BIDDING INTO BALANCING MARKETS IN A HYDRO-DOMINATED ELECTRICITY SYSTEM

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Overview

In many European countries hydropower (HP) represents an important pillar of their energy system. With the ongoing changes in the European energy system HP is becoming even more important. In the energy transition, HP is expected to increase its generation while at the same time ensure system security by providing back-up and storage capacity and flexibility (Gaudard and Romerio, 2014). However, due to an increasing share renewable energies as well as low fuel and carbon prices the electricity prices decreased in the past years. Consequently, the profitability of HP decreased in the past years. While in theory balancing market participation could contradict decreasing spot market profits, in reality optimal balancing market participation is complex due to market characteristics and uncertainties (Schillinger et al. 2017). In this paper, we want to have a closer look at the operation of HP plants in the balancing markets in order to identify market characteristics and uncertainties, technical limitations, and their effect on the market prices. Therefore, we developed a short-term HP operation model to simulate the operation of a generic but representative HP plant in the spot and balancing markets.

Methods

We develop a short-term HP operation model to capture both the market opportunities of HP companies and the technical and natural constraints of the plants. The objective of the plant is to maximize its profits in the energy spot and reserve markets given the technical characteristics of the plants (i.e. turbine and storage characteristics) and the hydrological constraints of the system (i.e. inflows). The model is formulated as MILP in GAMS with the nonlinear relationship between turbine efficiency, discharge and head approximated by piecewise linear unit performance curves (Conejo et al. 2002). The model has an hourly resolution and is solved on a weekly time horizon. To take into account inflows and prices of future weeks, water values were estimated based on a yearly LP model. In Switzerland, balancing markets are split according to their call-up time into a primary reserve market (PRL, within seconds), a secondary reserve market (SRL, within few minutes) as well as into tertiary positive and negative markets (TRL+, TRL-, within 15 minutes) (Swissgrid, 2015). Since the SRL market provides the highest revenue potential for Swiss HP (see e.g. Schillinger et al. 2017), we focus on SRL market in this paper. Instead of applying the model to a real case study, we developed a generic but representative seasonal storage HP plant based on average values of real Swiss HP plants.

Expected Results

We will perform an in-depth assessment of the market opportunities for Swiss hydropower on balancing markets between 2011 and 2016 using historic market prices. Figure 1 shows an exemplary model result for the Swiss market setting in 2015 (average SRL prices, opportunity costs for bidding into the balancing market of the generic HP plant for 1MW of SRL, and the storage levels). Since the SRL market is on weekly basis, all values are on weekly basis as well. In addition, since the SRL market is organized as paid-as-bid market, the SRL prices for 2015 represent weighted average accepted prices from Swissgrid (2017).

As illustrated in Figure 1, the opportunity costs for 1MW of SRL are below the SRL prices in most of the weeks of the year. If the opportunity costs are above the SRL prices, the HP plant would not bid into the SRL market because it would be better off being only active on the spot market. However, if the opportunity costs are below the SRL prices being active on the SRL market would increase profits. Since the opportunity costs of our average HP plant and the average SRL price are not in line in most of the weeks, it seems that HP plants do not bid their opportunity costs into the SRL market in Switzerland.

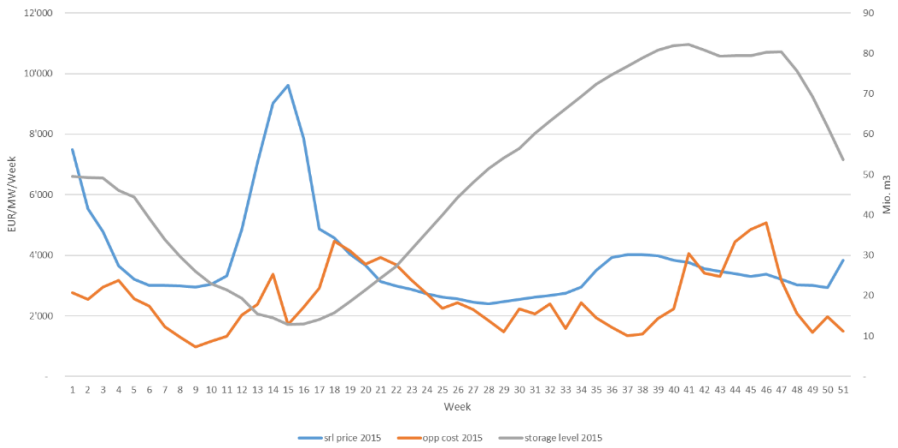

Figure 1. Swiss secondary reserve market prices (Swissgrid, 2017), opportunity costs and storage levels by week for 2015.

There are many reasons why HP plants may not bid their opportunity costs. First, the spot and the balancing market are not perfectly coordinated since they differ in their underlying market characteristics. Thus, directly translating the spot market behavior of a HP plant into the balancing market seems to be difficult from a company perspective. Second, uncertainties in future inflows (and prices) may cause a mark-up on the opportunity costs to capture the related (uncertain) trading potential. As shown in Figure 1, the SRL prices are highest in weeks in which the storage level is lowest. If the storage level is low and the future inflows are uncertain, the mark-up on the opportunity costs is much higher since the flexibility is low at that time. Additional reasons why SRL prices deviate from the opportunity costs need further investigations.

The objective of our model approach is to account for those potential impacts and identify the different drivers for balancing market prices. In a next step, we will couple the existing technical model outlet with estimates of intraday trading opportunities, long term uncertainty aspects, as well as pay-as-bid market bidding strategies. After accounting for most of the potential technical and market related constraints, the remaining difference between the balancing opportunity costs and the observed balancing prices may be seen as indicator for a mark-up companies can impose due to market power.

Conclusions

HP plays an import role in the current and future energy system. However, due to decreasing spot market prices HP profitability decreased in recent years and balancing market participation could only partly compensate the decreasing spot prices. Since the balancing market characteristics and the related uncertainties are complex for companies in placing their balancing market bids, Swiss balancing market prices seem to exceed the opportunity costs by a mark-up. The model analysis performed for this paper will help to identify the drivers for the Swiss balancing prices and thereby also provide insights on the general role of hydropower in balancing markets.

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