Competition vs. Coordination: Optimising Wind, Solar and Batteries in Renewable Energy Zones

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Renewable Energy Zones or 'REZs' have become a key policy initiative of the State Governments that comprise Australia's National Electricity Market (NEM). In the NEM's Queensland region, REZs are developed by the transmission utility under a semi-merchant model where user charges are levied on the connecting generators.

Well before the optimal levels of Variable Renewable Energy (VRE) plant capacity enter a REZ, some level of 'spilled energy' or congestion-driven curtailment arises. And as entry continues and the fleet-wide average rate of curtailment rises, the Annual Capacity Factor of renewable projects within the REZ begins to fall – and will ultimately reach a tipping point of *"bankability"*. Critically, the marginal rate of curtailment arising from transmission line congestion will rise at 3-4 times the average rate of curtailment, meaning the final MW of wind capacity installed in a congested REZ may produce as little as 40% of the first MW of wind capacity installed. The implication of these dynamics for (i) transmission access policy, and (ii) the role of storage, is material.

This article identifies the process for identifying the optimal mix of complementary VRE plant capacity in a REZ under two different access regimes, with and without battery storage in a multi-zonal electricity market setup. While optimising complementary REZ plant capacity has previously been examined – prior research excluded the impact of battery storage. This article aims to fill that gap.

Battery investment commitments in Australia's NEM, and in the Queensland region, are surging. At the time of writing, almost 1800MW of batteries across 30 sites were operational, with a further 26 projects at financial close or under construction, taking the total to more than 8000 MW in a 35GW system. Underpinning NEM battery entry are market dynamics associated with a 'solar-rich' power system, combined with largely inelastic aggregate final electricity demand and inflexible baseload plant. Collectively

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these characteristics have produced some of the highest intra-day price spreads across the worlds' major electricity markets over the period 2021-2024.

Given the extraordinary level of investor interest in battery storage, it is appropriate to explore the welfare implications of battery additions *within a REZ* under varying access arrangements (open vs. priority) and industrial organisation (coordination vs. competition). For this purpose, a REZ Optimisation Model is used drawing on renewable resources and market data from the NEM's Queensland region.

REZ Optimisation Model reveals some striking results. To summarise, Queensland wind and solar are complementary resources, and so a ~1500MW transmission line will host vastly more installed wind and solar capacity than 1500MW. The outer-bound of *"bankable"* complementary VRE capacity will be regulated by capital markets and their *tolerance* for expected renewable plant curtailment. Second, in a multi-zonal market setup, open access (cf. priority access) proves welfare enhancing because of peak-to-average output ratios of VRE plant. While at first glance it may seem logical that wind and solar average unit costs are minimised when congestion is minimised, such calculations exclude connection costs – and these are minimised when output is maximised. Accordingly, when the fixed and sunk costs of REZ transmission infrastructure are incorporated under a priority access regime, lower VRE unit costs are offset by higher (total) connection costs.

Furthermore, coordinated portfolio batteries are preferred to competitive rival batteries *within a REZ*. Rival batteries compete for scarce REZ transmission transfer capacity and aggravate congestion. Portfolio batteries would be sized, and scheduled, to alleviate congestion. They do so by opportunistically charging during congestion events and withholding dispatch during congestion events.

Finally, early entrant batteries within an (uncongested) REZ may harm welfare through oversizing, ex ante, and crowding-out latter-entrant VRE plant. This is the case whether the entrant is a *coordinated portfolio battery*, or *competitive rival battery*. The intuition here is that batteries do not generate renewable energy, they merely help move intermittent output through time. An oversized battery may drive reverse flows into a REZ during renewable lulls, and visibly compete for REZ line access during dispatch cycles. Either way, the effect may be the *crowding-out* of otherwise optimal levels of wind and solar plant capacity.