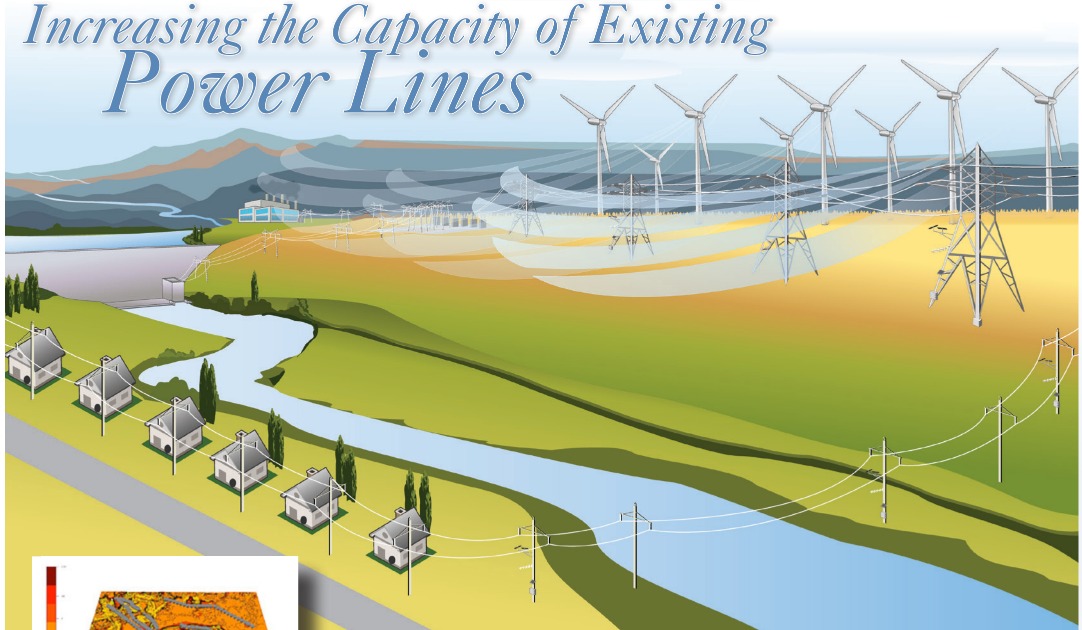
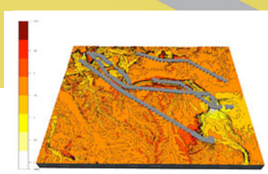
Concurrent cooling enables increased transmission line capacity and renewable energy integration.





INL researchers use data from weather stations to create a 3-D mean wind speed map. The scale shows wind speeds in meters per second.

A cool way to increase existing overhead power line capacity

In the continental United States, some 500 power companies operate a complex network of more than 160,000 miles of high-voltage transmission lines known as "the grid." The capacity of the grid has been largely unchanged for decades and needs to expand to accommodate new power plants and renewable energy projects. The difference in time and cost between using existing transmission lines or the construction of new ones can make or break plans for new wind or solar farms.

Wind power researchers at INL believe moving more electricity through existing transmission lines is both possible and practical. In areas where wind farms are being developed, there is potential to take advantage of wind cooling on transmission lines concurrent with wind power generation, identifying additional capacity and line sag and clearance concerns to the ground, or nearby object.

The key is to pay close attention to the weather. The more electric current a line carries, the hotter it gets. After a certain point, a line operator can not add additional current without overheating and damaging the line. However, an increase in wind speed blowing at a right angle to a high-voltage line can cool the line enough to safely increase the amount of current it can carry by 10 to 40 percent. INL researchers are funded by the Department of Energy's Office of Energy Efficiency and Renewable Energy Wind and Water Power Technology Office, and collaborate with Idaho Power Company, to research these efficiency gains.

Concurrent cooling project area

The amount of wind cooling a line receives varies with the wind's speed, its direction relative to the line, local ambient air temperature, and solar radiation exposure. To better understand this concept, researchers collaborate with several regional and national entities to study a windy part of southern Idaho's complex terrain and interstate utility transmission corridor. Together, they translate detailed weather, line loading, and conductor temperature information into dynamic line

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ratings—real-time estimates of how much current each segment of high-voltage line can safely carry, at the same time wind power is generated.

Power utilities operate transmission lines based on static ratings, which set a conservative limit on the amount of current the lines can safely carry without overheating. Static ratings assume there's little or no wind blowing, so in moderately windy places, a line's static rating is often much lower than its real transmission capacity. Those windy places are synergistic with wind power farms and are called concurrent cooling areas because the wind that generates power also cools transmission lines. Using dynamic line ratings to manage capacity on high-voltage lines in such places, helps increase the overall efficiency of power transmission.

Concurrent cooling model

INL researchers and Idaho Power installed 17 weather stations along transmission lines in a windy part of southern Idaho's interstate utility corridor.

Working with Idaho Power, researchers installed the weather stations to measure weather conditions along the more than 100 mile-corridor of high-voltage transmission lines. Due to the number of weather stations, researchers also use sophisticated computational fluid dynamics software to analyze air flow and fill in the environmental gaps—and expand the measurement points into full coverage—of the line sections between the weather stations.

The research team started with a weather simulation program that meteorologists, wind power developers and researchers typically use to model climate over uneven terrain—and modified the software to boost the simulation speed—and to add new data processing capabilities. Researchers also developed a new tool that takes weather model results and estimates how much the weather affects a power line's real transmission capacity. This helps determine the relationship between wind energy generation and resulting concurrent cooling of the transmission lines carrying that wind power to homes and businesses.

Improved line capacity forecasting

The research team continues to validate and refine its weather simulation model to run faster and generate increasingly more accurate results for extreme terrain. The team also works with Idaho Power engineers to train system operators in the use of weather station data and software tools to generate transmission capacity operating limits. The ability to reliably make such estimates on a large scale with high spatial resolution—brings power utilities one step closer to using a transmission system dynamically coupled with concurrent cooling processes—to yield greater all-around benefits.

INL researchers and Idaho Power installed 17 weather stations along transmission lines in a windy part of southern Idaho's interstate utility corridor.

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