The holy grail of flexibility usage – multi-use-operation of batteries in future energy systems

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***Abstract*— Battery projects are getting increasingly attractive for various applications due to decreasing prices. One possible use case is also to exploit the flexibility for grid usage to avoid/defer conventional grid reinforcements and to effectively integrate decentralized renewables, active prosumers and new loads in the future into the grid. Hereby, batteries provide maximum flexibility for the electricity grid due to their "power-only" characteristic. The profitability of storage assets can be improved substantially if a "multi-use-approach" can be realized. These approaches consider grid usage in time periods with grid restrictions and system or market usage could be applied in non-critical time periods. Based on real-world projects, approaches for such operations have been derived and implemented. The combination of the grid-oriented usage of battery storages with further use cases is analyzed in this work.**

Keywords—smart grids, storage, battery, regulation

I. Introduction

In Germany, the ongoing "Energiewende" has led to a rise of the installed power of Renewable Energy Sources (RES) up to 96 GW in 2015, whereby 96 % of these power plants are connected to the distribution grid [1]. One possibility to cope with the occurring challenges is the usage of battery storages for a better integration of RES. In addition, the Energiewende will soon bring additional challenges as active prosumers and additional loads are connected to the grid. Further studies such as [2], [3] show that storage operation in general and mid/large scale battery introduction in particular might provide a benefit for local grid operation. According to these studies, market usage without considering grid constraints will even increase the need for reinforcements due to insufficient correlation of price signals from (spot-)markets and local grid profiles. In this context, the German BDEW defines the three types of flexibility use for the

a) market: utilisation on the wholesale market (e.g. spotmarket arbitrage),

b) system: utilisation of flexibility by the Transmission System Operator (TSO) to maintain system stability (e.g. as balancing power) and

c) grid: utilisation of flexibility by TSO or DSO to manage mostly local network situations.

The multi-use operation or multi-purpose-use is defined as an approach for exploiting the flexibility of the storage asset while combining at least two of the three options. Some initial studies tried to evaluate if these options are more beneficial than conventional grid reinforcements (see e.g. [4]) and have shown that these situations occur, but are dependent on the specific grid constellation. In this work some analysis and current status of discussion is summarized based on publications focused on real projects, algorithms for exploiting the flexibility in a best way and starting the discussion on a suitable regulatory framework considering the unbundling rules given in most European countries (see e.g.[5]-[8]).

Given several R&D projects introducing battery systems and other flexibilities to real-world grids by innogy SE and Westnetz GmbH further work has focused in the corresponding R&D groups on determining the "free flexibility" and ways to develop business models for the operation of such assets. Hereby, "free flexibility" means the flexibility usage of power2heat, power2gas, demand-side-management assets or batteries which is not oriented on avoiding a local grid problem but to be operated in "non-grid-critical" time periods. A main challenge is how to combine the competitive part of the energy supply chain (see usage in model a) and b)) with the regulated part (c) and how to find suitable steering algorithms for this way of operation and exploiting the flexibility most efficiently.

II. Findings from Projects and Approaches

Several dimensions are relevant for the multi-use analysis of flexibilities (see more detailed also in [5]-[8]) which will be further explained at the presentation on the conference.

A. Potential

First of all, a main question is whether or not there is potential for such ways of operation. This question has to some extend already been answered in certain publications (see e.g. [4], [8]). The meaningfulness becomes obvious when considering the profiles of batteries for peak-shaving as given in Fig. 1. In this pilot, the mid-scale battery is used in approx. 800 hours a year for peak-shaving. The battery could be used for other purposes in the rest of the year ("free flexibility"), given an accurate way for predicting the energy flows.

