Title: Coordinated maintenance scheduling and congestion management in electric power systems

Description: Maintenance scheduling for electric power system assets is a core task of generation companies, Transmission System Operators (TSOs) and Distribution System Operators (DSOs). Typically, asset managers of these companies determine the maintenance schedules independently and operational planners at the TSO check the feasibility of the combined schedules by means of N-1 security analysis in multiple time frames to identify potential congestions. If no suitable remedial action would be available in system operation to mitigate the congestion, then some maintenance schedules should be modified. Today, this requires significant coordination effort among the TSO, DSOs and generation companies with a large amount of iterative, manual work.

This student project will develop a method to coordinate and optimize maintenance scheduling and congestion management decisions in order to reduce complexity of today's processes, increase efficiency, and enhance energy security. The project will focus on Swissgrid's needs, will be part of a larger ongoing R&D activity in the company, and the method will be packaged into a software tool.

Mathematically, this is a hard, large-scale, mixed-integer non-linear optimization problem. The R&D team has conceptualized a solution approach with two levels. The objective of Level 1 is to compute maintenance schedules that are as close as possible to preferred maintenance windows submitted by the asset managers. Level 2 ensures feasibility of maintenance work and avoids grid congestions by optimally activating remedial actions (topological actions, phase shifters and redispatch).

- <u>Level 1 – Master problem:</u> Optimization of discrete variables (including but not limited to maintenance decisions) using population-based or non-population- based metaheuristics.
- <u>Level 2 – Slave problems:</u> Security Constrained Optimal Power Flow (SCOPF) problem for each grid snapshot and contingency to optimize the operational continuous variables. Optimization modules of the commercial software PSS/E can be used in this level.

Current work has focused on Level 1 and built a proof-of-concept prototype in Python based on Genetic Algorithms (GAs). Under the guidance of the R&D team, the student will extend and improve the prototype for Level 1 and work on Level 2. Specifically, the following activities are conceivable:

- Extend Level 1 formulation (e.g., additional objective terms and maintenance constraints, consideration of multiple preferences, iterative solution approaches, etc.).
- Propose enhancements of the GA to improve performance (e.g., adaptive GA parameter settings, constraints modeling, combination with local search or machine learning).
- Investigate the use of other metaheuristics as alternatives to GA for the Level 1 problem, which are well suited for applications with limited fitness function evaluations.
- Familiarize with PSS-E's Python interface to link Level 1 and Level 2 and its SCOPF modules, and potentially make modifications to them depending on the needs of Level 2 problems.
- Improve computational efficiency and scalability (e.g., using a divide and conquer approach, decomposition techniques, or reducing the SCOPF problem size with contingency filtering).
- Build a simple Graphical User Interface (GUI) to facilitate usage of the tool.
- Experiment with using cloud computing to solve the problem (Azure cloud).
- Conceptualize different solution approaches and/or stochastic extensions for this problem.

Based on the list above, the exact tasks will be defined together with the student depending on the progress of the larger ongoing R&D activity, the student's interests and the project duration.

Type: Master thesis, internship, or combination of these (duration 6 – 12 months).

Student profile: The skills of a successful candidate include:

- Strong background in mathematical optimization and/or metaheuristic optimization (e.g., genetic algorithms, cross-entropy methods, particle swarm optimization, or similar).
- Solid background in electric power systems and, ideally, prior experience with optimal power flow problems.
- Very good programming skills for developing software prototypes (preferably in Python, experience with Matlab is a plus).
- Ability to work independently and efficiently prioritize tasks.
- Very good communication and presentation skills and willingness to excel in a business environment.
- Languages: excellent command of English; knowledge of German and/or French is a plus.

Benefit for the student: As part of an innovative team, the student will have the chance to work on a mathematically intriguing problem, apply optimization methods and create added value, while solving an important problem for the TSO industry in general and Swissgrid in particular.

Application process: Interested candidates can either submit their applications directly to the email address below or through the posting of the open position at Swissgrid's website: https://recruitingapp-2472.umantis.com/Vacancies/1810/Description/2?lang=eng.
Applications should include a cover letter, a CV, and transcripts of records.

Contact details:

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