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Getting a (Firm) Grip on Renewables

By Noah Buhayar

ONE OF THE BIGGEST DRAWBACKS INVESTORS and utilities have found with solar and wind power is that they are "variable." Simply put: they can't generate electricity when the sun's not shining or the wind isn't blowing. That's problematic because we've grown accustomed to getting energy whenever we want it. Flick a switch and the lights should go on, regardless of whether it's sunny or windy outside.

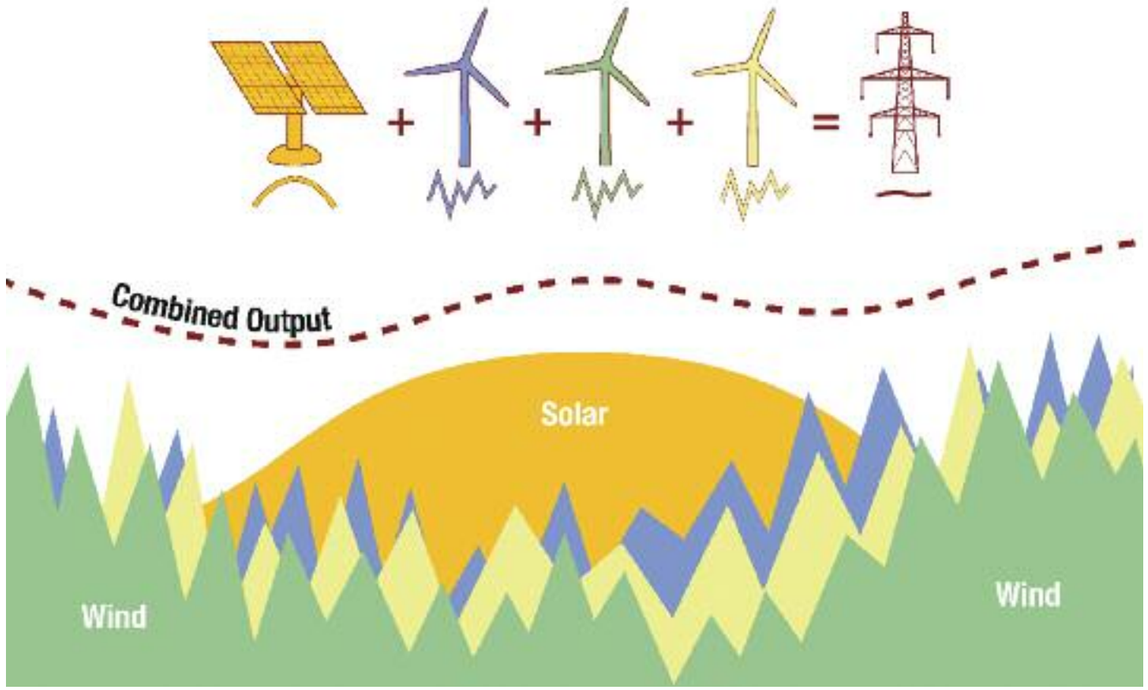
In the past, utilities believed that they had to compensate for this variability by installing more traditional, fossil-fueled power plants. The more wind or solar power on the grid, the thinking went, the greater the need for backup generating facilities to be there when the wind or sun wasn't.

Enter RMI's Energy & Resources Team. Over the past year, Senior Consultant Lena Hansen has led a series of research projects to rethink the implications of wind and solar's variability. In the process, she and her colleagues are re-evaluating the economics of putting more renewable energy on the grid.

The key, according to Hansen, is for utility managers to think of all their wind and solar installations as a portfolio.

"No person would invest in just one stock," says Hansen. In the financial markets, most people forego the huge risks and potentially large gains of owning shares of one company for the reduced risk and smaller rates of return of owning shares in multiple companies, she explains.

Hansen argues that the same should go for utilities investing in wind and solar. "By diversifying the portfolio of sites, you mitigate variability," she says. "Put another way, the wind blows differently in different locations. So spread out your resource to reduce total variability."



By combining multiple wind sites with solar generation, total power generated for the grid becomes much more stable. This potentially replaces base load generation sources such as coal and nuclear.

The trick is to balance risks and rewards. Very windy and very sunny sites produce more power than sites that are less windy or less sunny. But they also tend to be more variable.

Ultimately, explains Hansen, utility managers have to make a tradeoff between variability and power output. However, by modeling a bunch of geographically spread-out sites, Hansen and her colleagues hypothesized, utilities can start to make educated guesses about the optimal portfolio—one that maximizes power generation and minimizes variability.

To test the hypothesis, Hansen and former RMI fellow Jonah Levine compiled hundreds of tables of meteorological data for a one-year period, then set about looking for overlaps in the times when the wind is blowing.

As it turned out, 2004 data were the most complete, enough to model what would happen at 63 sites across the Great Plains.

"The basic idea," explains Levine, "was to look for a complementary effect." Simulating wind sites over a large geographic area should have decreased variability in the whole system without adversely affecting power output. The results were promising. Overall, Hansen and Levine noticed decreases in system variability for all the portfolios they studied.

