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Impact assessment of flood damage on power grid customers

Panagiotis Asaridis[1], Daniela Molinari[1], Francesco Di Maio[2], Francesco Ballio[1], and Enrico Zio[2,3]
[1]Department of Civil and Environmental Engineering, Politecnico di Milano, Milan, Italy
[2]Department of Energy, Politecnico di Milano, Milan, Italy
[3]MINES ParisTech, PSL Research University, Sophia Antipolis, France

Natural hazards are a leading driver of power outages worldwide. Although flooding has lower impact compared to other natural hazards, it may still have a significant impact on power grids functionality in terms of frequency, magnitude, and duration of power outage. Maintaining the security of power supply under emergency conditions triggered by natural hazards, such as floods, is a challenging task because of the inherent structural and dynamic complexity of the system. In such a context, this paper presents a new model for the estimation of direct, indirect, and systemic flood damage to power grids. The key objective of the model is to be an operational tool able to: (i) consider the magnitude, probability of occurrence, and spatiotemporal variability of flood hazard, (ii) identify the vulnerable components of power grids and evaluate their probability of failure in case of flood, (iii) analyze the cascading effects of individual or multiple failure states on the power transmission and distribution networks, (iv) and assess the impacts of power outages on the power-dependent economic activities and infrastructures. To achieve this goal, the model combines deterministic flood hazard scenarios, a spatially distributed power flow model, fragility curves of power grid components for different voltage levels, and a social model, describing the various users connected to the power grid. For quantitative illustration purposes, a synthetic model has been developed by referring to the IEEE 14 bus system benchmark, to which a spatial dimension has been allocated. Furthermore, to account for differentiated social impacts, the power flow model has been linked to a synthetic social model including several communities (hubs) with different social and economic characteristics.

The development of the synthetic model constitutes a preliminary step in understanding and quantifying the impacts that sustained power interruptions caused by floods can have on the customers of power grids. Next research efforts will be devoted, on the one hand, to the adoption of a probabilistic approach, by substituting deterministic hazard scenarios with spatial dependent, probabilistic ones; on the other hand, to the sensitivity analysis of the different modeling phases to identify the components of the model on which the final damage scenario depends mostly. The final aim is to provide a modeling and simulation tool for risk analysis, so as to enable stakeholders, authorities, and policy makers to formulate effective strategies to guarantee public security and ensure financial well-being.