DATE August 25, 2024

Fast and Robust Security Constrained AC Optimal Power Flow for the Dutch Electricity Grid

Master Thesis Project Description

Introduction

TenneT is a Transmission System Operator (TSO) that designs, builds, operates and manages the high-voltage electricity grid in the Netherlands and large parts of Germany with a fundamental purpose of reliably and efficiently transporting electric power at all times. Due to the energy transition and rapid expansion of the energy sector that are pushing the transmission grid to its limits, the need for optimizing the grid has in recent times been greater than ever. Optimal power flow calculations play a significant role in facilitating efficient transport of electric power.

AC Optimal Power Flow

Optimal power flow in the simplest definition involves determining operating setpoints for controllable assets in the grid such as generators, shunts and transformers that lead to minimal costs while satisfying demand and operational constraints such as voltages and line loading within safety bounds. As the electricity grid is predominantly based on Alternating Current (AC), the underlying physics of the grid is inherently non-linear making the AC optimal power flow problem non-linear and possibly non-convex. Hence, solving the AC-OPF problem is non-trivial, computationally expensive and prone to divergence. Furthermore, when N-1 security constraints are imposed over time, solving the AC-OPF problem becomes prohibitively slow. This stimulates the use of approximate methods that compromise on accuracy for speed.

Thesis Project

Voltage management has recently been an increasingly difficult problem for TenneT in the Netherlands due to the rapid increase in distributed generation that leads to high voltages. To solve this, a new voltage control policy is being conceptualized at TenneT that involves defining voltage and reactive power setpoints for generators during grid operation. This requires fast and robust security constrained AC optimal power flow calculations to be performed close to real-time. In this master thesis project we will work on speeding up SC-ACOPF problems for the Dutch transmission grid. We will also investigate convergence problems and design a calculation framework that is robust enough to be used close to real-time grid operation.

Approach

1. Literature review on AC optimal power flow problems.
2. Solving SC-ACOPF problems for small test networks.
3. Solving SC-ACOPF for the onshore Dutch TenneT grid.
4. Speeding up calculations for the Dutch grid and solving convergence problems.

Deliverables

The student is expected to deliver the following:

1. Literature review on AC optimal power flow problems
2. Python code with implementations for solving SC-ACOPF problems
3. MSc thesis describing the results
4. Presentation of the results at TenneT office in Arnhem

Workplace

The project is to be performed in the ODINA team. Daily supervision is by Shravan Chipli. ODINA meetings are to be attended twice a week (Tuesdays and Thursdays). Weekly supervision by the ODINA team during live meetings at Arnhem office is preferred, at least once a week. Daily contact and supervision is live at Arnhem office or by web-meetings.