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# Overbuilding wind and solar grid connections for cost-efficient grid expansion

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**Extended Abstract**

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**Abstract Summary**

Electricity network investments are increasing globally, not least due to the connection of new wind and solar generators. Notably, these variable renewable energy (VRE) generators seldom produce at nominal capacity, and when they do, their simultaneous output typically has a low market value. This article analyzes how overbuilding grid connections, i.e., choosing a connection capacity below the generator capacity, can reduce total system costs. To this end, we develop a partial equilibrium model of northwestern European electricity markets, which trades off the marginal cost and value of grid expansion. As an input to our model, we estimate that average distribution grid expansion costs per installed VRE capacity range from €5/kW in high-load grids to €165/kW in high-VRE grids based on German network development plans. For multiple 2030 scenarios in Germany, our results show that optimal grid-connection capacities are substantially lower than the corresponding installed VRE capacities. When onshore wind and utility-scale plants are connected separately, average optimal grid connection capacities are only 77% and 56% of the installed capacities, respectively. Co-locating wind and PV reduces the optimal connection capacity to 45% of total installed VRE capacity, and co-location with batteries leads to further declines. The resulting estimated grid investment cost savings range from €131 mn/a for separate connections to €377 mn/a for co-location of wind, PV, and batteries. Meanwhile, the net losses from curtailed electricity are less than €30 mn/a in all scenarios, yielding welfare gains of €103–365 mn/a. The results remain robust across a range of parameter sensitivities.