Study: China could go big on wind power—if it adjusts its grid operations

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Credit: Massachusetts Institute of Technology

China has an opportunity to massively increase its use of wind power—if it properly integrates wind into its existing power system, according to a newly published MIT study.

The study forecasts that wind power could provide 26 percent of China's projected electricity demand by 2030, up from 3 percent in 2015. Such a change would be a substantial gain in the global transition to renewable energy, since China produces the most total greenhouse gas emissions of any country in the world.

But the projection comes with a catch. China should not necessarily build more wind power in its windiest areas, the study finds. Instead, it should build more wind turbines in areas where they can be more easily integrated into the operations of its existing electricity grid.

"Wind that is built in distant, resource-rich areas benefits from more favorable physical properties but suffers from existing constraints on the operation of the power system," states Valerie Karplus, an assistant professor at the MIT Sloan School of Management, director of the Tsinghua-MIT China Energy and Climate Project, and a member of the MIT Energy Initiative. Those constraints include greater transmission costs and the cost of "curtailment," when available wind power is not used.

The paper, "Integrating wind into China's coal-heavy electricity system," is appearing in *Nature Energy*. In addition to Karplus, the authors are Michael R. Davidson, a graduate student in MIT's Joint Program on the Science and Policy of Global Change and the MIT Institute for Data, Systems, and Society; Da Zhang, a postdoc in MIT's Joint Program on the Science and Policy of Global Change; and Weiming Xei and Xiliang Zhang of Tsinghua University. Karplus and Zhang are the corresponding authors of the paper, and lead an MIT-Tsinghua collaboration focused on managing energy and climate change in China.

Co-existing with coal

While China has invested heavily in renewable energy sources in recent

years, more investment in the sector will be needed if the country is to meet its pledge of having 20 percent of its energy consumption come from non-fossil fuel sources by the year 2030, as part of the Paris climate agreement of 2015.

While several previous studies have evaluated China's wind-energy potential based on the country's natural environment, the MIT study is the first to study how wind energy could expand, based on simulations of China's power system operations.

When operational constraints are considered, the MIT team found, China may only be able to use 10 percent of the physical potential for wind power cited in their analysis and other studies. Nevertheless, even harnessing that 10 percent would be enough for wind power to provide the study's estimated 26 percent of electricity by 2030.

A key challenge the study identifies is integrating wind power into a system that has traditionally been geared toward consumption of coal. Wind power, being intermittent, currently requires flexibility in the operation of the electricity system to ensure wind can be used when it is available.

That, in turn, requires flexibility in the delivery of electricity from coal-fired power plants, which accounted for over 70 percent of electricity generated in China in 2015. However, China has regulations determining high minimum output levels for many coal-powered electricity plants, to ensure the profitability of those plants. Reducing these requirements and creating more flexible generation schedules for coal would create more space for wind power.

"Renewable energy plays a central role in China's efforts to address climate change and local air quality," Da Zhang explains. "China plans to substantially increase the amount of wind electricity capacity in the

future, but its utilization—and ultimately its contribution to these environmental goals—depends on whether or not integration challenges can be solved."

New policies possible?

As the researchers see it, new policies can help create the conditions for increased use of wind power—but may be difficult to implement. As Davidson notes, "establishing regulatory structures and policy incentives to capture these benefits will be difficult in China because of legacy institutions."

And as Karplus adds, current regulations have been designed to ensure profitability for power producers, rather than making them compete to lower costs. "Existing policies prioritize sharing benefits equally among participants rather than facing strict price competition," she says. "As electricity demand growth has slowed in recent years, the limited size of the pie means sharper conflicts between wind and coal."

To be sure, as Karplus notes, government planners in China have been experimenting with using energy markets that do not rely strictly on the system that uses a quota for coal power, but encourages competition for long-term contracts to deliver coal-based electricity, while creating additional markets for flexible operation.

Such market mechanisms could prove beneficial to renewable energy sources, principally wind and solar power. As Karplus concludes: "Our work shows the value of continuing these reforms, including introducing markets and relaxing the administrative constraints ... for China's ability to utilize its present and future wind capacity to the fullest."

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More information: Michael R. Davidson et al. Modelling the potential for wind energy integration on China's coal-heavy electricity grid, *Nature Energy* (2016). DOI: 10.1038/nenergy.2016.86

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