Distributionally Robust Power Distribution Network Configuration

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Topology design is a critical task for the reliability, economic operation, and resilience of power distribution systems. This paper proposes a distributionally robust optimization (DRO) model for designing the topology of a new distribution system facing random contingencies (e.g., imposed by natural disasters). The proposed DRO model optimally configures the network topology and integrates distributed generation to effectively meet the loads. Moreover, we take into account the uncertainty of contingency. Using the moment information of distribution line failures, we construct an ambiguity set of the contingency probability distribution, and minimize the expected amount of load shedding with regard to the worst-case distribution within the ambiguity set. As compared with a classical robust optimization model, the DRO model explicitly considers the contingency uncertainty and so provides a less conservative configuration, yielding a better out-of-sample performance. We recast the proposed model to facilitate the column-and-constraint generation algorithm. We demonstrate the out-of-sample performance of the proposed approach in numerical case studies.