



## RESEARCH BRIEF

# Wind Capacity Investments: Inefficient Drivers and Long-Term Impacts

Ian Schneider and Mardavij Roozbehani

*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.*

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. Ian Schneider and Mardavij Roozbehani 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.

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.

Due to the near-zero marginal cost of wind energy production, the availability of wind serves to suppress energy market prices. Ian Schneider and Mardavij Roozbehani use 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.

Ian Schneider and Mardavij Roozbehani 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, Ian Schneider and Mardavij Roozbehani 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.

## References

Schneider, I., and M. Roozbehani (2017). "Wind Capacity Investments: Inefficient Drivers and Long Term Impacts," MIT CEEPR Working Paper 2017-002.

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## About the Authors



Ian Schneider graduated from Thayer School of Engineering at Dartmouth College in Hanover, New Hampshire in 2014. Ian is currently a graduate student at MIT, working towards a PhD in Engineering Systems in the Institute for Data, Systems, and Society at MIT. Ian is a research assistant in the Laboratory for Information and Decision Systems, where he studies optimal strategy for wind power producers and mechanism design in electric power markets. He is especially interested in game theory, market design in power systems, and economic policy.



Mardavij Roozbehani received the B.Sc. degree from Sharif University of Technology, Tehran, Iran, in 2000, the M.Sc. degree in Mechanical and Aerospace Engineering from the University of Virginia, Charlottesville, VA in 2003, and the Ph.D. degree in Aeronautics and Astronautics from the Massachusetts Institute of Technology (MIT), Cambridge, MA in 2008. Since 2012, he has held a Principal Research Scientist position at the Laboratory for Information and Decision Systems (LIDS) at MIT, where he previously held postdoctoral, course instructor, and research scientist positions between 2008 and 2011. His main research interests include distributed and networked control systems, dynamics and economics of power systems with an emphasis on robustness and risk, analysis and design of software control systems, and finite-state systems. Dr. Roozbehani is a recipient of the 2007 AIAA graduate award for safety verification of real-time software systems.

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