MSc thesis proposal

- ## Title of the research

Development of a probabilistic modelling and simulation framework for evaluating the resilience of power grids to floods.

- ## Objectives of the research

Floods are increasing in frequency and magnitude due to the changing climate and socio-economic development. These events can trigger power outages with widespread impacts on social and economic activities that rely on electricity supply. A probabilistic modelling and simulation framework has recently been proposed for assessing flood risk to power grids (Asaridis et al., 2025). This framework enables the identification of critical components that are essential for maintaining power supply during flooding. Post-disruption restoration efforts of critical components often involve uncertainties related to the required repair tasks and the condition or accessibility of the supporting transportation network (Alkhaleel et al., 2022). While such aspects are central to resilience planning, they are not yet fully addressed in the existing framework. Assessing the time required for a power grid to recover after a flood event will allow identifying effective resilience-enhancing strategies (Movahednia et al. 2022).

The objective of this thesis is to model the recovery capacity of power grids affected by floods within an extended framework aimed at evaluating their resilience. Specifically, the research will contribute to the development of a resilience assessment framework incorporating a post-flood water retreat model to simulate recovery dynamics.

The research activities will include the following steps:

i. Literature review on the resilience assessment of power grids under natural hazards, with a focus on recovery phase and the use of restoration curves;
ii. Characterization of recovery strategies for flood-affected power grids, distinguishing between different types of interventions and their associated timelines;
iii. Development of a recovery capacity model that accounts for the diversity of strategies and accessibility constraints involved in post-flood recovery scenarios;
iv. Implementation of the model and algorithms using MATLAB and/or Python;
v. Application and validation of the framework on a realistic case study.

References

- Alkhaleel, B. A., Liao, H., and Sullivan, K. M.: Risk and resilience-based optimal post-disruption restoration for critical infrastructures under uncertainty, European Journal of Operational Research, 296(1), 174–202, https://doi.org/10.1016/j.ejor.2021.04.025, 2022.
- Asaridis, P., Molinari, D., Di Maio, F., Ballio, F., and Zio, E.: A probabilistic modeling and simulation framework for power grid flood risk assessment, International Journal of Disaster Risk Reduction, 120, 105353, https://doi.org/10.1016/j.ijdrr.2025.105353, 2025.
- Movahednia, M., Kargarian, A., Ozdemir, C. E., and Hagen, S. C.: Power grid resilience enhancement via protecting electrical substations against flood hazards: A stochastic framework, IEEE Transactions on Industrial Informatics, 18(3), 2132–2143, https://doi.org/10.1109/TII.2021.3100079, 2022.

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