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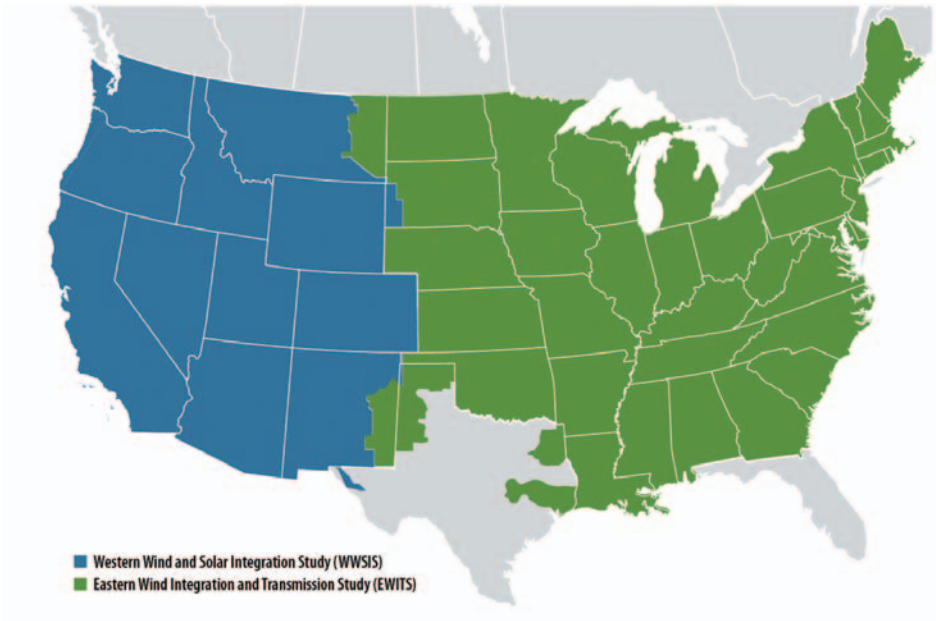
NREL Confirms Large Potential for Grid Integration of Wind, Solar Power

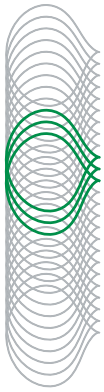
To fully harvest the nation's bountiful wind and solar resources, it is critical to know how much electrical power from these renewable resources could be integrated reliably into the grid. To inform the discussion about the potential of such variable sources, the National Renewable Energy Laboratory (NREL) launched two key regional studies, examining the east and west sections of the U.S. power grid. The studies show that it is technically possible for U.S. power systems to integrate 20%–35% renewable electricity if infrastructure and operational improvements can be made.

The first report, the "Eastern Wind Integration and Transmission Study" (EWITS), explored the impact of shifting up to 20%–30% of the power in the Eastern Interconnect of the United States to wind energy by 2024. The appraisal provided a high-level analysis of the integration and transmission requirements needed to deliver the wind energy—located principally in the Midwest and off the Atlantic Coast—to load centers concentrated along the eastern seaboard.

The report sought to answer questions that utilities, regional transmission operators, and planning organizations had about wind energy and transmission development in the East. For example, researchers compared infrastructure needs for harnessing local, low-capacity wind resources with the requirements for developing more distant, higher capacity resources. The analysts also determined the amount of transmission infrastructure needed to support higher penetrations of wind power.



The Spectrum of Clean Energy Innovation



Through deep technical expertise and an unmatched breadth of capabilities, NREL leads an integrated approach across the spectrum of renewable energy innovation. From scientific discovery to accelerating market deployment, NREL works in partnership with private industry to drive the transformation of our nation's energy systems.

This case study illustrates NREL's analysis and decision-support capabilities, which enhance innovation across the spectrum. This example highlights analysis contributions in Systems Integration.

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

The study consisted of three main parts: a wind resource assessment and wind plant siting study, a transmission study, and a wind integration study. Using a database of potential wind power sites and detailed, time-dependent estimates of the power that would be produced at those sites over the course of three years, NREL analysts examined three scenarios for reaching 20% wind power and one scenario for reaching 30% wind power in the Eastern Interconnect.

