Business & Technology Advisory

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NRECA
America's Electric Cooperatives

RADWIND Project Summary of NREL Report:
Wind and Solar Hybrid Power Plants for Energy Resilience

Highlights

- There is an increased interest in wind-solar hybrid power plants due to decreasing costs for these technologies.
- This report summarizes a national complementarity analysis to identify locations most suitable for wind-solar hybrid power plant development.
- Results show that regions in the Great Plains, Midwest, Southeast, and non-mountainous Northeast are particularly suitable for hybrid power plants. Also, pairing of wind and solar assets better meets constant load demand and reduces storage requirements compared to using only solar assets.

Background

The *Rural Area Distributed Wind Integration Network Development* (RADWIND) project[1] has identified wind-solar complementarity as a major topic of interest because hybridization or co-location of these technologies on the same distribution grid can deliver significant advantages in energy production and capacity contribution when compared to standalone projects. Battery energy storage systems (BESS) can provide additional value to these hybrid systems by further reducing intermittency. In January 2022, the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) released a report entitled *Wind and Solar Hybrid Power Plants for Energy Resilience*[2] which looks at this topic. This advisory offers a summary of that report.

Overview

The electric grid is evolving at a rapid pace due to driving factors like decarbonization, decentralization and digitalization. In addition to these, end-use consumers are beginning to demand more flexibility in their power mix. They are also asking for a change in the traditional one-way transactional rate payer relationship with their power providers to a two-way transumer relationship where they can both buy from and sell power to grid operators. All these changes make the grid more susceptible to planned and unplanned disruptions.

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[1] ***This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and RenewableEnergy (EERE) under the Wind Energy Technologies Office Award Number DE-EE0008958.***

[2] Clark, Caitlyn E., Aaron Barker, Jennifer King, and James Reilly. 2022. Wind and Solar Hybrid Power Plants for Energy Resilience. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5R00-80415. https://www.nrel.gov/docs/fy22osti/80415.pdf.

Now, more than ever, there is a need for resiliency strategies in the face of evolving consumer needs, aging infrastructure, and extreme weather events.

The combination of diverse distributed generation technologies and storage can offer inherent resiliency benefits when compared to a single centralized generator. However, large standalone wind and solar power plants are usually location-specific and sited based on the strongest available resources. For example, a large wind farm depends on a location's resources (*Is it windy?*), its temporal pattern (*How often or when is it windy?*), and the availability of complementary sources (*Is there hydropower for backup?*).

While the wind and solar industries have often been seen as competitors, there is a growing recognition that these technologies can complement each other in many parts of the country. In general, wind energy's ability to generate when the sun is not shining offers an obvious source of complementarity. In particular, wind and solar resources are most complementary if the windy season is not also the sunny season; modeling finds that in this situation a combination of both technologies is typically less expensive than either alone. This study developed a method to identify areas in the United States where wind and solar hybrid plants can provide enhanced resilience value to distributed grid systems, using both resilience and reliability metrics. Due to the sensitivity to local conditions, especially at the distribution level, a microgrid near Memphis, TN was used as a reference system to validate the results.

Data & Methods

The *Wind Integration National Dataset Toolkit* (WIND Toolkit) was used to collect hourly wind speed and direction data at a modeled height of 100 meters. Global horizontal irradiance (GHI) data were used as a representative metric for total solar resource.

Complementarity was measured from wind speed and GHI by calculating the Pearson coefficient (r) using the equation below:

$$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$$

Where $\bar{x}$ is the mean of the vector x, $\bar{y}$ is the mean of the vector y, and the vectors x and y represent the wind and solar data, respectively. The resulting Pearson coefficient r is on a scale from -1 to 1, with a score of -1 representing perfect negative correlation, a score of 0 representing no correlation, and a score of 1 representing perfect correlation.

A perfect positive correlation means that the wind and solar resource profiles occur at the same time in a given location, while a perfect negative correlation means that the wind and solar resource profiles are perfectly complementary, occurring inversely at a given location.

Results & Conclusions

As shown in figures 1 and 2, daily-averaged and hourly-averaged complementarity analyses show that areas in the Great Plains, Midwest, Southeast, and non-mountainous Northeast are all regions with high complementarity. In the daily-averaged analysis (figure 1), there are fewer regions of the United States that are complementary compared to the annual, hourly-averaged analysis (figure 2). This indicates a need to use hourly-averaged analyses to fully account for the ability of hybrid resources to meet hourly local demand.

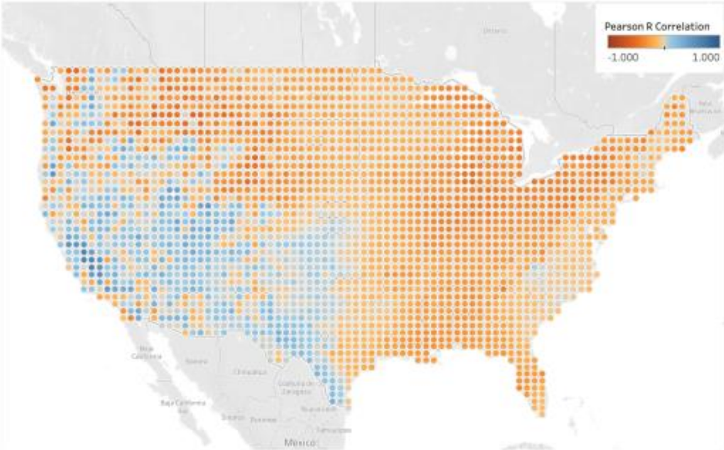

Figure 1: Annual, daily-averaged complementarity for 2013

Figure 2: Annual, hourly-averaged complementarity for 2013

Potential Future Research by NREL

The authors identified two areas of future work. First, reducing uncertainty in local resources by ensuring consistent, multiyear resource data which are analyzed at the local level to estimate power system reliance through reliability-based hybrid metrics and resilience frameworks. Second, considering low-probability events with metrics that estimate hybrid benefit to renewable energy generation reliability. In addition, while this report touches on the addition of battery energy storage to wind-solar hybrids, more research on how and when storage is most valuable would be useful.

Additional Information on NRECA Research's RADWIND Project

For more information on the RADWIND project and additional resources, please visit the project landing page at www.cooperative.com/radwind.

Want to stay informed of our progress with the RADWIND project, and provide your input and feedback? We welcome all NRECA voting members to join the project as advisors. Contact our team at: RadwindProject@nreca.coop.

Contacts for Questions

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