How not to short-circuit the clean energy transition

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Researchers at the National Renewable Energy Laboratory (NREL) have learned a lot about how to reliably integrate large amounts of wind and solar power onto the grid—but there are a few outstanding challenges.

One such challenge is making sure the grid is protected if there is a fault, such as a short circuit. In a new guidebook and explainer video, NREL explains how to solve this challenge and maintain power systems protection with higher levels of renewables in the future grid.

The next challenge to tackle after inertia

In the electric power sector, there has been considerable effort to understand how grid planning and operation might change with large-scale deployment of resources like wind and solar photovoltaics (PV), which use inverters instead of the synchronous generators in conventional power plants.

The associated decline in power system inertia had been thought to pose a major challenge to maintaining a reliable future power system. In 2020, NREL countered this by releasing a video and guide explaining the role of power system inertia in keeping the lights on.

These pieces described how although growth in inverter-based resources will reduce the amount of inertia on the grid, there are multiple existing or possible solutions for maintaining or even improving system reliability—so grid planners and operators have no need to panic.

However, inertia is just one of several challenges that need to be addressed as the grid evolves.

"While it hasn't been discussed as widely as inertia, fault protection is another issue to figure out as inverter-based generation continues to grow," said Paul Denholm, NREL principal energy analyst and lead author of both guides. "And we have ideas on how it can be addressed."

What is fault protection and why does it matter?

The most typical type of fault is a short circuit. On the power grid, short circuits can occur, for example, when two wires touch, or when a tree touches a wire. This causes the generators to produce a big surge of electrical current. This is called fault current, and it can lead to fires and damage equipment if not corrected.

In today's power system, fault current is mostly produced by synchronous generators in fossil, nuclear, and hydroelectric plants, which can inherently produce large amounts of current. However, inverter technology is not typically designed to produce large amounts of fault current—so in a future grid with high levels of solar PV and wind, the power system may need to find new ways to provide fault protection.

Report gives the full story

To educate policymakers and other interested stakeholders, NREL researchers have released Understanding Power Systems Protection in the Clean Energy Future, which provides a brief overview of system protection and fault current in in maintaining a safe power system. It describes why alternative approaches may be needed with increasing deployment of wind and solar generation, and it addresses various approaches to maintaining system protection in the evolving grid.

"There are a range of options that can maintain system protection, including some that are very well understood and have a high degree of certainty, like synchronous condensers," said Ben Kroposki, director of NREL's Power Systems Engineering Center and co-author of the guide. "Other options could include entirely new protection schemes that do not rely on large fault current. These are in earlier stages of development so they're less certain, but they could ultimately provide the same or even higher levels of protection at a lower cost."

So, while there is little doubt that future power systems can maintain

adequate fault protection with increased renewable deployment, significant uncertainty remains as to what will be the best approach.

"The biggest challenge to determining the cost-optimal mix of resources might be understanding both the need and cost of various options, which will likely vary significantly based on location and mix of existing and future resources," Denholm said.

At NREL, our work continues, as researchers seek answers to one challenge at a time on the road to a cleaner, more affordable, and more resilient grid.

More information: The report is available online: www.nrel.gov/docs/fy22osti/82269.pdf

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