RWTH AACHEN UNIVERSITY

E.ON Energy Research Center
ACS | Institute for Automation of Complex Power Systems

Master-Thesis:

Quantification of Resilience in Current and Future Interdependent Power Systems

Context:
In times of climate crisis and increasing global tensions, a fundamental transformation of energy supply systems is necessary to ensure the security, environmental compatibility and independence of energy supply. The power grid plays a key role in this transformation by replacing fossil power plants and integrating additional consumers, from industrial processes to heat pumps and electromobility. Consequences of this ongoing transition include stronger sector coupling (Power-to-X) and integration of modern ICT into the automation infrastructure in order to coordinate millions of decentralized generation plants and consumers safely and reliably. The interdependencies of systems in different domains and their aspects have been described in [1] on a high level. The aforementioned transitions also have the potential to make power systems more reconfigurable and provide self-healing capabilities and functionalities, thus making grids more resilient. The resilience concept and definition have been refined and sharpened over the last years, and quantification of resilience has been explored and formalized as shown in the resilience trapezoid shown in Figure 1 (see also [2]).

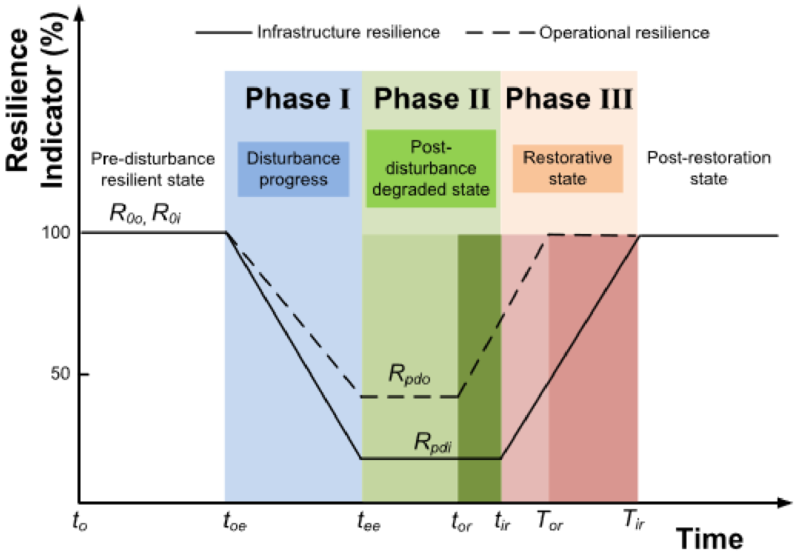

Figure 1: Resilience trapezoid [2]

The authors in [3] apply graph theory to show how resilience of cyber-physical power systems faced with typhoon disasters can be quantified. Yet this approach for quantification still focuses on the electrical part of the power system and does not incorporate the interdependence with other energy domains and the ICT and automation systems explicitly in the resilience indicators. The scope of this thesis is to identify relevant trends and impact factors that are likely to have an influence on power system resilience, with a focus on interdependencies to other domains. Based on these findings, shortcomings of current approaches to quantification of resilience are to be identified and addressed in specific example cases and metrics to improve resilience quantification.

Your tasks:

- Conduct a literature review to distinguish resilience from related concepts
- Critical literature review on what is the state-of-the-art for resilience quantification
- Identification of trends that are likely to impact power system resilience
    - Including both negative and positive effects
    - Focus on interdependencies with other domains and external factors and systems
- Identification of shortcomings and gaps for resilience quantification in the future
- Definition of specific example cases for resilience quantification in future power systems based on selected relevant trends and impacts
- Development and implementation of new or extended metrics for resilience quantification in the previously defined example cases

Your profile:

- RWTH student of Electrical Engineering or similar
- Knowledge of non-electric energy systems and/or ICT and automation systems is a plus

Notes:

The supervision can be in German or in English

References:

[1] S. M. Rinaldi, J. P. Peerenboom, and T. K. Kelly, ‘Identifying, understanding, and analyzing critical infrastructure interdependencies’, IEEE Control Systems Magazine, vol. 21, no. 6, pp. 11–25, Dec. 2001, doi: 10.1109/37.969131.

[2] M. Panteli, P. Mancarella, D. N. Trakas, E. Kyriakides, and N. D. Hatziargyriou, ‘Metrics and Quantification of Operational and Infrastructure Resilience in Power Systems’, IEEE Transactions on Power Systems, vol. 32, no. 6, pp. 4732–4742, Nov. 2017, doi: 10.1109/TPWRS.2017.2664141.

[3] B. Ti, G. Li, M. Zhou and J. Wang, "Resilience Assessment and Improvement for Cyber-Physical Power Systems Under Typhoon Disasters," in *IEEE Transactions on Smart Grid*, vol. 13, no. 1, pp. 783-794, Jan. 2022, doi: 10.1109/TSG.2021.3114512.

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