The most frequent N-k line outages occur in motifs that can improve contingency selection

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Multiple line outages that occur together show a variety of spatial patterns in the power transmission network. Some of these spatial patterns form network contingency motifs, which we define as the patterns of multiple outages that occur much more frequently than multiple outages chosen randomly from the network. We show that choosing N-k contingencies from these commonly occurring contingency motifs accounts for most of the probability of multiple initiating line outages. This result is demonstrated using historical outage data for two transmission systems. It enables N-k contingency lists that are much more efficient in accounting for the likely multiple initiating outages than exhaustive listing or random selection. The N-k contingency lists constructed from motifs can improve risk estimation in cascading outage simulations and help to confirm utility contingency selection.