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Robust Network Hardening Strategy for Enhancing Resilience of Integrated Electricity and Natural Gas Distribution Systems Against Natural Disasters

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Abstract:
Recent revolution of the electricity distribution sector, especially a deeper penetration of gas-fired distributed generations (DGs), intensifies the interdependence of electricity on natural gas distribution systems. Such integrated electricity and natural gas distribution systems (IENDS) are facing with significant threats from frequent natural disasters that cause enormous economic losses. Network hardening is regarded as an effective technique for enhancing resilience of IENDSs against natural disasters. This paper presents a trilevel robust optimization-based network hardening model for minimizing worst-case total weighted electricity and gas load shedding of IENDSs with respect to hardening budget limits and random damages caused by disasters of different severity levels. Specifically, distinct failure probabilities of overhead power lines and underground gas pipelines are considered, while DGs and gas storages are modeled as effective emergency response resources for supplying high-priority electricity/gas loads during disasters. The proposed model is solved by a column-and-constraint generation approach, in which nonlinear gas network constraints are linearized via Taylor series expansion. Numerical case studies evaluate the proposed robust hardening strategy against natural disasters.

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