Opportunities for flexible resources to improve transmission utilisation in NSW Renewable Energy Zones

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Introduction

The Australian National Electricity Market (NEM) is undergoing an unprecedented transition from emissions intensive coal generation to high penetrations of variable renewable energy (VRE). The location of the rapidly increasing capacities of VRE does not typically coincide with the location of the legecy generation and existing transmission infrastructure in the NEM. Renewable energy zones (REZ) have been proposed to coordinate and facilitate investment in renewable energy generation, storage and transmission.

Congestion may well be exacerbated in REZs due to the large capacities of VRE connecting to still limited transmission capacities. Maximising the transmission utilisation of existing and new infrastructure – the amount of electricity transmitted through a line compared to the nominal line rating – while avoiding excessive renewables curtailment is crucial for meeting the National Electricity Objective (NEO) of efficient operation of the NEM. In New South Wales, efficient use of transmission is needed to meet State Government transmission constrained curtailment targets and to provide certainty to investors that curtailment will be minimised under the proposed closed transmission access rights scheme.

Integrating flexible resources in the REZs will reduce network congestion and increases transfer capacity of transmission lines (Freire-Barceló et al. 2022), enabling both a larger shares of VRE to be connected and support the efficient use of existing generation (Ranjbar et al. 2022). Battery energy storage systems (BESS) are a particularly important flexibility option. To date, literature has not explored the opportunity for batteries and other flexible resources to improve transmission utilisation in the REZs.

This study analyses the impact of BESS and price-responsive loads, such as hydrogen electrolysers, on transmission utilisation and VRE curtailment, the market conditions under which they provide the greatest benefit and the cost of replacing transmission upgrades with flexible resources was considered.

Method

Modelling using PLEXOS, an electricity market modelling software, was undertaken for the three declared REZs – Central-West Orana, New England and South-West NSW. The modelling analysed the role of different capacities and durations of BESS and price-responsive loads on transmission utilisation, prior to and following proposed transmission upgrades. PLEXOS, an electricity market modelling tool, was used to simulate dispatch in the NEM. The AEMO 2020 Integrated System Plan (ISP) central scenario model was used, with transmission and generation inputs updated to reflect the 2022 ISP. The REZs were modelled as radial networks, with the remaining generation and demand in each region connected to regional reference node (RRN).

The PLEXOS short-term schedule was run with 30-minute dispatch intervals and a 24-hour lookahead (with 30-minute intervals). Scenarios were defined based on the REZ transmission

capacities, network augmentation options and government energy storage targets. Scenarios were run for February and/or July in 2025, 2030 and/or 2035.

A cost-benefit analysis (CBA) was undertaken, primarily using assumptions from the 2022 ISP. The benefits considered were the avoided NEM generation cost and avoided social cost of carbon, and the costs considered were the capital and operating costs of the BESS or transmission. Each scenario used in the CBA was run for the year of 2030.

Results & Discussion

BESS improve transmission utilisation. The major factors that impact the improvement BESS provide for utilisation are the composition of generation in the REZ (and by extension, the correlation of wind and solar generation) and the ratio of generation to transmission capacity (impacting congestion on the line). Both of these factors change over time and depend on the REZ location. The relative magnitude of impacts are broadly summarised in Table 1.

Table 1 Relative transmission improvement by BESS observed under different REZ scenarios

Ratio of generation to transmission capacity	Composition of generation in the REZ		
	Solar only	Solar and wind	Wind only
Rarely congested (small VRE capacity & large transmission capacity)	Low	Low	Low
Sometimes congested	Highest	Moderate	High
Always congested (large VRE capacity & small transmission capacity)	-	Lowest	-

The largest increase in utilisation was observed for a solar only REZ where the capacity of generation and transmission are well matched. In a solar only REZ, BESS improved the utilisation by nearly 45%, shown for an illustrative week in Figure 1. In a REZ with both solar and wind generation, BESS improved the utilisation by a much smaller amount, around 5%.

