MBS+ Development of a Decentralized Small Battery Energy Storage Network to Compensate for Schedule Deviations

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1 Motivation

From 2013 to the end of 2015 more than 36,000 battery storage systems in combination with PV systems have been promoted and installed in Austria [1] and Germany [2]. Investment subsidies as well as the desire of private households for energy self-sufficiency are the main drivers for this trend, which will most likely increase further more in the future. These systems are mainly used to increase the on-site usage of PV energy. However, charging the battery without considering the feed-in power of the PV and the current state of the grid will not relieve the grid. Therefore, the benefit of these battery storage devices for the grid or the energy system is currently poor. Taking into account the subsidies from public authorities, it seems to be economically feasible, to use these battery systems within a defined scope also for system or grid relevant applications.

Within the research project "MBS+", a concept for a decentrally-organized battery-storage-network (BSN) to enable the usage of battery storage devices for balancing generation schedule deviations within balancing groups (minimize imbalance energy), as well as for other system- or grid relevant applications, has been developed.

Furthermore, decentrally organized software systems (e.g. multiagent systems, blockchain technology) have been evaluated to minimize implementation and operation costs for the planned implementation of such a battery-storage-network in the field.

2 Methodological Approach

The analyses in this paper are based on a storage dispatch model implemented in MATLAB which computes the operation of storage devices in order to maximize self-consumption of PV generation on household level (reference case). Knowing the storage dispatch in the reference case, the potential of each storage system to provide imbalance energy is calculated based on parameters such as the state of charge (SOC), the storage capacity and the charging and discharging capacity of each individual storage system **(Figure 1)**.

Positive imbalance energy can be provided by discharging a storage device or by preventing the storage from being charged. Negative imbalance energy, however, can be provided by charging a storage device or by preventing the storage from being discharged.

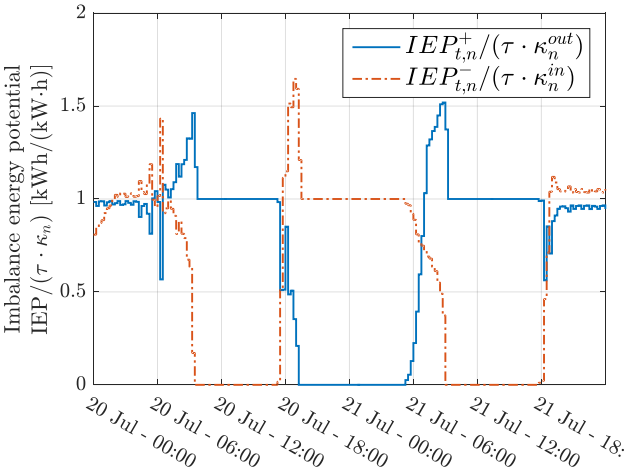

Figure 1 Schematic illustration of the imbalance energy potential (IEP) of a single battery storage system for a period of two days in July (charging/discharging capacity κ = 5kW, time resolution τ = 1/4h).

The duration curve of the imbalance energy potential (IEP) for a network comprising 89 storage systems with an accumulated storage capacity of 602 kWh is shown in **Figure 2**. The maximum amount of positive imbalance energy that can be provided by the BSN per hour amounts to 60% of the accumulated storage capacity, while the maximum amount of negative imbalance energy amounts to 40% of the storage capacity.

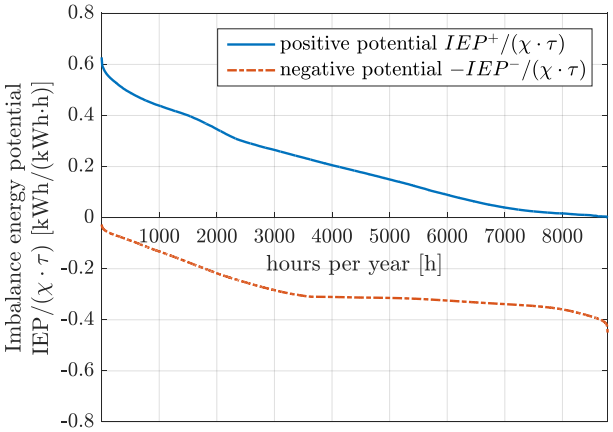

Figure 2 Duration curve of the imbalance energy potential (IEP) of a battery storage network of 89 small storage devices (accumulated storage capacity of the storage network χ = 602 kWh, time resolution τ = 1/4h).

3 Technical Implementation

The key questions that are tackled include an investigation of technological options that are available and feasible for realizing and operating the envisaged decentralized battery-storage-network (BSN). A key constraint is the identification of an optimal solution for integrating the BSN-algorithms into – existing – household's energy or home automation system components.

To date, no or just limited support is available for collaboration among participants of a balancing group to utilize distributed storage devices for balancing generation schedule deviations within this balancing group. Especially, owners of PV systems and (private) battery storage systems are not able, e.g., to autonomously and jointly decide how to fulfil the requests of a balancing group officer through utilization of their aggregated battery storage potential.

We are investigating the potential application of a novel technology – called blockchain [3] – as enabler for the envisaged decentralized BSN.

The motivation of conceptualizing a solution based on blockchain technology results from an investigation of several approaches that are considered feasible for fulfilling the given requirements of a decentralized system. As such, peer-to-peer (P2P) architectures represent a quite obvious choice [4] [5]. However, it is not only the notion of a computing architecture that does not rely on a central (server) component that makes P2P systems feasible for the envisaged BSN. In fact, there is an analogy of early P2P computing systems and the current discussion of using private and distributed PV systems and battery storage systems in a P2P manner. According to [6], P2P applications are taking advantage of previously unused resources – storage, computing cycles etc. –, which lets them make new, powerful use of big numbers of devices that have been connected to the Internet. It is similar with the distributed components in the energy domain, like battery storage systems, PV systems, electric cars etc.

In addition to P2P systems, work on multiagent systems (MAS) [7] provide relevant concepts for distributed consensus finding among autonomous (network) entities, called agents. Among those algorithmic options that are relevant for the participants of the BSN are, e.g., distributed constraint optimization, negotiation, auctions, voting or mechanism design.

Interestingly, a blockchain network represents a P2P network with a distributed consensus algorithm on its core. Additionally, through the abstraction of 'smart contracts', participants of the network are able to cooperate like it is the case with MAS.

Based on this kind of apparent symbiosis of P2P and MAS technologies, MBS+ is investigating blockchain as technology base for the envisaged BSN. Thereby, we are aiming at insights if blockchain technology really keeps the promises and high expectations it currently raises, or, if it is necessary to stick to more mature (P2P, multiagent, container, cloud) technologies for extending energy devices with the MBS+ algorithms.

4 Acknowledgments

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5 Literature

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