

Abstract

PhD Dissertation Robert Brehm

“Methods for Distributed Optimal Energy Management”

The presented research deals with the fundamental underlying methods and concepts of how the growing number of distributed generation units based on renewable energy resources and distributed storage devices can be most efficiently integrated into the existing utility grid. In contrast to conventional centralised optimal energy flow management systems, here-in, focus is set on how optimal energy management can be achieved in a decentralised distributed architecture such as a multi-agent system. Distributed optimisation methods are introduced, targeting optimisation of energy flow in virtual micro-grids by prevention of meteorologic power flows into high voltage grids. A method, based on mathematical optimisation and a consensus algorithm is introduced and evaluated to coordinate charge/discharge scheduling for batteries between a number of buildings in order to improve self-consumption of renewable energy resources in low voltage grids. It can be shown that this method prevents mutual discharging of batteries and prevents peak loads, a supervisory control instance can dictate the level of autarchy from the utility grid. Further it is shown that the problem of optimal energy flow management can be described as a transportation problem. As a basis for usage in energy management systems, methods and scenarios for solving non-linear transportation problems in multi-agent systems are introduced and evaluated. On this premise a method is presented to solve a generation units dispatching problem on the basis of the formulation as a transportation problem. Based on use scenarios, the response of the system to load fluctuations is evaluated. The used distributed optimisation methods are based on decomposition methods which are solved in distributed iterative parallel computation on nodes in a decentralised distributed system. This requires extensive communication between neighbouring nodes. A layered multi-agent system is introduced to provide a low latency communication based on a software-bus system in order to efficiently solve optimisation problems.