

Risk Sharing Among Microgrids: Connectivity Requirements and Optimal Control

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Abstract—We consider a collection of microgrids (MGs) with renewable generation capability that can operate independent of the main power grid. Such microgrids are increasingly becoming popular for critical services such as hospitals to function during catastrophic failures as well as among local communities. Microgrids must provide high probability guarantees for service over a finite horizon so they invest in battery energy resources (BES) to mitigate the risk of generation or load curtailment arising from the uncertainty in production/demand. With appropriate connectivity and control, the microgrids can share this risk and reduce the BES requirements for the same level of probabilistic guarantee. To study this, we present a chance-constrained BESs sizing methodology combined with power-sharing policy between microgrids (MGs) in a multi-MG power distribution network. In particular, given a power network and stochastic models of the RESs production and load demand, we provide a methodology to decide the minimum required BESs capacity of the MGs and a power transfer policy governing the amount of power transfer between the MGs, to minimize load and generation curtailment over a given time horizon $[0, T_f]$ with high probability. We further characterize the trade-offs between the BESs capacity and the power line capacity to provide a comprehensive system planning guideline. We find that there is a sharp threshold such that if and only if the power line capacities are above the threshold then the microgrids are able to completely pool their risk. Surprisingly, this threshold decreases with the increase in the time horizon. Our work suggests that it is feasible to design sparse and minimally connected microgrid networks that can operate with high probability service guarantees.

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