Those findings spurred a second study, conducted earlier this year, that combined both wind and solar resources in one portfolio. The team's hypothesis was that just as wind tends to blow differently in different places, the sun often shines when there is no wind. Using data from the National Renewable Energy Lab and Levine's study, Hansen and ERT fellow Bryan Palmintier simulated 43 wind and solar sites throughout the Midwest. All 43 sites were within the Midwest Reliability Organization's (MRO) area of responsibility regarding the grid. MRO is one of nine North American electric reliability regions, comprising Minnesota, North Dakota, Nebraska, as well as portions of Montana, South Dakota, Iowa, Wisconsin, the Upper Peninsula of Michigan, and two Canadian provinces. After running the numbers, they found that variability in the whole system went down by 55 percent compared to the average of all sites studied. Surprisingly, those results bore out whether they looked at the entire study group, or as few as six optimally selected sites.

"If you look at the average wind or solar site alone, there's a good amount of time each day that it's not generating electricity," explains Palmintier. "But if you combine all the wind and solar sites together, you find that 90 percent of the time you can get seven megawatts out" of facilities that at peak production might generate 100 megawatts.

That increase in electric output may sound small, but Palmintier contends that it's substantial enough to get utilities to think differently about their investments, especially if paired with programs to help users better manage the times at which they draw power from the grid.

To bolster these findings, the RMI team then expanded their analysis, first over a longer time period and then over a larger geographic area.

For MRO, Hansen and her colleagues simulated what would happen if they took into account three years of data. The findings were essentially the same as those from the first simulation, meaning that under "normal" weather patterns, the "optimal" portfolio of sites still reduced variability by the same amount.

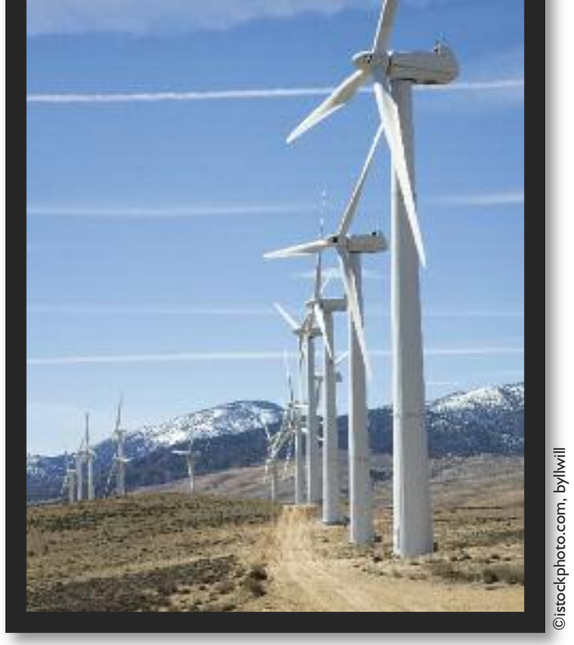
Also, the composition of the optimal portfolio didn't change much between the one-year and three-year simulations that the team did, explains Josh Traube, a fellow with the Energy & Resources Team. Three-quarters of the sites that were in the optimal one-year portfolio were also in the optimal three-year portfolio. And even if the three-year simulation were constrained to the sites chosen by the one-year simulation, the electrical output and variability stayed relatively similar.

This means utilities don't necessarily have to gather multiple years of data to make an informed decision about where to site the wind or solar installations in their portfolios.

"At least in this example, if you were to do only a one-year analysis, you wouldn't penalize yourself unnecessarily," says Traube.

The next step was to expand the simulation to include most of the Great Plains. Using additional data from the Southwest Power Pool and the Electric Reliability Council of Texas, Traube and Hansen simulated the power output and variability for 63 sites. Their conclusions: increasing the size of the study area tends to decrease variability as well. Much like the previous simulation, these results could be obtained with an optimal portfolio of as few as eight sites.

For Hansen, this last finding is crucial. If you're a utility, she explains, "you don't have to spend all your money on a huge number of sites to get the really big benefit" of a diversified portfolio.



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Ultimately, the RMI team hopes its research will demonstrate to utilities how to put more solar and wind on the grid. There's a financial incentive to decrease wind and solar's variability, says Hansen. If utilities can rely even a little more on power from these installations, they won't have to make as large of capital expenditures on coal or natural gas plants.

"The industry needs to properly understand the value (or conversely the cost) of variability," she says.

During the spring, the team presented their findings at the Power-Gen Renewable Energy & Fuels conference, the American Solar Energy Society's annual conference, and the American Wind Energy Association's annual conference. By participating in these industry forums, Hansen says she and her colleagues hoped to "seed the conversation with these kind of strategies and help wind [and solar] developers think about how they can apply them" in their long-term planning.

There's no panacea for moving away from fossil-fueled power generation. But Hansen and her colleagues' leading-edge research on variability, together with new storage technologies, better methods for responding to electricity demand, and two-way communication on the grid can go a long way toward supplying electricity—when we want it—without emitting greenhouse gases. •

Fellow Bryan Palmintier (center) of the Energy & Resources Team gets a "firm grip" on Senior Consultant Lena Hansen and Fellow Josh Traube.

Photo by Kyle Duba