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Optimal transmission network expansion planning in real-sized power systems with high renewable penetration

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Abstract— The deregulation of power markets and the high amount of renewable energy expected in the coming decades have originated new needs for the expansion of the transmission network. Transmission expansion planning (TEP), the problem that deals with identifying the optimal grid reinforcements, is therefore becoming increasingly relevant. TEP, notoriously difficult to solve, is also deeply affected by uncertainty in factors such as renewable generation. Approaches for TEP based on optimization have not been widely used given that their high computational requirements mean that they could not be efficient for large-scale, real systems.

We present a model that performs optimal TEP efficiently in a Stochastic Optimization context. The model uses a modified version of Benders' decomposition that benefits from several improvements that are described. It deals with the incorporation of contingencies by using a double architecture for Benders cuts and a progressive contingency incorporation algorithm. In addition, it is able to identify the potentially interesting candidate transmission lines automatically, which is especially interesting in large-scale problems. Finally, it incorporates some other enhancements to the decomposition, which enable a faster problem resolution.

This paper describes the optimization model in detail as well as its implementation. This is completed with a realistic case study that illustrates that optimal TEP can be applied to large systems with high renewable penetration as long as efficient models and implementations are used.

Index Terms— Transmission expansion planning; Power systems; Energy; Stochastic programming

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