 1 uses the existing network capacity to help meet the VRET. VNI West (Shepparton route) supports the development of wind and solar within this region beyond the existing hosting capacity.

Renewable Resources

Resource	Solar			Wind		
Resource Quality	C			D		
Renewable Potential (MW)	1,900			1,600		
Demand Correlation	2019-20	2029-30	2039-40	2019-20	2029-30	2039-40
	F	F	F	D	D	D

Climate Hazard

Temperature Score	D	Bush Fire Score	D

Variable Renewable Energy Outlook

	Solar PV (MW)				Wind (MW)			
	Existing/ committed	Projected			Existing/ committed	Projected		
		2029-30	2034-35	2039-40		2029-30	2034-35	2039-40
Central	185	400	400	1,200	There is no existing or committed wind generation in this REZ.	400	400	400
Step		400	400	1,900		400	400	650
Fast		100	100	750		400	400	400
High DER		200	200	200		400	400	400
Slow		300	300	300		0	0	0

Storage

			Suggested Storage for REZ (MW)		
		Depth	Projected		
			2029-30	2034-35	2039-40
Central North Victoria REZ is not considered to have potential for significant pumped hydro generation. Due to the lack of potential pumped hydro generation, shallow and medium storage has been suggested for this REZ.	**Central**	**Shallow**	0	0	0
	Step		0	0	0
	Fast		0	0	0
	High DER		0	0	0
	Slow		0	100	100
	Central	**Medium**	0	0	0
	Step		0	0	0
	Fast		0	0	0
	High DER		0	0	0
	Slow		0	0	150

Existing Network Capability

Description	Approximate Existing Hosting Capacity	Loss Factor Robustness
The current hosting capacity of the 220 kV network between Dederang–Glenrowan–Shepparton–Bendigo is approximately 800 MW.	800 MW	D

Associated Interconnector Augmentations

Description	Additional Hosting Capacity	Loss Factor Robustness
VNI West (of which early works are actionable): A new 500 kV interconnector from a substation north of Ballarat in Victoria to Wagga Wagga in New South Wales, via Shepparton.	+2,000 MW[A]	A

A. Only if VNI West traverses through Shepparton.

Possible REZ Augmentations

Description	Additional Hosting Capacity	Upgrade Cost Estimate	ISP Development
Augmentation Option 1 (If built before VNI West): Extend Central North Victoria by augmenting the 500 kV network: • Build a new 500 kV substation near Shepparton • Build a new 500 kV double-circuit line from a new substation north of Ballarat to Shepparton • Install 2 x 500/220kV transformers at Shepparton	+1,700 MW	$490 million to $900 million	Not identified as required under any ISP scenario
Augmentation Option 2: Extend Central North Victoria with additional 220 kV lines:	+ 600 MW	$270 million to $500 million	Not identified as required under any ISP scenario

<table>
<tr><td colspan="3">

- A new double-circuit 220 kV line from Bendigo to a new substation north of Ballarat.
- A new double-circuit Bendigo–Shepparton 220 kV line

</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">

Augmentation Option 3:

Extend Central North Victoria with additional 220 kV lines:

- A new double-circuit 220 kV line from Bendigo to a new substation north of Ballarat
- A new double-circuit Bendigo–Shepparton–Glenrowan 220 kV line

</td><td>+800 MW</td><td>$390 million to $730 million</td><td>Not identified as required under any ISP scenario</td></tr>
<tr><td colspan="6">Available Fault Level (MVA)</td></tr>
<tr><td colspan="2" rowspan="3">Available fault level in this REZ is influenced by planting of wind from the late 2020s.</td><td>Scenario</td><td>Existing</td><td>2029-30</td><td>2034-35</td></tr>
<tr><td>Central</td><td>250</td><td>-500</td><td>-500</td></tr>
<tr><td>Step</td><td>250</td><td>950</td><td>-500</td></tr>
<tr><td colspan="6">System Strength Remediation Augmentation</td></tr>
<tr><td></td><td colspan="2">Description</td><td>Date Required</td><td colspan="2">Cost</td></tr>
<tr><td>Central</td><td colspan="2">Establish 1 x 125 MVAr synchronous condenser.</td><td>2028-29</td><td colspan="2">$40 million to $55 million</td></tr>
<tr><td>Step</td><td colspan="2">Establish 1 x 125 MVAr synchronous condenser.</td><td>2030-31</td><td colspan="2">$40 million to $55 million</td></tr>
</table>