Strategies for Decentralised Balancing Power

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Abstract There are many different approaches to central load management in power supply systems, such as direct load control or price signals to control production and consumption. Despite these measures there will always be an imbalance between production and consumption, i.e. due to fluctuating resource availabilities and unforeseen changes in consumption. As CO_2 emissions and sustainable electricity production have entered the focus of attention in politics and industries, ecologically advantageous concepts avoiding inefficiencies in power supply are strongly promoted. In this article, a self-organising approach to small devices such as freezers or washing machines as well as Combined Heat and Power plants (CHP) is presented, which aims at avoiding imbalances in the power network. While each device has its own constraints and specific task (e.g. provide heat or wash clothes), most of them have a limited degree of freedom in their schedules. A P2P approach with an Evolutionary Algorithm in combination with a local search is used to identify suitable partners to cover their production or consumption and thus to adjust the load in a way to minimise network imbalances.

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1 Introduction

Due to the increasing cost of energy carriers, new approaches to a more efficient use of the available resources are gaining importance. In particular, strategies are sought to efficiently manage the permanently occurring imbalances between production and consumption. These imbalances are, for instance, caused by inevitable differences between the expected energy usage and the actual consumption, or through fluctuating resource availabilities. They cause malfunctions on or damages to electrical appliances.

To balance consumption and production, an effective but expensive system of so-called balancing power markets has been installed. Imbalances occurring at lower voltage levels (i.e. in balancing groups) are summed up and balanced on the highest voltage level. The balancing group on lower voltage levels is charged the incurring costs. The amount of balancing power needed is provided by special power plants. The capacity restrictions for power plants participating in balancing power markets are rather high. They can only be met for larger power plants. In the last few years several balancing power pools were created, in which smaller power plants and larger responsive loads pool to jointly reach the critical size in order to participate in balancing power provision. Smaller loads like home appliances cannot be pooled efficiently. However, even these small devices can be used to reduce imbalances and the balancing costs on lower voltage levels resulting from this.

In the following sections a decentralised P2P approach to pool small home appliances and privately owned Combined Heat and Power (CHP) plants is introduced. Thus, they can be used to reduce the amount of balancing power needed in balancing groups. The devices and CHP plants belong to private households and have to meet their owners demands. Only the remaining degree of freedom is used to balance the consumption and production. For the optimisation, an Evolutionary Algorithm in combination with a local search is used to group the devices so that existing imbalances are reduced. This decentralised approach has to be integrated into the existing system of balancing power, and the corresponding restrictions must be met.

Therefore, sections 2 and 3 will first give a brief introduction of the German power supply system, balancing power as well as the German power markets and balancing power markets. In section 4, existing approaches to decentralised balancing pools on a larger scale are shown. In section 5, a new pooling approach with the Evolutionary Algorithm is introduced. The chapter closes with a conclusion.

2 The German Power Supply System

Today, electricity is used in almost all processes of industrial production as well as for most household appliances. With about 20% it is the third most important final energy carrier in Germany [12]. To supply end consumers with electricity, complex network structures have been built. These so-called electricity supply systems consist of power sources (power plants) and power sinks (consumers) as well as power