

Multicut Benders Decomposition for Generation Expansion with Dynamic Probabilistic Reserves

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This study implements and compares single and multicut Benders decomposition (BD) for the generation expansion problem (GEP) involving numerous renewable energy plants, incorporating Time-Varying Dynamic Probabilistic Reserve (DPR). We first identify the conditions under which the second stage (operation problem) of the GEP is convex. However, even when the resulting problem is convex, the incorporation of DPR introduces complexity to the optimization process, which justifies the investigation of enhanced forms of BD.

DPR is computed by considering the forecast error of non-dispatchable renewable generation between consecutive hours. The forecast error accounts for the renewable generation at each hour for each scenario and day within the relevant horizon. It is defined using a convex combination of the expected value and the Conditional Value at Risk (CVAR) of the absolute value of the forecast error between consecutive hours. We show that this function is convex, and since it only appears on the Right-Hand side (RHS) of the reserve requirement constraint, the resulting second stage is convex.

Unlike most BD applications, the bottleneck in each iteration of solving a GEP lies in the second stage, which requires using Stochastic Dual Dynamic Programming (SDDP). Solving this stage takes significantly longer than the first stage, a small mixed-integer programming (MIP) problem. Therefore, implementing a multicut strategy in the first stage is particularly advantageous, as it trades a slight increase in the complexity of an easier subproblem for a decrease in BD iterations and, consequently, the number of second-stage solves.

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