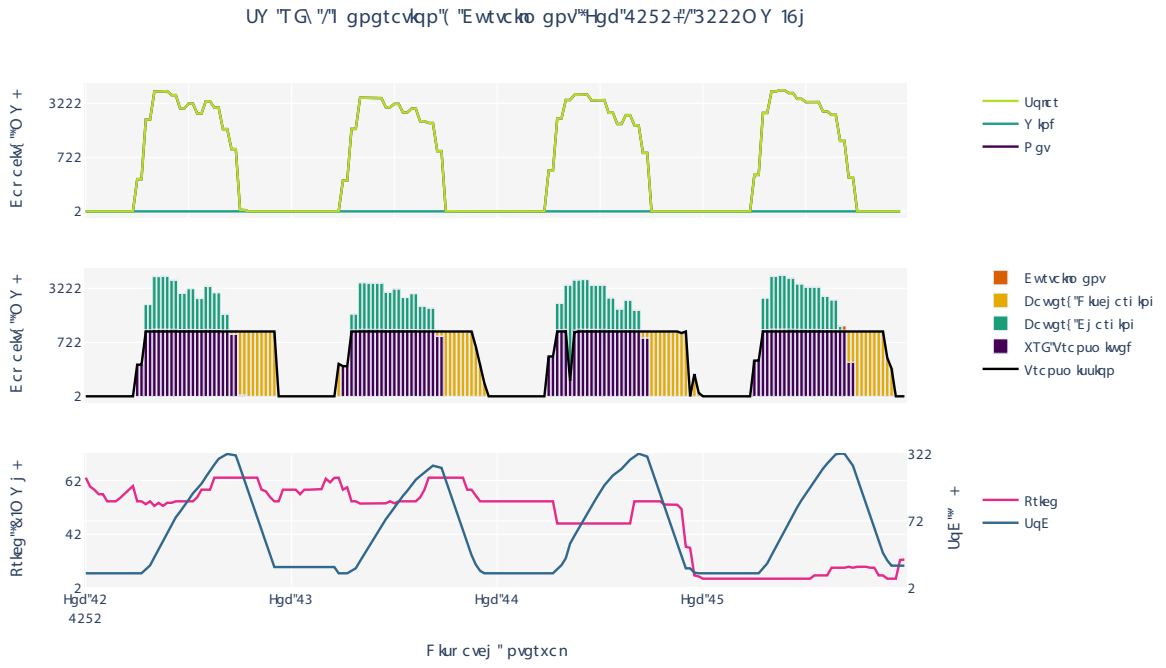

Figure 1. South-West NSW REZ with 600 MW of transmission hosting capacity and a 1000MW/4h battery from 20th to 24th Feb 2030

Consequently, the improvement to transmission utilisation delivered by appropriately sized BESS can defer transmission upgrades by 10 to 15 years in the South-West REZ. This highlights the benefit of co-optimising the size and timing of BESS and transmission upgrades.

The 4 hour BESS was shown to be the most economic investment for the market of all durations, in all REZ compositions because it arbitrages generation to the evening demand peak when it can maximise profit and infill the gap between the typical generation profile of daytime solar and evening wind. As a consequence of all the projected future VRE capacity in the NEM, very low spot prices and very few price spikes were observed in the model. This reduces the overall profit derived by the BESS because both the lower average spot price and more frequent occurrences of VRE not being dispatched due to an abundance of low-cost generation. Resultantly, even though the result illustrate BESS are economically viable under nearly all market sensitivities, the financial analysis in this study is conservative.

Flexible resources reduce curtailment in the REZs. Reducing curtailment increases the amount of renewables transmitted from the REZ to displace higher cost, emissions intensive generation elsewhere in the NEM. The relative reduction in curtailment is again impacted by the factors presented in Table 1. The largest reduction in curtailment was observed for a solar only REZ, with a 1000 MW, 4 hour BESS reducing VRE curtailment in the REZ by up to 95%. In a wind and solar REZ, the same capacity BESS reduced curtailment by around 80% and a flexible load by 78%. This could be further reduced by locating flexible resources, especially large loads, behind the meter to ensure excess generation can be consumed, regardless of dispatch outcomes in an electricity market with growing proportions of VRE. It is unlikely BESS will operate without incentive to improve transmission utilisation, making the reduction in curtailment important because it provides the financial driver for BESS to energy arbitrage by following market price signals, which in turn improves utilisation.

The improved efficiency of network operation with BESS enables low-cost electricity to be more consistently transmitted from the REZs, contributing towards meeting the NSW Government's goals for REZs to be "modern-day power stations" and to maintain "downward pressure on energy prices for consumers" (NSW Government 2022).

Conclusion

BESS are demonstrated as a viable investment to reduce transmission upgrades to the REZs. BESS with a duration of 4 hours were identified as the most cost-effective duration, in all three REZs under various market sensitivities. BESS deliver significant market benefits by reducing spilled VRE and time shifting energy to displace high-cost, emissions-intensive coal generation. Even if the improvement to utilisation is only small in some cases, BESS are needed in the NEM regardless and are worthwhile in nearly every REZ arrangement.

Price responsive loads have been identified to reduce VRE curtailment, again making them a valuable addition to the REZs, despite not improving transmission utilisation.

References

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