FEEDBACK-DRIVEN TOPOLOGY OPTIMIZATION IN TRANSMISSION GRIDS

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Introduction and objective

Driven by Germany's energy transition, grid congestions arise more frequent and in growing severity. Transmission system operators (TSOs) are responsible for operating the transmission grid and are tasked with ensuring safe and stable operation [1]. For congestion management, TSOs have multiple options, ranging from cost-efficient grid related remedial actions (RA) such as topological actions, phase-shifting-transformer (PST) tap changes or HVDC setpoint adjustments to more costly market related RA such as countertrading or redispatch. According to §13 EnWG and the System Operations Guideline, market related actions should be considered secondarily if grid related actions do not suffice for remediating congestions [2]. [3]

While mathematically optimizing PST tap changes and HVDC setpoints along market related RA is state-of-the-art, in Germany topological actions are not optimized within the same mathematical optimization methods. The amount and combinatorics of different topological actions as well as their interdependencies result in a discrete, exponentially growing and non-linear solution space, which may result in large optimization runtimes. When using topological actions, the validity and safety of each action must be ensured before implementation. Here, in contrast to other RA, short-circuit currents, grid stability limits or grid restoration procedures increase in importance. Both complexity in terms of optimization runtime as well as increased number of real-world constraints result in the current state-of-the-art regarding topology optimization: Based on empirical knowledge, TSO operational planning personnel manually searches for suitable topological actions using grid operation simulations, making use of humans-in-the-loop when deciding on topological actions. [4]

This work aims to develop a method for integrating operator's knowledge into an existing topology optimization method by designing a human-in-the-loop interface [4]. Not only does a human-in-the-loop allow for complexity reductions in the mathematical topology optimization model but also allows for operators to steer the optimization process towards realistic and acceptable solutions within all relevant technical and operational constraints.

Methods

For integration of a human-in-the-loop scheme into topology optimization, the scheme must fulfill several distinct functions:

- Graphical user interface (GUI)
- Displaying topology optimization result
- Display additional information about topology optimization result
- Adjusting topology optimization result
- (Partial) Locking of topological decisions

In order to enable operators to easily view and adjust data from a topology optimization result, a GUI was developed. The optimized, initial topology schedule is displayed in matrix form. When a topology (a unique set of distinct topological actions) is selected for further viewing, the individual topological actions contained therein are displayed graphically side-by-side with the baseline station configuration. If

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desired, the station configuration can be directly edited through clicking on the line which is to switch busbars. This allows operators to choose not just from recommended configurations, but also allows them to fully use their expertise in satisfying relevant technical and operational constraints. Topological degrees of freedom can be restricted in the GUI, resulting in three modes of the reoptimization. In *static* mode, all topology variables are locked-in; accordingly, only the required redispatch is calculated. In *full* mode, topologies are optimized with maximal degrees of freedom. The *selective* mode enables a preselection of topologies: independently for every time point and topologies may be eliminated from the solution space.

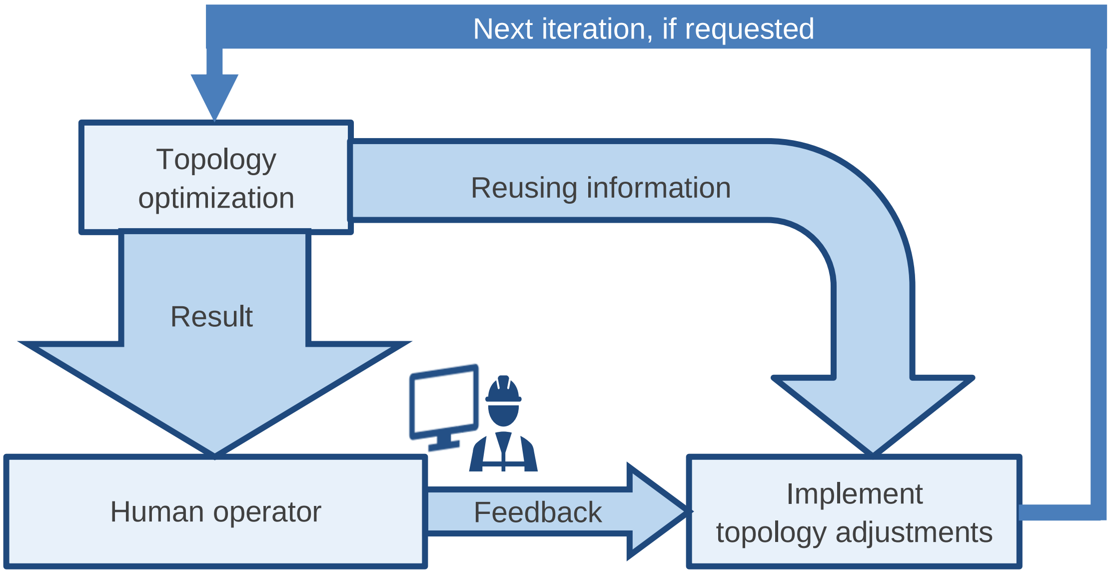

Figure 1: Overview of proposed feedback-driven iterative reoptimization scheme leveraging a human-in-the loop concept.

References

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