THE VALUE OF FLEXIBILITY OPTIONS FROM AN OPERATOR'S PERSPECTIVE

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Overview

The increasing expansion of renewable energy sources (RES) and the accompanying volatile feed-in of photovoltaic and wind power lead to a growing demand for flexibility in the German power system [1]. To compensate the fluctuations of electricity demand and supply, and to ensure an optimal integration of a high RES share, additional flexibility options (FO) are required in future years. However, at present the price signals given to operators at the day-ahead and electricity balancing market are too low, to incite investments in new or even to activate existing FO. To be prepared for the rising flexibility demand, it is important for operators to estimate the value of FO over time. The purpose of the paper is therefore to develop a methodology to determine the value of flexibility options from an operator's perspective. Thereby, it is essential to identify relevant determinants, which influence the value of flexibility. This paper investigates the flexibility values of different assets, which are in ownership of the public utility of Dresden (DREWAG GmbH) and the regional energy provider of East Saxony (ENSO AG).

Methodology

Based on a systematic literature review, relevant determinants for calculating the flexibility value, are identified in a first step. FO are evaluated by using different methods. Some authors apply a model based approach to assess the value of flexibility by minimizing the system costs in a power plant dispatch model (e.g. [2], [3]). A second type of studies estimate the value of FO by comparing market data such as technical characteristics, flexibility provision costs or feasibility studies (e.g. [4], [5]). Determinants with a significant influence on the value of FO are technical and economical characteristics, ecological effects, social acceptance and regulatory frameworks. However, the flexibility value is mainly composed of a technical and an economic value. The technical value is characterized by factors such as efficiency, activation time, maximum duration time and load gradients. Whereas the economic value is specified by the contribution margin, which is the difference between the expected revenues on the spot and electricity balancing market, and the short-term activation costs. The value of FO from an operator's perspective can be defined as the result of minimal flexibility provision costs and maximal revenues by expected market prices under consideration of technical flexibility characteristics and operation management regimes [6]. By using an optimization approach in Excel and BoFiT[1] the value of the flexible operation mode of selected FO is calculated in a second step. The considered assets are a photovoltaic and wind onshore power plant, pumps for drinking water storages, a battery storage (lithium-polymer) and a CHP unit (natural gas fired). Their flexibility value is assessed in different scenarios, taking the day-ahead and electricity balancing market into account. On the day-ahead market the value is estimated for the years 2017, 2020, 2030 and 2040. The flexibility value on the electricity balancing market is determined for 2017 and varied by sensitivities of the balancing power prices.

Results

The main results of the scenario analysis regarding to the flexibility value on the day-ahead market are illustrated in Figure 1. The delta contribution margin is the difference between the contribution margin of the flexible operation mode and the inflexible standard operation mode. The flexible operation mode of the RES assets takes the six-hour-rule (§ 51 EEG 2017)[2] into consideration. The wind power plant as well as the photovoltaic plant are marketed directly on the day-ahead market. As a result the curtailment of the photovoltaic power plant is neither in 2017 nor in 2040 economically, as the delta contribution margin is negative. The opportunity costs, which consist of the waived income regarding the market premium, are always higher than the saved costs by curtailment in negative price periods. The contribution margin of the flexible wind power operation mode is from 2030 higher than the margin of the inflexible operation mode. However, the flexibility value is rather minor. The flexibility values of the battery storage, pumps and CHP unit have in all years positive delta contribution margins. Hence, the contribution margins of the flexible operation modes of the three assets are always higher than the contribution margins of the inflexible operation modes.

The flexibility values according to the electricity balancing market are represented in Figure 2. The maximal balancing power revenues on the ordinate axis illustrate the sum of revenues for provision and call of balancing power. The provision and call of secondary and minute control reserve are remunerated by capacity and energy prices. Whereas, the provision and call of primary control reserve (PCR) is only remunerated by capacity price. It is assumed that operators receive 80 % of the capacity price revenues and 85 % of the energy price revenues. The

[1] BoFiT is an optimization software from ProCom. The calculations were done by DREWAG GmbH.

