Central-West Orana REZ Transmission Link Non-Network Options

May 2021

Assessment of Submissions

Important notice

PURPOSE

AEMO publishes the Assessment of Non-Network Submissions pursuant to clause 5.22.12 of the National Electricity Rules.

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VERSION CONTROL

Version	Release date	Changes
1	14 May 2021	

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1. Background

The Central-West Orana Renewable Energy Zone (REZ) is highlighted in the New South Wales State Government's Electricity Strategy for development as the first pilot REZ in New South Wales. The New South Wales State Government has stated in the strategy that it will support the transmission upgrades for a pilot 3,000 megawatt (MW) REZ in the Central West REZ by the mid-2020s[1], and the Australian Commonwealth Government has committed to financially support the infrastructure via the Grid Reliability Fund or the Australian Renewable Energy Agency (ARENA)[2].

This Central-West Orana REZ Transmission Link was identified as an actionable project in the 2020 Integrated System Plan (ISP). AEMO therefore requested submissions on non-network options for the project[3].

A non-network option is a solution or service that does not involve investing in transmission system apparatus, such as transmission lines or substations. A non-network option may partially or wholly meet the identified need.

1.1 Requirements for assessment

Where the ISP identifies an actionable project, the National Electricity Rules (NER) require AEMO to request submissions for non-network option proposals[4]. AEMO and the relevant Transmission Network Service Provider (TNSP) must provide a preliminary assessment on each non-network proposal as to whether it meets or is reasonably likely to meet the relevant identified need. If the assessment concludes this is the case, the TNSP must assess the non-network proposal in its Project Assessment Draft Report (PADR).

1.2 Scope of assessment

Non-network option proposals are assessed on whether they are reasonably likely to meet the identified. The non-network option could completely meet the identified need or may be part of a hybrid solution with reduced transmission network investment or additional market benefit.

Identified need

The identified need[5] is to increase the capability of the transmission network to enable the connection of expected generation in the Central-West Orana REZ by:

- Increasing the transfer capacity between expected generation in the Central-West Orana REZ and the existing 500 kilovolt (kV) transmission network between Bayswater, Wollar and Mount Piper; and
- Ensuring sufficient resilience to avoid material reductions in transfer capacity during an outage of a transmission element,

or as otherwise consistent with the New South Wales State Government's Central-West Orana REZ program, including any change of law.

[1] New South Wales State Government. New South Wales Electricity Strategy, at https://energy.nsw.gov.au/government-andregulation/electricity-strategy.

[2] The Commonwealth of Australia, The State of NSW. Memorandum of Understanding – NSW Energy Package, at https://energy.nsw.gov.au/media/2001/download. Commonwealth underwriting will only be called upon if there remains a gap between the cost-benefit requirements of the RIT-T and the cost of developing the transmission upgrades, less funds raised from generators through the auction process and any funding received from ARENA.

[3] Call for Non-Network Options – Central-West Orana REZ Transmission Link, at https://aemo.com.au/-/media/files/major-publications/isp/2020/consultation-document.pdf?la=en.

[4] National Electricity Rules, section 5.22.12, available at https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules/current.

[5] 2020 ISP, Table 12, https://aemo.com.au/-/media/files/major-publications/isp/2020/final-2020-integrated-system-plan.pdf?la=en and 2020 ISP Aopendix 3 Network Investments, Section A3.4.4, at https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix--3.pdf?la=en.

