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Connecting dead ends increases power grid stability

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Climate change mitigation strategies such as the German Energiewende require linking vast numbers of new power generation facilities to the grid. As the input from many renewable sources is rather volatile, depending on how much the wind blows or the sun shines, there's a higher risk of local power instabilities and eventually blackouts. Scientists from the Potsdam Institute for Climate Impact Research (PIK) now employed a novel concept from nonlinear systems analysis called basin stability to tackle this challenge. They found that connecting dead ends can significantly increase power grid stability. The findings are confirmed by a case study of the Scandinavian power system.

"The cheapest and thus widespread way to implement new generators into a high-voltage power grid is by simply adding single connections, like creating dead-end streets in a road network," says Peter J. Menck, lead author of the study to be published in *Nature Communications*. To test the resulting system's stability, the scientists simulated large perturbations in a standard electrical engineering model. "We found that in the power grid nodes close to the dead-end connections, the ability to withstand perturbations is largely reduced," Menck says.

"Yet it turned out that this can be easily repaired by judiciously adding just a few transmission lines," Menck says. Apparently, the provision of alternative routes in the network should allow for a dispersion of perturbation effects. Thereby, technical protection mechanisms at the different nodes of the grid can deal with problems, while dead ends make the effects culminate at single points of the network.

Applying a novel mathematical concept for the first time

These new insights are the result of applying for the first time the novel mathematical concept of basin stability developed at PIK. "From energy grids to the Amazon jungle or human body cells, systems possess multiple stable states," explains co-author Jürgen Kurths who leads the institute's research domain 'Transdisciplinary Methods and Concepts'. "To understand blackouts, forest dieback, or cancer, it is crucial to quantify the stability of a system – and that's precisely what we're now able to do."

The concept conceives a system's alternative states as points in a mountainous landscape with steep rocks and deep valleys. The likelihood that a system returns to a specific sink after suffering a severe blow depends on how big this basin is. "We're putting numbers on this," says

Kurths.

Compared to the costs of a blackout, adding lines would be affordable

"Compared to the potential costs of a blackout, adding a few transmission lines would definitely be affordable," says co-author Hans Joachim Schellnhuber, director of PIK. "The new study gives just one example that innovative solutions, in our case even based on already existing technology, can indeed help master the transformation of our energy system, for many good reasons such as climate stabilization."

More information: Menck, P.J., Heitzig, J., Kurths, J., Schellnhuber, H.J. (2014): How dead ends undermine power grid stability. *Nature Communications* DOI: 10.1038/ncomms4969

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