Researchers use real-world data to model the effect of more solar on the grid

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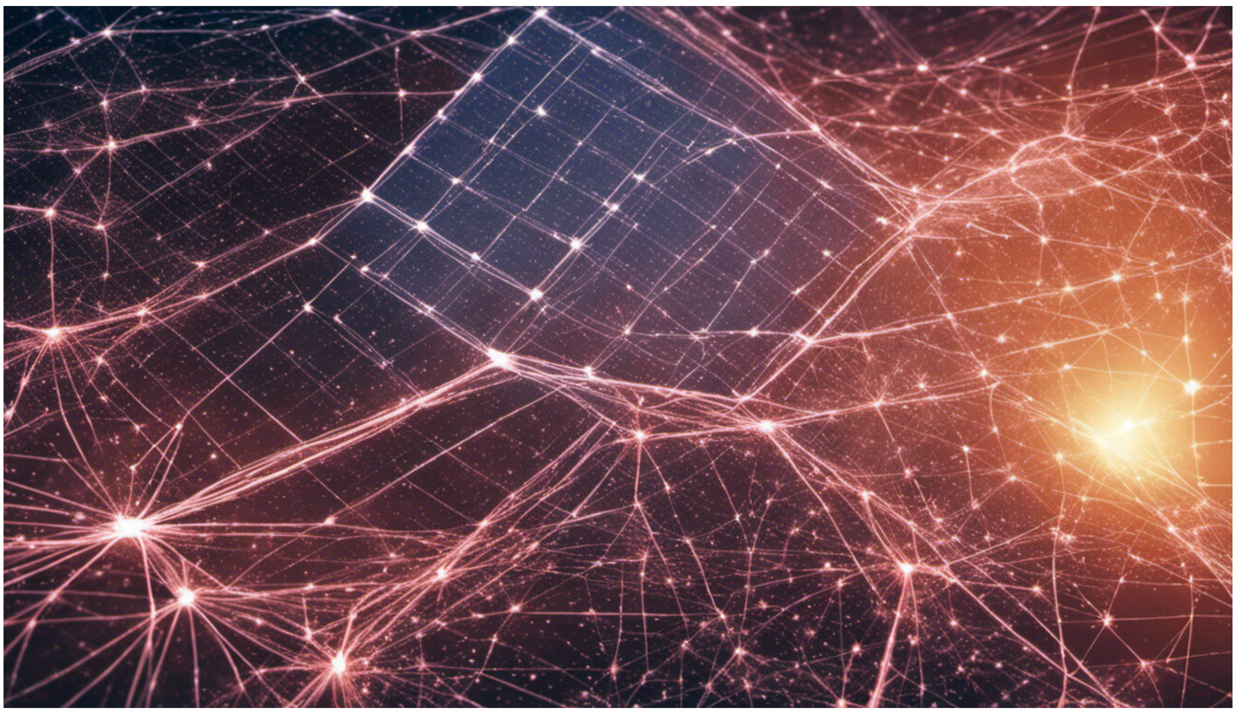

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American electrical utilities do a pretty fantastic job of getting us electricity when we need it. In 2006, the power was out on average for just 0.03 percent of the year in the United States. But right now, this system depends on getting most of its power from coal, nuclear and gas plants: big, dependable power plants that can be turned on and off when needed.

As we add more electricity from renewable sources that can only make electricity when the sun shines or the wind blows, researchers from the U.S. Department of Energy's Argonne National Laboratory have been modeling the power system to help utilities adjust their operations to make sure they can maintain those high levels of electricity reliability.

The fact that utilities deliver us power 99.97 percent of the time is all the more impressive when you consider the fact that electricity is not easily stored. In effect, we have to make it right at the moment that we need it.

This means that power companies must carefully balance the demand with the number of power plants they have up and running and how much they produce. This is called load balancing. The cardinal rule of load balancing is that you must always have more electricity generation capacity ready than you expect to need. Otherwise, a sudden surge in demand or a failure at a generator can lead to blackouts.

Adding renewable energy sources, like wind and solar, makes the process trickier because these kinds of installations can't supply power on command. Thus, as they add more renewable energy to the mix, utilities have to increase the amount of capacity they hold in reserve—often in the form of conventional power plants like coal or gas—in case the sky clouds over or the wind stops blowing at a crucial time.

But because holding reserves is both financially and environmentally costly, utilities would like to minimize the amount they need to keep while still getting enough electricity to reliably meet consumers' needs.

"How to best handle this is still very much an open question for utilities," said Argonne energy systems engineer Audun Botterud.

In the case of solar farms, utilities base their operational decisions on forecasts of solar power generation —from days ahead all the way down to an hour ahead or even less. But if the actual amount of sun deviates too much from the forecast—for example, a sudden cloud layer forms at the same time a lot of people turn on the air conditioning—a system that depends on solar becomes unstable, more costly and more vulnerable to blackouts.

"Utilities have been forecasting for a long time," Botterud said. "But their main experience is in forecasting the demand—that is, how much electricity consumers need. Adding solar power means they must also forecast supply as well."

In a recent study, Botterud and colleagues used real-world data from a power company to analyze patterns of forecasting errors and model possible scenarios to reduce the cost of adding more solar to the mix.

Working with operations data from southwestern power utility Arizona Public Service Company, they modelled the utility grid with various scenarios ranging from nine percent solar all the way up to 17 percent solar.

They created a framework to estimate the costs of forecast errors and solar power variability, both at the day-ahead and hour-ahead time horizon. The most costly incidents tended to happen in the hour-ahead range, when it is expensive to suddenly ramp up extra power plants.

"Flexibility is a key aspect of integrating renewables into the grid," Botterud said. "Traditionally, this flexibility comes from both the supply side—flexible thermal generators, for instance—but the demand side could contribute as well."

It's also important for utilities to be able to trade power with each other, especially in times of low demand and very high solar energy generation, he said. This helps smooth out the peaks and valleys of electricity generation and consumption.

The study presents a model to estimate the increase in operating costs as the utility adds more renewable power, and options for utilities to manage that cost.

Botterud and others are planning to look more closely into consumer flexibility on the demand side and how much that could help utilities fit more renewables in the mix. For example, giving consumers tools to monitor their energy use and the price of electricity could allow them to reduce their power use at critical (and typically pricey) times.

Another source of flexibility would be from advanced operational strategies. For instance, if utilities use probabilistic forecasts of solar generation, they can change the amount of reserves they hold based on the uncertainty in the weather forecasts. If there is a very low probability of clouds, the utility could allow itself to keep less capacity in reserve that afternoon.

The aim is to create models for forecasters and utilities that use comprehensive data to reduce the costs of integrating solar power and devise ways to manage it.

"This study was unique for the high resolution of data we used—down to the minute for load, solar and wind power yield," Botterud said. "We hope this contributes to a body of research that can help utilities as they transition to more renewable power sources.

The report, "Integrating Solar PV in Utility System Operations," is available on Argonne's website. Other Argonne authors were Zhi Zhou and Jing Wu. The study was conducted in collaboration with Lawrence

Berkeley National Laboratory and the National Renewable Energy Laboratory and supported by the U.S. Department of Energy SunShot Initiative.

More information: The report, "Integrating Solar PV in Utility System Operations," is available online: www.ipd.anl.gov/anlpubs/2013/11/77596.pdf

Provided by Argonne National Laboratory

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