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Closure of "A Unified Analysis of Security-Constrained OPF Formulations Considering Uncertainty, Risk, and Controllability in Single and Multi-area Systems"

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This note is a response to the discussion on the session "Managing uncertainty in power systems" by O. Alizadeh Mousavi and R. Cherkaoui [1] from the IREP Symposium 2013.

Alizadeh Mousavi and Cherkaoui discuss many important points regarding management of uncertainty in power systems. A key issue they mention is how one can account for low probability events with severe consequences in optimization algorithms, and how one can evaluate the performance of algorithms against these events, for example, cascading outages. We would like to address three key points from their discussion: 1) the concept of risk; 2) the definition of robustness and resilience, and 3) proper evaluation of risk.

1. Risk

Uncertainty is one of the main causes of power system unreliability and/or inefficient operation. It arises mainly from load and renewable energy production forecast deviations and equipment outages. Risk indices can improve decision making in power systems operation, as they provide information both about the impact/severity of an event and its occurrence probability. Several risk indices have been used in the literature. Each reflects the information that one wishes to extract. One class of risk indices considers customer side metrics, e.g. Expected Energy Not Served (EENS), which directly reflects the risk faced by consumers [2]. This class of risk indices incorporates the risk of blackouts through cascading events, as discussed in [1]. The computational effort involved in the evaluation of these criteria, which is typically based on Monte Carlo simulations, is usually high.

Another class of risk is defined by risk indices that depend on the amount of technical violations, i.e. component overloads, voltage drop, etc. [2], [3]. The evaluation of such risk indices is more directly related to specific components and requires less computation, making these indices more suitable for incorporation in optimization during the scheduling phase. They do not directly reflect the risk of cascading outages, but implicitly assume that a higher amount of constraint violations lead to a higher risk of cascading. In addition to the above mentioned classes of risk indices, there exist probabilistic criteria that address security problems arising from forecast deviations by providing guarantees that the constraints will only be violated in a certain percentage of the cases.

The idea of a probabilistic and risk-based optimization is to include more information in order to allow for a better trade-off between security and cost. The risk index (or indices) used in the optimization must be chosen such that the resulting dispatch achieves the desired performance. One measure of desired performance can be the probability of constraint violation as in [4]. The method in this paper can capture different risk indices; however, incorporating the risk of cascading events or blackouts in planning algorithms is a challenging problem, as pointed out in [1].

2. Robustness and resilience

There are many competing interpretations of robustness and resilience. For example, one could define a system as robust only if it is resilient to extreme perturbations. Therefore, we do not believe there has to be a tradeoff between these two system attributes. Systems are generally designed to be robust over classes of perturbations and when a perturbation outside of these classes occurs they may be unable to recover. If we would like to be robust against these extreme events we should take them into account in the design of the system and the operation of it (of course, this comes at a cost). As [1] mentions, it may be very difficult to analytically account for complex perturbations and events like cascading outages in the optimization algorithms. We agree that this is an open question.

3. Evaluation of risk

There are two important steps when evaluating planning algorithms. The first step is to evaluate the desired performance, which is part of the optimization problem design. For example, in [4], we check that the probability of constraint violation is kept below the chosen level. Then, as mentioned in [1], we should evaluate the proposed solution for customer related risk indices, such as EENS, in order to understand the influence of optimal planning outcomes on the correlation between small and large blackouts, shown in [5]. This could provide valuable information about how the choice of a risk index based on technical violations (for optimization purposes) influences the risk faced by the customers. However, depending on the selection of the index, the evaluation process could be computationally demanding and care must be taken in the design to capture the relevant effects. Further, the outcome of this evaluation would only be empirical and depend on the specific case.

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