Abstract

With the growth in fluctuating renewable energy sources more volatile power is provided to electricity grids. This results in an increased need for flexibility for distribution grids. Distributed Energy Resources are able to provide this flexibility. Optimization techniques and detailed models of Distributed Energy Resources are required to coordinate and fully exploit the flexibilites of Distributed Energy Resources. Many Distributed Energy Resources, such as deferrable loads and electro-thermal heating units, require discrete control decisions. This leads to the introduction of discrete decision variables in order to model Distributed Energy Resources as close to reality as possible. As a result, an entity which tries to coordinate Distributed Energy Resources needs to solve a Mixed Integer Programming problem.

Finding solutions for Mixed Integer Programming problems can be computationally challenging. Central optimization algorithms are not highly scalable and hence not applicable to complex optimization problems containing many Distributed Energy Resources with discrete control decisions. Thus, provably convergent distributed solvers are necessitated for such Mixed Integer Programming problems. Distributed solvers are able to share the computational workload between multiple computing nodes.

This thesis analyzes the convergence of distributed solvers for optimizing day-ahead balancing applications in city district scenarios. In these city district scenarios all entities try to flatten their electricity consumption load curve. The three distributed solvers analyzed in this thesis are based on the Alternating Direction Method of Multipliers algorithm.

Although not all the solvers considered in this work are originally intended to solve Mixed Integer Programming problems, they are able to yield good solutions within a few hours. However, as the optimization problem is not convex, these solvers are prone to getting trapped in local optima. Alternating Direction Method of Multipliers based solvers can also oscillate. However, this oscillation could not be observed in this thesis. The Heuristic Release-and-Fix Method is designed for loosely coupled Mixed Integer Programming problems and mitigates these disadvantages of an Exchange ADMM Algorithm. However, the Exchange ADMM Algorithm yields in this thesis up to 10% better solutions than the Heuristic Release-and-Fix Method. For all city district scenarios in this thesis, a temporary reduction of the penalty value for the Exchange ADMM Algorithm results in a more appreciated solution.

Keywords: City districts, Discrete Control Decisions, Distributed Optimization, Alternating Direction Method of Multipliers, Mixed Integer Programming