[2] The six-hour-rule induces that the market premium will lapse, if the spot price is negative for a period of six hours.

remaining share is for the pool operator service. The abscissa axis demonstrates the variation of the maximal revenues in case of increasing or decreasing prices. It is noticeable that the revenues for providing negative secondary control reserve (SCR) by photovoltaic are minor. The supply of negative SCR by wind power and positive SCR by pumps has with 3.000 €/MW per year a relatively small value compared to the battery storage and CHP unit. The flexibility of the RES assets is restricted by low availability. The pumps of drinking water supply have in addition to their low availability a restricted flexibility because of the filling levels of their water tanks. The battery storage is the most flexible balancing option. It has a high availability and is technical able to fulfil the ambitious requirements to provide PCR. Therefore, its flexibility value is with 75.000 €/MW per year of total control reserve revenues the highest. Besides, the provision of SCR by the CHP unit with 30.000 €/MW per year has a rather high value in comparison to the other flexibility options.

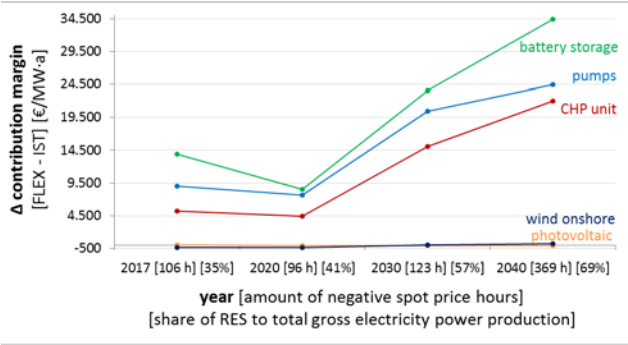

Figure 1: Day-ahead market – value of flexibility options

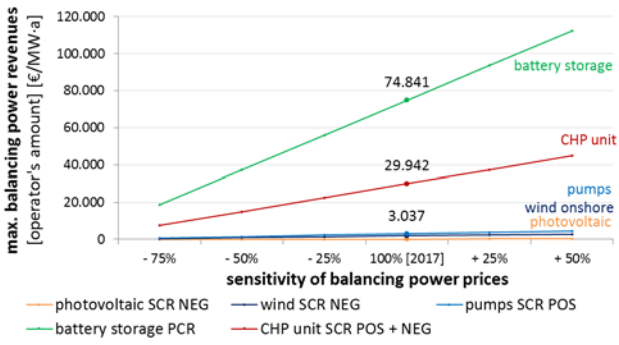

Figure 2: Electricity balancing market – value of flexibility options

Conclusions

To conclude it can be highlighted that the flexibility value on the day-ahead market by RES curtailment is rather low. While the flexibility value of the photovoltaic power plant is minor, it should be concentrated on the curtailment of wind power from 2030 if necessary. The flexible electricity price guided operation mode of drinking water pumps, battery storages and CHP units has always a higher contribution margin (flexibility value) than the inflexible standard operation mode (e.g. water or heat guided operation mode). With an intelligent use of the storage systems, an optimal and maximal contribution margin can be ensured. Furthermore, it can be emphasised that the flexibility value is growing by rising demand for system flexibility and increasing volatility of electricity prices.

However, at present only the provision of PCR and positive SCR has a significantly economic benefit on the German electricity balancing market. In future the prices will probably decline such as in the past years. One reason is the increasing number of market participants caused by the development plans of the Federal Network Agency regarding the adaption of the secondary and minute reserve control market, as well as the progressive European balancing market coupling. Forecast errors mainly caused by RES are compensated increasingly on the intraday market (curative redispatch). Only assets with high technical flexibility and availability can provide high payed PCR and positive SCR such as battery storages and CHP units. Therefore, it is more profitable for an operator to market flexibility options with low availability and limited flexibility on the day-ahead market.

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