Johns Hopkins University
Whiting School of Engineering
Department of Geography and Environmental Engineering

Brent Eldridge

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Optimal Power Flow in Electricity Markets

The optimal power flow problem, solved in all wholesale electricity markets in the US, finds the most efficient dispatch of power generation to serve electric demand. This typically means that the cheapest power generation is selected first, but the physical flow of power over the transmission grid can complicate the set of feasible solutions. Two examples are the limits to power flowing across transmission lines and the additional power that must be generated to account for line losses. Other concerns such as local reactive power reserves and voltage support are ignored in the common optimal power flow formulation used by electricity market software.

The AC optimal power flow is an accurate mathematical model of power flow, but it is nonlinear and non-convex and cannot solve within the time frame required for clearing the markets using currently available software. Software with linear approximations is used instead, but inaccuracies within the approximation cause the market solution to be different from the cheapest solution. There is a cost to using approximations.

My current research analyzes the effect of increasing intermittent generation on the performance of a generic dispatch model and proposes an alternative formulation. Uncertainty in the availability of renewable generation can cause network conditions to change dramatically, which can lead to uneconomic dispatch or unforeseen violations of physical limits. An alternative formulation could improve the physical accuracy of the optimization model while also keeping the constraints linear. As renewable generation increases, this model could help markets operate more economically and closer to the grid's physical limits.