Wind Capacity Investments: Inefficient Drivers and Long-Term Impacts

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Overview

There is substantial concern that high variability of wind energy production on the electricity grid can increase outage risks, reliability costs, and energy market price fluctuations. Ian Schneider and Mardavij Roozbehani of the Massachusetts Institute of Technology explain how existing production-based subsidies for wind energy bias marginal investments to underweight the market value of energy produced, which leads to higher production correlation between developed wind sites and therefore increases system wide variability of wind energy production.

A pure energy-only market has been shown, under certain conditions, to create optimal incentives for market entry. This research extends these results to the case of potential entrants with variable and non-controllable production, such as wind generators. It also examines the effects of subsidies on these incentives for market entry and investment.

Two important criteria for investment in wind capacity are the total energy production and the average market value for energy produced at the wind site under consideration. The tradeoff between these values is important because high-production sites are frequently located near previous wind development, which suppresses local prices and thus the expected energy market value of future production.

Production based subsidies for wind energy, like the federal Production Tax Credit (PTC) and many state Renewable Portfolio Standard (RPS) credits or subsidies, bias investment at the margin towards sites with higher expected capacity values, i.e. with higher total production per unit of site capacity, but with less concern for the correlation between energy output and market prices. This research explains explain how this tradeoff is derived from the optimization problem of a profit-maximizing wind investor, and they derive the impact of the PTC and other energy market policies on the efficient frontier of optimal investments.

Furthermore, since wind production depresses prices, this bias is linked to covariance between wind sites. Fixed-price support mechanisms like the PTC lead to market equilibriums with higher levels of wind correlation, which can increase system costs for capacity and grid stability.

This research is based on previous work that was published by Ian Schneider and Mardavij Roozbehani as a working paper by the MIT Center for Energy and Environmental Policy Research. It aims to add additional insight by measuring the effect of these subsidies in real-world systems. With new results, we aim to clarify which subsidy mechanisms can be expected to inefficiently bias long-term subsidies. We also focus on extensions with special relevance to the European context. In particular, feed-in tariffs represent a particular edge case, whereby potential investors no longer have any incentive to consider the correlation between planned new generation and existing generation. While volumetric based subsidies that are used in conjunction with wholesale offers for electricity might be seen as more efficient, this paper suggests lingering downsides to that approach.

Finally, this research proposes more efficient methods for subsidizing renewable energy generation. It compares these methods to approaches that focus on carbon regulation (e.g. carbon taxes and cap-and-trade) and explains when they might be efficiently used alongside one another.

Methods

We use a microeconomic framework to explain how subsidies of a certain functional form impact the decision of investments of renewable energy generation at the margins. They use tools from general equilibrium analysis to explain how these changes in investment strategy impact the long-term equilibrium portfolio of electricity generation. The authors also use data from California to indicate the potential effect of the PTC on theoretical investment decisions, detailing how the efficient frontier for investments shifts as a result of the PTC.

Results

Due to the near-zero marginal cost of wind energy production, the availability of wind serves to suppress energy market prices. The research uses this fact to develop results that link the correlation between a wind project's energy production and energy market prices to the overall variance of system-wide wind energy production. This

result shows how production-based subsidies bias investment outcomes in electricity markets towards long-run equilibria with proportionally higher variance of total wind energy output. This particular impact of the PTC is especially relevant because of the greater risk, system reliability costs, and price fluctuations associated with a higher variance of total wind energy output.

The paper explores explore the effects on long-run equilibria of policies that bias investments towards proportionally higher correlation of wind energy outputs. They show that highly correlated wind production supports long-run equilibria with higher capacity served by midrange plants and with less capacity served by peaker and baseload plants, as compared to investment in wind capacity with lower overall output variance. This effect reduces the availability of highly-responsive peaker plants, which could further limit the ability of the system to cope with high variability from wind generation.

Finally, we propose a price-proportional subsidy, where the subsidy received per unit of production varies proportional to the energy market price at the time of production. For instance, a proportional subsidy could always award an additional 20% of the energy market price for each unit of wind energy produced; the specific fraction that determines the subsidy amount can be determined such that program costs are equal to any existing production-based subsidy. Unlike existing production-based subsidies, a price-proportional subsidy scheme does not bias potential investors away from sites with higher average energy value. As such, a price-proportional subsidy would mitigate the effects detailed in this research by which traditional subsidies for wind energy increase the total variance of wind energy from new investments.

Conclusions

This paper examines optimal investment decisions in wind capacity, based on a simplification of analytical research on spot market pricing theory. It examines the investment frontier and considers trade-offs between marginally better capacity factors and marginally better covariance of output and prices.

The analysis shows that decisions along this investment frontier are biased by fixed price subsidies like the production tax credit (PTC), resulting in wind investment that is marginally less likely to be available in periods of high prices and/or demand. Further results show that lower covariance or a wind site's output with price is equivalent to higher covariance with the remainder of system wind output. Therefore, subsidies like the PTC lead to investment decisions at the margin that inefficiently increase the total variance of the wind portfolio. The effects of portfolio variance on long-run market equilibriums were presented. Contrary to the typical assumption, more highly correlated wind investments actually support less peaker capacity in the long-run equilibrium versus a portfolio of wind investments with less correlation in their outputs.

References

Schneider, I., and M. Roozbehani (2017). "Wind Capacity Investments: Inefficient Drivers and Long Term Impacts," MIT CEEPR Working Paper 2017.