SPECIALIZATION PROJECT PROPOSAL:
COMPLEX NETWORK APPROACHES TO ANALYSING LARGE BLACKOUTS

Large blackouts or cascading outages are events in the electrical power system that have a very small probability of occurring but very serious societal consequences if they do. For this reason, such events are also referred to as high-impact low-probability (HILP) events or extraordinary events. Understanding and identifying such events has proven a great challenge that defeat conventional methods of power system analysis. Such problems are challenging because cascading outages involve a large and diverse number of complex phenomena. Furthermore, for power transmission systems with thousands of components, the number of possible outage combinations to consider is enormous.

Over the last decades, such problems have also attracted much interest from the physics community, and methods from complex network theory[1], self-organized criticality[2] and other branches of statistical physics have been proposed to complement the conventional power system analysis methods. Simply put, the idea is that applying such methods to simplified models can provide some fundamental insights that are not easily obtained through the simulation of very detailed power system models. In addition, using alternative methods with less detailed models can reduce computation time substantially, which makes them promising as quick "screening" methods for identifying high-impact outage combination.

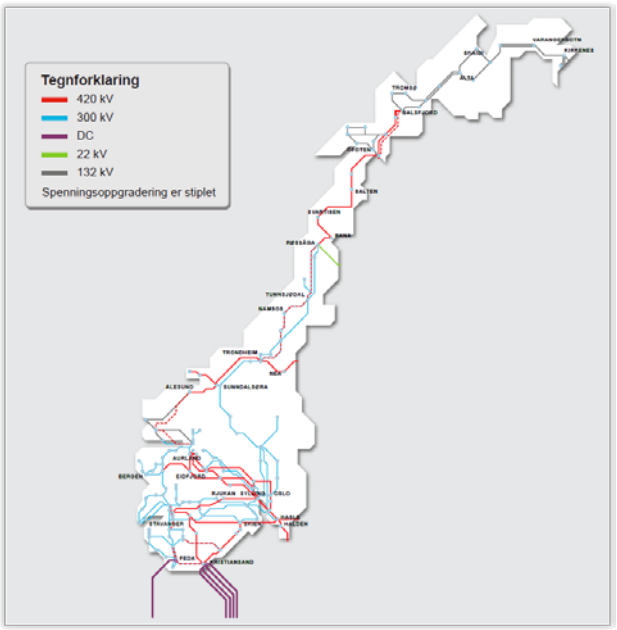

Figure: The Norwegian transmission system, from [3].

SINTEF Energy Research is currently leading the research project "Analysis of extraordinary events in power systems" in collaboration with Norwegian transmission system operator Statnett and other partners. The proposed specialization project and master thesis work will be carried out in collaboration with this project, under the co-supervision of research scientists at SINTEF Energy Research with a background in physics and mathematics. The main objective of the specialization project and master thesis is to assess the benefits and drawbacks of using a complex network approach to analysing large blackouts. Exactly which tasks are to be carried out to meet this objective can be adapted to interests of the candidate. A natural first task in the specialization project is to perform a literature study to familiarize oneself with the relevant

methods, the state of the art and most recent developments in the field[4], as well as the main characteristics of the electric power system. Based on the literature study, the candidate can then select a relatively simple model to implement and test it on a realistic test system. During either the specialization project or the master thesis work, the model could be extended and/or compared with more detailed simulation tools developed at SINTEF Energy Research.

Depending on the interests of the candidate and the developments during 2017 in the SINTEF research project overall, there are several possibilities for extending the scope of the specialization project or the master thesis. Examples of areas that could be discussed include Monte Carlo simulation (including importance sampling and uncertainty quantification), Bayesian networks, investigation of heavy-tailed (power law) distribution functions, and decision entropy theory. As for the prerequisites of the specialization project, it is an advantage if the candidate has a strong background in statistics, statistical physics and numerical physics. Interested candidates are encouraged to contact us for any questions they might be having regarding the proposed specialization project.

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References:

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[3] Statnett, *Nettutviklingsplan 2015*. Available online: http://www.statnett.no/Nettutvikling/Last-ned-Nettutviklingsplan-2015/.

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