Assessment methodology

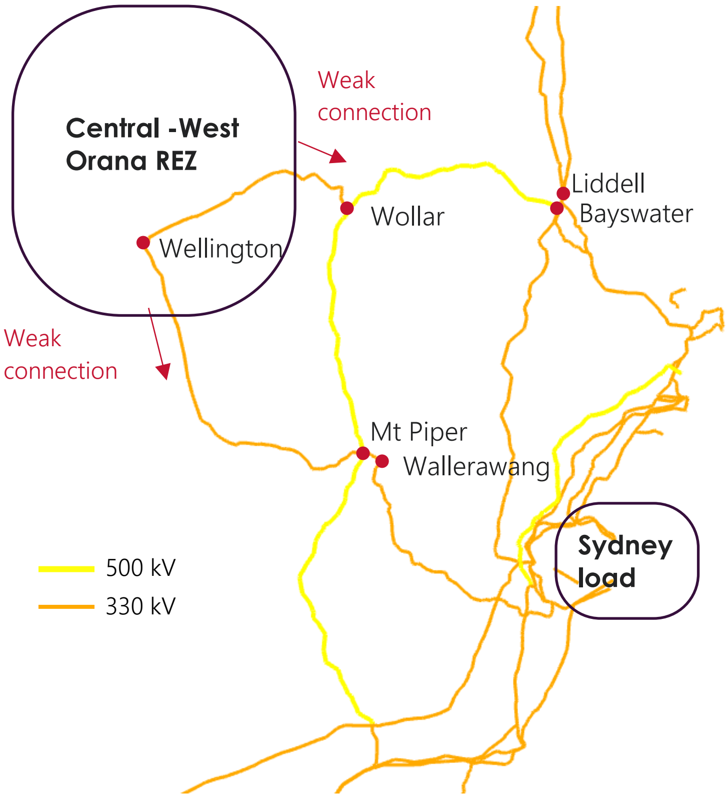
The TNSP in New South Wales is TransGrid. AEMO received the submissions and worked with TransGrid to assess each individual submission. AEMO's assessment is only at a high level for two main reasons:

1. There are still many uncertainties in the project, including the route option and which generators will participate in the REZ. These aspects will be refined as the Central-West Orana REZ develops, according to either the RIT-T process or an alternative process initiated through the New South Wales Government.
2. The purpose of this first stage of non-network proposal submissions is to obtain an early indication of the types and characteristics of the non-network option and provide a feasibility assessment of each submission in meeting the identified need.

1.3 Existing transmission network

The area covered by the Central-West Orana REZ is currently supplied by two 330 kV lines forming a loop from Mount Piper-Wellington-Wollar substations. These lines were originally designed to supply regional loads, and their capacity is well below the level required to transfer 3,000 MW of generation. In addition to the line limits, there is insufficient system strength in these areas to facilitate 3,000 MW of inverter based generation.

Figure 1 Existing network showing weak 330 kV connections to the REZ



AEMO considers that there are opportunities for non-network solutions to increase the transfer capacity and ensure sufficient resilience for the proposed 3,000 MW REZ. The non-network solutions could be strategically placed to reduce the investment in the transmission system.

2. Submissions

AEMO received several confidential submissions for non-network options to address the identified need.

Many of the proponents have proven experience in delivering renewable energy projects in both Australia and across the world. Some submissions also stated their solution had already secured land and easements.

The submissions can be categorised into several technology types:

- Battery storage in the REZ.
- Battery storage with automated control schemes.
- Synchronous condensers.
- Pumped hydro.

2.1 Battery storage

Battery storage is a very flexible technology, where the instantaneous power output (MW), and storage capacity (megawatt hour, or MWh) characteristics are highly customisable. The inverter and its associated control systems can be customised to the exact needs of the network.

The designs in the submissions had the following characteristics:

- Between two and three years to develop and commission.
- Lifespan of 20 years, or can be designed for more.
- Grid-forming inverters are used, potentially providing virtual inertia and limited levels of system strength. Trials are underway to investigate these technologies[6].
- Inverters can have a short-time overload capacity to help meet system strength needs.
- No requirement to access other resources, so can be installed in most locations.
- Low capital expenditure (CAPEX) compared to other technologies.

The technical characteristics of battery storage give the potential for meeting the network need through several mechanisms – including demand shifting and ancillary services.