After analyzing the resulting data, NREL found that there are no fundamental technical barriers to the integration of 20% wind energy into the electrical system. However, the report noted that transmission planning, system operation policy, and market development would need to continue to evolve for this penetration level to be achieved.

The EWITS study showed that interconnection-wide costs for integrating large amounts of wind generation would be modest under a scenario in which operating pools were coordinated over larger geographic areas. This is because increasing the geographic diversity of wind power projects in a given operating pool generally makes the aggregated wind power output more predictable and less variable. The study concluded that wind power could provide a highly cost-effective means of reducing carbon emissions.

The companion study, the "Western Wind and Solar Integration Study" (WWSIS), looked at adding enough wind and solar power capacity to the grid to produce 35% of the WestConnect's electricity by 2017. WestConnect is a group of utilities in Arizona, Colorado, Nevada, New Mexico, and Wyoming that are working to enhance wholesale electricity markets in the West. The study was undertaken by a team of wind, solar, and power systems experts across both the private and public sectors. WWSIS simulated power systems operations in WestConnect and across the West, with an aggregate wind and solar penetration of 27% across the Western Interconnection. Similar to EWITS, this study was set up to answer questions that utilities, public utilities commissions, developers, and regional planning organizations had about renewable energy use in the West. It used detailed, time-dependent models of wind speeds and cloud cover over the course of three years to estimate the power production from posited wind and solar plants in the region.

Among other questions, NREL analysts explored the issue of whether geographic diversity of renewable energy resources in the West would mitigate variability for the grid. The team also analyzed the role and value of energy storage and evaluated how reserve requirements could be modified. Given the expanse of the area, NREL staff weighed the benefits of wind and solar forecasting and how it might help the scheduling of conventional power sources. Because of the abundance of hydropower in the West, the analysts also considered how hydropower might help with the integration of renewable energy.

The study showed that it is operationally possible to accommodate 30% wind and 5% solar energy penetration in the West. To accomplish this, utilities will have to substantially increase their coordination of operations over wider geographic areas and schedule their generation deliveries on a more frequent basis than the hourly timetables currently in use.

The study also found that if utilities generate 27% of their electricity from wind and solar energy across the Western Interconnection grid, carbon emissions would decrease by 25%–45%, depending on the future price of natural gas. Fuel and emissions costs would also decrease by 40%. Finally, WWSIS authors concluded that wind and solar forecasts are essential for integrating these renewable energy sources into utility operations in a cost-effective manner.

For more information on these studies, access the systems integration page on the NREL Web site at www.nrel.gov/wind/systemsintegration/.

NREL's System Advisor Model Used in Study

Analysts for the WWSIS used NREL's System Advisor Model (SAM) to model hypothetical concentrating solar power (CSP) plants in the western United States. This NREL-developed tool was key in evaluating the technology's contributions to reliability and capacity in the region.

SAM, which looks at solar power systems from all angles, can be used to evaluate the levelized cost of energy. It combines detailed performance modeling, cost data, and financial models for most solar technologies within a user-friendly interface.

For the WWSIS, SAM's computer scripting language allowed it to quickly process data from hundreds of weather locations to provide a wealth of information to the study participants. Approximately 200 gigawatts of CSP plants with thermal energy storage were modeled in this effort. This information was then combined with modeled wind production data to carry out the study.

The types of solar power represented in SAM include such CSP technologies as parabolic troughs, dish-Stirling systems, and power towers, as well as flat-plate and concentrating photovoltaic technologies. SAM incorporates the best available models for analyzing the impact of changes to the physical system on the overall economics. But, most importantly, it promotes the use of a consistent methodology for analysis across all solar technologies, including financing and cost assumptions.

More than 5,000 users have downloaded the most recent version, which is available at https://www.nrel.gov/analysis/sam/.

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