B. Prediction

Thus, the prediction of the occurring energy flows based on historical (load) data and future (weather, load) data for the generation of photovoltaic energy is crucial and needs to be accurate. These algorithms should consider forecasted weather

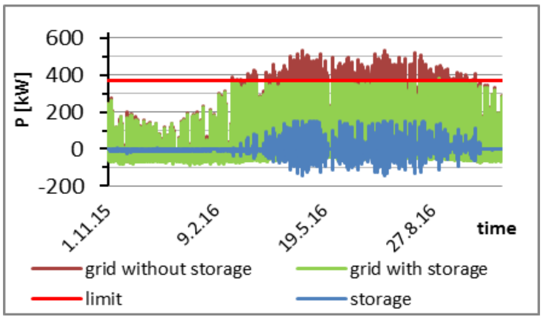

Fig. 1: Operation of battery for peak shaving in a pilot [6]

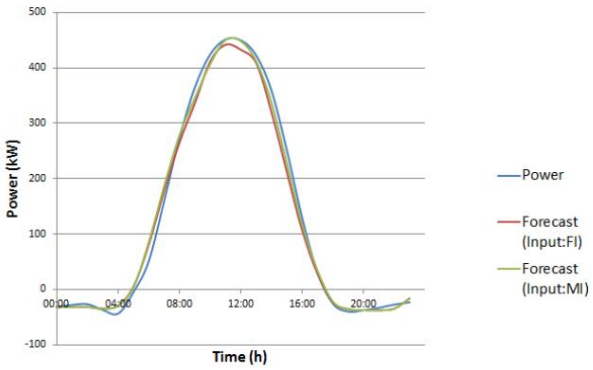

Fig. 2: Prediction of energy flows (regression) [5][7]]

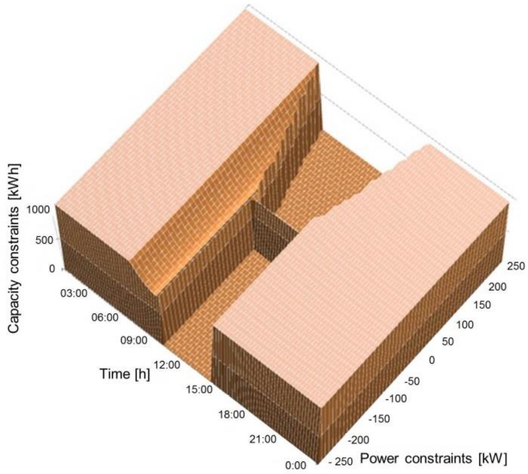

Fig. 3: Free flexility of the operation for one day [5]

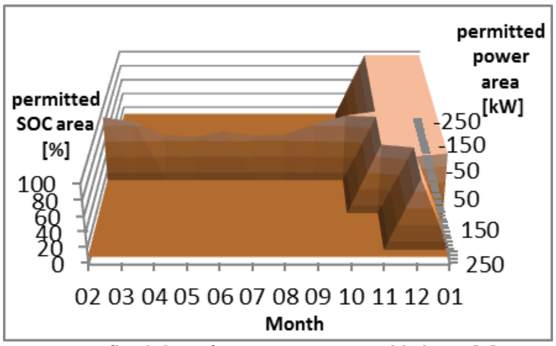

Fig. 4: Free flexibility of operation on a monthly basis [6]

and load data (FI) as well as measured data (MI) to derive the power profiles in the grid as can be seen in Fig. 2.

C. Creating business models and use cases

Next step is to combine the opportunities of operation to the most promising overall use case. For this, the different single use cases have to be considered and e.g. the required foreruns for offering the flexibility (based on the prediction), the tendering period (especially for the system oriented usage), etc. Based on this the most promising combination can be found and realized in operation. An example for the possible operation mode with "free" flexibilities for a day in summer is given in Fig. 3. Hereby, the capacity [kWh] and power range [kW] for the multi-use-case is depicted depending on the time of the day. An example for the complete year is given in Fig. 4. It is shown that only in winter time periods an "unlimited" usage of the storage parameters is possible since in other time periods of the year grid limitations might be valid. This is further explained in the presentation as well.

D. Regulatory framework.

As mentioned beforehand, the multi-use operation is only possible if an appropriate regulatory frameworks is in place. Most countries have implemented unbundling rules which do not take into account the opportunities of such multi-use-cases. Hence, this has to be a main focus of future activities in terms of adapting regulation and market design. An example of according research is given [5]. A possible way of operation might be the tendering of required flexibility by the grid operator or the offering of "left flexibility" in a non-discriminatory way to the market. Both options have to consider the legal framework as well as the incentives for grid operators to participate.

III. References

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