Demand shifting

The required thermal network capacity to support the Central-West Orana REZ could be reduced by placing batteries inside the REZ. They could act as local demand during periods of high local generation and when thermal constraints are binding, and could then discharge later during periods of lower local generation.

Several of the proposals were alongside existing solar farms connected within the REZ, so the operation of the batteries could be optimised for maximum benefit.

Multiple aggregated units could also be configured to work in conjunction to provide additional benefit.

Ancillary services

An energy storage system can be configured to provide power system services such as frequency control ancillary services (FCAS), or voltage control ancillary services (VCAS). Batteries would need to allocate spare headroom to either charge or discharge as appropriate, reducing the benefit of demand shifting.

[6] See https://arena.gov.au/projects/hornsdale-power-reserve-upgrade/ and https://arena.gov.au/projects/transgrid-wallgrove-battery/.

AEMO has several mechanisms for procuring ancillary services, so adding battery storage systems would provide more competition to those markets and processes.

2.2 Battery storage with automated control schemes

Battery storage systems can also form part of automated control schemes, referred to as System Integrity Protection Schemes (SIPS). These systems can increase the capacity of the transmission network because they are able to respond rapidly to contingency events.

Supplementing generator runback schemes

Generators are often required to install runback schemes, so if there is a contingency their output is automatically reduced so the remaining network can operate securely. This response causes a sudden drop in generation, suddenly reducing the power output from the REZ and potentially leading to network instability.

One proponent suggested a SIPS where a battery placed outside the REZ would respond to the event by increasing its output when generators inside the REZ have been forced by their runback schemes to automatically reduce. This means the net contingency size would be reduced, allowing more generation to be dispatched in the REZ.

Virtual transmission line

A virtual transmission concept involves a use of fast active power response at both ends of a transmission line which is likely to be a constraining element. Immediately following a contingency, the sending end reduces the power and the receiving end increases the same amount of power minus the line losses, relieving any overload on remaining parallel transmission lines. This design is an alternative to uprating, replacing or building new line.

A virtual transmission line can be implemented in a variety of ways. One submission proposed several different configurations of installing battery storage systems outside the REZ (at the receiving end of the connection into the Central-West Orana REZ). If there was a contingency, the battery systems would respond to prevent overloading of the network.

2.3 Synchronous condensers

Some submissions included installing synchronous condensers inside the REZ alongside battery storage. The submissions did not include details or sizing, but synchronous condensers are known to provide system strength and inertia in the power system, improving overall stability for the REZ and increasing network limits such as voltage stability.

2.4 Pumped hydro

Pumped hydro systems can provide long-duration energy storage. The design in the submission had the following characteristics:

- Five years to develop and commission.
- Lifespan of 50 years.
- Uses a synchronous machine, so can provide system strength when pumping or generating.

Demand shifting

Pumped hydro systems typically have a high storage capacity (MWh) compared to present battery technologies. This would give the Central-West Orana REZ greater flexibility to be effective during multi-day weather conditions.

Ancillary services

There is scope for pumped hydro to provide a wide range of ancillary services. In addition, a synchronous pumped hydro system can provide system strength, improving stability in the REZ and increasing limits.

