Estimation of Flexibility Potentials in Active Distribution Networks

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Abstract

Replacing conventional power plants by distributed energy resources (DER) in the MV and LV grids poses great new challenges for the planning and operation of distribution grids. Controlling a handful of conventional power plants demands significantly less resources than operating numerous decentralized plants, especially when in involves the supply of ancillary services to maintain the grid stability. Nevertheless, most ancillary services are required at the transmission system level, meaning that vertical supply of flexibility becomes necessary, requiring new methods to quantify how much flexibility can be provided from distribution (DSO) to transmission system operators (TSO). The feasible operation region (FOR) allows capturing the aggregated flexibility potential of DER within a distribution grid, while respecting the technical restrictions of both plants and grid.

This thesis proposes a novel approach to compute the FOR, the Linear Flexibility Aggregation (LFA) method, based on the solution of linear OPF. With the objective of reducing the computation time, without compromising the accuracy of the assessed FOR.

The LFA algorithm is comprehensively evaluated throughout this thesis, focusing on the accuracy of speed of the approach. The analysis quantifies the impact of the linear OPF model in the FOR computation, as well as it identifies all relevant parameters that can have an impact in the computation time.

It is shown that the proposed method provides a considerable reduction in processing time compared to similar methods, e.g. Monte-Carlo simulations or non-linear OPF-based methods. The linearization of the power flow equations has an impact in the accuracy of the solution, however, the trade-off with the reduction of the computational time is acceptable.

The dissertation closes with the suggestion of three use cases for the LFA method. Firstly, it is described how a fast computation of the FOR could be used to study the long-term provision of flexibility in distribution grids. Secondly, the usage of the LFA for the vertical aggregation of flexibility over different voltage levels is shown. Finally, the inclusion of the FOR concept in a congestion management approach, including redispatch at the distribution grid level is demonstrated. The proposal and analysis of these use cases applied to large distribution grids would not have been possible without a fast and reliable computation algorithm, like the LFA.

Overall, the coordination between grid operators can benefit significantly from the fast computation of the FOR, allowing its inclusion not only in planning processes, but also in everyday operation processes.

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