Transmission line modeling tool suite

Advanced systems work together to increase power line efficiency

The more electric current an electric line carries, the hotter it gets. After a certain point, a line operator cannot add additional current without overheating and damaging the line. Yet researchers at Idaho National Laboratory believe moving more electricity through existing transmission and distribution lines is both possible and practical.

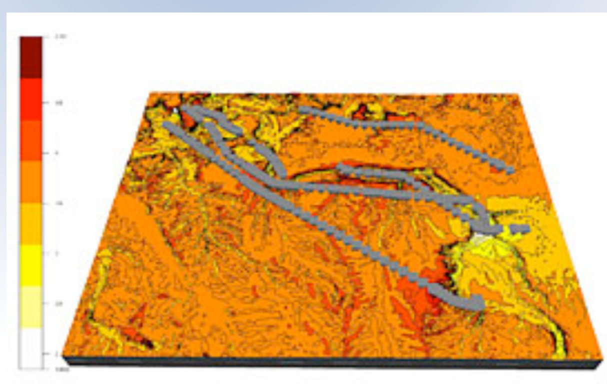
In areas where wind plants are being developed, there is potential to take advantage of wind cooling on transmission lines concurrent with wind power generation. Wind blowing at a right angle to a high-voltage line can cool the line enough to safely increase the amount of current it can carry by 10 to 40 percent.

Taking advantage of such conditions involves a dynamic line rating process that feeds real-time wind and power line data into models that compute a line's heat and current limits. INL researchers are developing a host of tools that can provide reliable data for each component of the equation. The research is funded by the Department of Energy's Office of Energy Efficiency and Renewable Energy Wind and Water Power Technologies Office.

Wind Data

Almost every country has created wind resource maps to find potential windy places suitable for building new wind farms. Modelers use a wide range of methods to create these

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.

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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The Human Systems Simulation Laboratory at INL is a reconfigurable virtual control room used for operator training and research.

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wind resource maps. Yet new methods are needed to capture the detail required to enable dynamic line rating.

INL scientists are working with the simulation company WindSim to develop specialized software supporting a new wind simulation method. Their wind atlas modeling method can create wind resource maps that can expand over hundreds of miles.

INL researchers and WindSim software developers are evaluating different approaches for combining computational fluid dynamics results for multiple smaller areas. To be as accurate as possible, the method combines wind speed and wind direction data from smaller simulation areas, and is based on scaling against measurements where available.

Line Data

Real-time information about line temperature and current is difficult to obtain.

The simultaneous presence of "slow" and "fast" dynamics in a transmission line makes the whole system computationally "stiff" — meaning its mathematical models are extremely challenging and time-consuming to solve. Furthermore, the current national standard (IEEE Std. 738) addresses neither the interactions between the inherent dynamics, nor how lines respond to perturbations.

INL researchers are developing a time scale analysis approach to capture the dynamic interactions and compute instantaneous values of line current and line temperature.

Line Capacity Limits

Based on instantaneous line temperature, the analysis approach can determine a safe level of ampere capacity, or "ampacity," which defines the maximum amount of electric current a conductor or device can carry before sustaining immediate or progressive deterioration.

INL researchers are developing a Java-based software package called General Line Ampacity State Solver (GLASS) to compute real-time limits based on current conditions at sparsely located weather stations. It does this by using actual Geographic Information System (GIS) data along with previously measured weather conditions and advanced computational models.

GLASS can help the end-user determine, in real-time, the limiting ampacities and thermal ratings for any given transmission line segment. This capability enables utility companies to use dynamic line rating to adjust power production throughout their grid network according to these computed restraints.

Control Room Recommendation

Providing advanced data directly to control rooms will allow operators to make decisions based on reliable data with less uncertainty about real-time conditions or limits. However, that information needs to be conveyed in a way that enables operators to quickly and safely adjust transmission loads.

Utility operators already monitor a massive amount of information in the control room. Numerous readings and data streams help them quickly match supply to demand. Rather than adding to the number of factors operators must consider, INL researchers want to integrate advanced modelling information into a simple recommendation for operators.

The goal, developers say, is to integrate advanced modeling into control rooms as seamlessly as possible. Rather than compounding control room complexity, the new information would be consistent with existing displays and presented in a way that's easy to process.

By considering the actual needs of control room operators, INL aims to help make dynamic line rating a tool that can be easily integrated into today's utility control rooms.

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