

Problem-Driven Scenario Reduction Framework for Power System Stochastic Operation

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Scenario reduction (SR) aims to identify a small yet representative scenario set to depict the underlying uncertainty, which is critical to scenario-based stochastic optimization (SBSO) of power systems. Existing SR techniques commonly aim to achieve statistical approximation to the original scenario set. However, SR and SBSO are commonly considered as two distinct and decoupled processes, which cannot guarantee a superior approximation of the original optimality. Instead, this paper incorporates the SBSO problem structure into the SR process and introduces a novel problem-driven scenario reduction (PDSR) framework. Specifically, we project the original scenario set in distribution space onto the mutual decision applicability between scenarios in problem space. Subsequently, the SR process, embedded by a distinctive problem-driven distance metric, is rendered as a mixed-integer linear programming formulation to obtain the representative scenario set while minimizing the optimality gap. Furthermore, ex-ante and ex-post problem-driven evaluation indices are proposed to evaluate the SR performance. Numerical experiments on two two-stage stochastic economic dispatch problems validate the effectiveness of PDSR, and demonstrate that PDSR significantly outperforms existing SR methods by identifying salient (e.g., worst-case) scenarios, and achieving an optimality gap of less than 0.1% within acceptable computation time.