3. Assessment

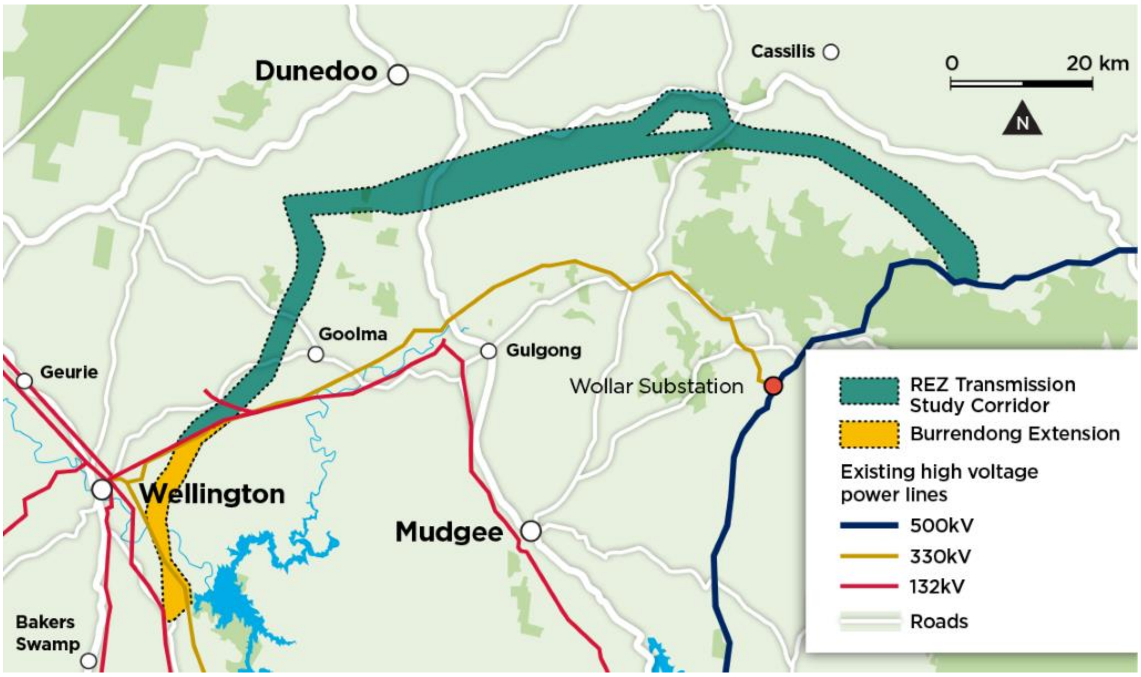
The purpose of this assessment is to determine whether each of the proposed non-network options meets, or is reasonably likely to meet, the relevant identified need, either as a standalone non-network option or in conjunction with a network option as a hybrid solution. Only preliminary power system analysis was carried out to determine this.

The assessment does not address each proposal individually. Instead it groups them by technology type and the services offered.

3.1 Existing limits

AEMO carried out the analysis in collaboration with TransGrid. The modelled network was based on the latest REZ transmission corridor, recently published by the New South Wales Government. Steady state and transient power system analysis was conducted.

Figure 2 Proposed map of Central-West Orana REZ transmission study corridor



Source: New South Wales State Government, Central-West Renewable Energy Zone pilot, at https://energy.nsw.gov.au/renewables/renewable-energy-zones#-centralwest-orana-renewable-energy-zone-pilot-.

Thermal limits

The power flow through a transmission element is limited to its maximum thermal capacity. TNSPs provide thermal transmission line and transformer ratings for different ambient temperatures, seasons, months, day or night. Normal ratings are applied for pre-contingent conditions and contingency ratings are applied for post-contingent conditions. Short-term ratings are applied for post-contingency conditions, if an operational solution is available to bring the line loading below the normal rating within the allowed time.

The determination of maximum transfer levels based on thermal capacity was assessed with power system analysis. Following the development of the Central-West Orana REZ, the result indicates that there would be post-contingency thermal limits on:

- Liddell–Bayswater 330 kV lines
- Mt Piper–Wallerawang 330 kV lines

Additionally, depending on the exact future renewable generation connection locations and operating conditions, the results indicate there would be post-contingency limits on:

- Wollar–Wellington 330 kV line
- Wellington–Mt Piper 330 kV line

Voltage stability

Voltage stability typically relates to maintaining stable voltage control following a credible contingency event or any protected event. Assessment of voltage stability covers the following requirements:

- A margin from the point of voltage collapse. This margin (expressed as a capacitive reactive power in megavolt amperes reactive [MVAr]) must not be less than 1% of the maximum fault level (in megavolt amperes [MVA]) at the connection point. However, a higher margin can be applicable if advised by the TNSP.
- Voltages are to be within limits. At all times, the steady state voltage magnitudes must remain between 90% and 110% of the nominal voltage, unless different voltage levels are applicable under contractual obligations with connected parties. The highest voltage capability of plant is lower than 110% of nominal voltage.

