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Gradient-Based Reliability Optimization of Integrated Energy Systems Under Extreme Weather Conditions: A Case Study in Ningbo, China

Authors : Da LI, Peng Xu

Abstract : Recent extreme weather events, such as the 2021 European floods and North American heatwaves, have exposed the vulnerability of energy systems to both extreme demand scenarios and potential physical damage. Current integrated energy system designs often overlook performance under these challenging conditions. This research, focusing on a regional integrated energy system in Ningbo, China, proposes a distinct design method to optimize system reliability during extreme events. A multi-scenario model was developed, encompassing various extreme load conditions and potential system damages caused by severe weather. Based on this model, a comprehensive reliability improvement scheme was designed, incorporating a gradient approach to address different levels of disaster severity through the integration of advanced technologies like distributed energy storage. The scheme's effectiveness was validated through Monte Carlo simulations. Results demonstrate significant enhancements in energy supply reliability and peak load reduction capability under extreme scenarios. The findings provide several insights for improving energy system adaptability in the face of climate-induced challenges, offering valuable references for building reliable energy infrastructure capable of withstanding both extreme demands and physical threats across a spectrum of disaster intensities.

Keywords : extreme weather events, integrated energy systems, reliability improvement, climate change adaptation
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