Distributed Stochastic Reserve Scheduling in AC Power Grids With Uncertain Generation

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Master Thesis Project

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Description

The large-scale integration of wind generation in power systems represents a significant challenge for the Transmission System Operators (TSO) due to the unpredictable and highly variable pattern of wind power generation. In order to accommodate the unpredictable nature of wind power, the productions and consumptions scheduled in an electricity market need to be modified during the actual operation of the power system. Operating reserves balance mismatches between generation and demand and their sufficient provision is crucial in terms of a secure power system operation.

Reserve scheduling problems are typically addressed under a loss less DC power flow set-up [1]. This is based on the assumption of constant voltages, while ignoring the active power losses. Recently, progress has been made toward formulating probabilistic variants of the reserve scheduling problems, still using a DC approximation of the power flow equations [2]. Operating power systems with high amount of renewable generation (e.g. wind power), highlights the necessity of formulating stochastic variants of standard day-ahead planning problems like reserve scheduling, while enhancing the developed algorithms with AC optimal power flow (OPF) models to achieve a more accurate representation of the grids.

Objectives

In [3], we formulated the reserve scheduling problem for a power grid with wind power generation as a chance constrained optimization problem, while using an AC OPF relaxation similar to [4]. This allows us to account for the stochastic uncertainty affecting the system, but also leads to a complex optimization problem that is in general hard to solve. Therefore, we proposed a heuristic approach where a few wind power profiles are extracted and only the corresponding constraints are enforced similar to [5, 6]. The resulting optimization problem involves then an AC OPF type of problem for each of the extracted wind power profiles.

This proposal concentrates toward investigating the potential of substituting the heuristic algorithm with a more sophisticated scheme, enabling to inherit probabilistic performance guarantees regarding the satisfaction of the chance constraints. Substantial current research focuses on formulating a large-scale semi-definite problem (SDP) and solving in a distributed fashion similar to [7, 8, 9]. A certain structure for employing distributed setting is considered and that has to be investigated by the student.

Of course other methods and directions, depending on the student's interest, could be analyzed and investigated. The mentioned goals here should be understood as some input thoughts and not as strictly recommended tasks.

Requirements

The project combines rigorous mathematical aspects with practical research and would be an excellent experience for those wishing to go to industry. A solid background in convex optimization is required. Any knowledge in optimal control is useful, however not required. The project is well suited for a student that enjoys to try out new ideas. By inspiration from the aforementioned problem, we promote to facilitate knowledge transfer from theory to practice. The work loads are as follows:

- Theoretical: 40%
- Computational: 60%

Supervisors

Vahab Rostampour and Tamás Keviczky are with the Delft Center for Systems and Control (DCSC) at the Delft University of Technology (TU Delft). Interested students are highly motivated to contact any of the supervisors listed above to discuss further details about the mentioned project.

References

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