For the Central-West Orana REZ, power system analysis found that the voltage stability limit is close to the thermal limit in the network. The stability limit is driven by both voltage limit violations and reactive power margin deficits depending operating conditions. Some examples include when nearby New South Wales synchronous machines are switched out-of-service, when there are high demand levels, or when there is high transfer on the Queensland to New South Wales interconnector.

System strength

System strength is an overarching term which includes many aspects of operating the system securely, including voltage stability limits[7]. It is the ability of the power system to operate in a stable manner under system normal conditions and for the system to recover following disturbances. The system becomes weaker when large amounts of power is being transmitted through long, weak lines. System strength is also reduced in areas with higher densities of inverter-based resources, such as solar farms, batteries, and some wind farms.

The system strength is currently low in the Central-West Orana REZ. Without system strength remediation, connecting a large amount of renewable generation in the area would further deteriorate the system strength, beyond the capability of the network.

3.2 Effectiveness of non-network solutions

Power system analysis has demonstrated that all proposed non-network solutions have an effect on improving the network limits, as shown in Table 1:

[7] AEMO, System strength explained, March 2020, at https://aemo.com.au/-/media/files/electricity/nem/system-strength-explained.pdf.

- The thermal limitations are improved by reducing the power flow on the network during normal operation and following a contingency.
- Voltage stability limits are improved following a contingency, partly due to the reduced power flow and also from the reactive capability of the proposed solutions. The scale of improvement is subject to the exact location of the solution and the connection points of future generator connections.
- System strength is improved by installing synchronous generation or though "grid-forming" inverters which can also have a positive impact on system strength.

Each solution is effective in improving the capability of the network provided it is designed well with reference to the existing transmission network. Options involving control schemes and special protection arrangements must be developed in conjunction with TransGrid and AEMO, and may be subject to a testing process before the additional capability is released.

Table 1 Limits improved by each technology type

Technology	Thermal limits	Voltage stability	System strength
Battery storage[A]	Yes	Yes	Yes[B]
Battery storage with automated schemes	Yes	Yes	Yes[B]
Pumped hydro	Yes	Yes	Yes
Synchronous condensers		Yes	Yes[B]

A. Standalone battery systems also have the potential to be integrated into the design of future automated SIPS.
B. Trials are underway to demonstrate the ability of grid-forming battery systems to contribute to system strength. Two examples are at https://arena.gov.au/projects/hornsdale-power-reserve-upgrade/ and https://arena.gov.au/projects/transgrid-wallgrove-battery/.

4. Conclusion

The New South Wales Government's Electricity Strategy and Electricity Infrastructure Roadmap outlines the Central-West Orana REZ, with an intended network capacity of 3,000 MW.

AEMO concludes that:

- All the submitted non-network options are reasonably likely to assist with meeting the identified need.
- The large scale of the REZ means that the non-network solutions on their own cannot fully provide the 3,000 MW transmission capacity for the Central-West. Instead, they could be part of a hybrid solution.

The next step in determining a solution is the Regulatory Investment Test for Transmission (RIT-T), which is conducted by TransGrid. Through this process, a cost-benefit assessment is performed and the submitted non-network options in this report must be included. The results of this analysis will be published by TransGrid in a Project Assessment Draft Report (PADR), specifying the draft preferred option. Following that publication, there is a written consultation prior to publication of a Project Assessment Conclusion Report (PACR).

If an alternative regulatory approval path is adopted, such as the New South Wales Government's Electricity Infrastructure Investment Act[8], AEMO recommends that non-network options assessed in this report be included as credible solutions to partly meet the identified need.

[8] Available at https://www.legislation.nsw.gov.au/view/html/inforce/current/act-2020-044.