Title:
TSO-DSO Integration in Modern Power Grids

Abstract:
The electrical grid is constantly evolving with new renewable-based technologies that enable distributed energy resources (DERs). Existing approaches often rely on set-based aggregation that overlooks network constraints or adopt computationally intensive OPF methods that are not tractable. In this paper, we propose a novel OPF-based framework that explicitly models aggregated DERs as a polygon-based flexibility region at the TSO-DSO interface. We extend the DSO-level OPF to include additional vertex dimensions in the active-reactive power p-q plane, comparing three objective functions: (1) area maximization, (2) perimeter maximization, and (3) weighted sum maximization. Once the flexibility region is estimated, the polygon vertices become linear inequalities representing the feasible DSO operating region, which is then integrated into the TSO's OPF. Compared to prior methods, the proposed framework (i) preserves AC feasibility by considering the full network constraints in the DSO-level OPF, (ii) estimates an accurate but tractable polygon representation for the TSO and (iii) adjusts granularity by tuning the number of vertices. The proposed methodology is tested on modified IEEE benchmark distribution systems augmented with DERs. The results demonstrate that enhanced TSO-DSO cooperation, enabled by the proposed flexibility region approach, leads to improved operational costs by effectively exploiting the flexibility of DERs in the network.

Bio:
Luis is a PhD student at Carleton University, specializing in the optimization, planning, and coordination of modern power systems. His academic work focuses on TSO–DSO interaction, distributed energy resources (DERs), and the valuation of operational flexibility under uncertainty. His research integrates advanced mathematical modeling, including stochastic and robust optimization methods, with practical implementation in Julia and Python.