

Optimal Spinning Reserves for Generation Outage Contingencies Satisfying AC Power Flow Constraints

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Abstract:

This research proposes a problem formulation that optimally allocates spinning reserves while satisfying AC power flow during contingencies. Those contingencies are all cases of single generation outage. For each contingency case, a generating unit is taken out of the system while the remaining units pick up the lost generation output by their spinning reserves. The problem takes into consideration power balanced equations along with their constraints of pre-contingency and all contingency states simultaneously while minimizing total cost as an objective function. The total cost consists of generation costs, spinning reserve costs and load shedding costs if any curtailments of load are needed during contingency. Load shedding could occur when the remaining generators fail to cover load and satisfy power flow constraints within specified ramping time. The proposed formulation is tested on a modified PJM's 5-bus case with seven generators including their ramping rates and ramping time as crucial parameters. The optimal solutions of generation output and spinning reserves considering generation outage contingency are illustrated and compared to basic optimal power flow (OPF) with no contingency. The generation outputs considering contingency are shifted from the basic OPF due to the prepared spinning reserves and changes of power flow during contingencies. The optimal pre-contingency generation outputs and their spinning reserves are calculated considering all post-contingency states so that the remaining generators can ramp up to cover lost generation for all contingency cases while satisfying power flow constraints. However, the optimal solutions may choose to curtail load in some contingency cases when losing a generator causes infeasible power flow. For future work, the formulation can be extended to determine optimal spinning reserves for typical N-1 contingency including transmission outage.