New modeling tool describes fairer electricity trade

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Figure 1. Optimal scenario for power trade between the nations of Northeast Asia, from the perspective of the conventional model. Greater arrowhead size indicates higher power throughput. Credit: Pavel Odinev/Skoltech

Skoltech researchers and their colleagues have proposed a new model for the interaction of nations trading electricity and their network lines planning. Described in *IEEE Transactions on Power Systems*, the model suggests an explanation for why there is no cooperation in some of the regions of the world where it seems well worth it from an economical standpoint, along with possible solutions for how to make it happen. At its core is the realization that earlier approaches failed to assign proper value to the stability of economic ties.

There are many reasons for countries to exchange electrical power. The most obvious ones are that some geographical locations are just better suited for producing electricity, to the point that it may be ludicrous to generate power at a cost several times higher than what you can buy it for from a neighbor. Also, the demand for electricity fluctuates widely throughout the 24-hour cycle, so a power supplier tends to have excess output at least at some point in the day that it is willing to export.

To find out optimal ways to expand power trade, researchers use mathematical models that balance the economic interests of the participating nations and suggest where transmission lines should best be positioned and what the optimal power throughput through each of them is. The output of such a model might look something like this (fig. 1).

The shortcoming of the conventional model is that planning is driven by economic cost-benefit analysis only, but with projects expected to last for decades it is also vital to account for the propensity of each of the parties to quit. This is something the new approach proposed by Skoltech researchers and their colleagues attempts to address, resulting in a different interconnections plan for the same region (fig. 2).

Figure 2. Optimal scenario for power trade between the nations of Northeast Asia, from the perspective of the new model. Note, for example, how the arrows from (1) to (2) to (4) are much smaller than in figure 1. Credit: Pavel Odinev/Skoltech

Compared in purely economic terms, the earlier model wins by a small margin. For the scenario depicted in figures 1 and 2, for example, it is predicted to generate about $7 billion per year in savings over the course of two decades, or about 6% more than the newer, stability-aware model. But since the latter promotes longer-enduring projects, the team expects this to more than offset the savings gap.

The innovative approach for the proposed methodological framework for planning electricity trading between countries lies in connecting concepts from operations research, economics, and cooperative game theory. In particular, the stability of the interconnection project and the propensity of a country to abandon such a project are, for the first time, captured in a cross-border transmission planning model via bilevel programming.

"One of the stability issues with the standard approach is that it does not assign enough importance to the interests of transit countries. So, for example, the interests of the two principal players—the importer and the exporter—might be balanced, but the transit country would have an inferior position, making it more likely to veto the project. Our model considers the interests of the transit country in a fairer way," study co-author David Pozo of Skoltech said.

"The tool we're developing can also predict the harm that comes as a result of a certain party quitting. It's a useful byproduct of the model that allows the participants to stipulate appropriate penalties in the contract," the researcher adds.

More information: Andrey Igorevich Churkin et al, Enhancing the Stability of Coalitions in Cross-Border Transmission Expansion Planning, *IEEE Transactions on Power Systems* (2021). DOI: 10.1109/TPWRS.2021.3124988

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