Electrothermal coordination in cable based transmission grids operated under market based conditions

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Based on the decision of undergrounding the entire transmission system up to and including 150kV plus large parts of the 400kV system, the Danish transmission system operator (TSO) Energinet.dk initiated a research project with the purpose of finding the most optimal approach to dimensioning the future individual cable lines. Also included was the goal to identify the most optimal way of operating a transmission grid consisting mainly of high voltage cables. This paper documents some of the findings in the research project, whereas a full report is presented in a PhD thesis.

All the different stakeholders who are involved in designing, installing, operating and maintaining the cable grid were taken into account in these investigations. Having investigated the present state of the art within dynamic rating of cables and optimal power flow (OPF) in transmission grids, it was determined that none of the methods found in the literature, or the tools available on the market, were sufficient to fulfill the needs related to the Danish transmission grid. Together with the stakeholders, it was therefore determined that a novel concept should be developed to suit such a market based approach to cable grid operation.

As it is the clear intention that the transmission grid should be operated based on the physical limitations of the cables under real time environmental and electrical conditions, the presently used method, where the ampacity of the cables is calculated for one (or a few) conditions only, is insufficient. Instead, the research team applied a concept denoted ElectroThermal Coordination (ETC) where the temperature of all lines in the transmission grid is monitored (by measurements and/or simulations), in real time, and can be predicted on the basis of measured and predicted load conditions. With this temperature information the grid operator can load the system harder and control it with higher precision than what is presently possible with the steady state approach to cable rating.

Until now ETC has been of mainly academic interest, but this paper describes how ETC can be implemented in transmission systems as they look today, taking into account both political decisions and market based conditions such as the ones, the European transmission systems are operated under. The description of implementation strategies is supplemented by studying real power cable cases from the Danish transmission system, and it is shown that great benefits can be achieved when utilising ETC instead of the present conservative approach to transmission cable dimensioning and operation. The case studies show that both the grid planning, day ahead planning and real time operation of the power grid will be able to benefit from the introduction of ETC.