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A Portfolio approach to wind and solar deployment in Australia

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Abstract

We develop a new framework that can be used to analyse interactions between solar and wind generation using a Mean-Variance Portfolio Theory (MPT) framework. We use this framework to understand the role of electricity transmission integrating a high share of Variable Renewable Energy (VRE) and investigate the optimal generation mix consisting of wind and solar for Australia's National Electricity Market (NEM). For the same level of risk, we find that the average capacity factor of VRE could be 7% higher if transmission constraints are alleviated. Our results show that in order to minimise the risks of a VRE-dominated generation portfolio, transmission capacity and efficient access will become very important – at a high level of VRE penetration in NEM, a marginal increase in transmission capacity reduces system risks associated with wind and solar uncertainties by ca. 0.25 p.p. Lack of transmission capacity therefore implies potentially greater risks to VRE generators and hence higher energy costs at high levels of VRE penetration. Using our proposed approach (residual demand minimisation), which accounts for the dynamics of electricity generation associated with wind and solar as well as with demand, we find investment in solar generation is rewarded more than when using an output maximisation approach that ignores patterns of demand. For example, on average, solar share reaches 15.4% under the residual demand minimisation approach versus 12.5% under output maximisation approach. Investment in solar is also sensitive to the way we formulate our risk objective, being less favourable if we consider only peak hours than if we consider all hours. Further, our results suggest that wind generation and transmission capacity expansion are complements NEM-wide while solar generation and wind generation are complements within the same region.

Keywords electricity planning, transmission capacity, geographic and technological diversification, mean-variance portfolio theory (MPT)

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