HYDROPOWER OPERATION IN A CHANGING ENVIRONMENT

Moritz Schillinger, University of Basel, +41 61 267 28 72, moritz.schillinger@unibas.ch
Michael Barry, HES-SO Valais, michael.barry@hevs.ch
René Schumann, HES-SO Valais, +41 27 606 90 61, Rene.Schumann@hevs.ch
Hannes Weigt, University of Basel, +41 61 267 32 59, hannes.weigt@unibas.ch

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. However, an increasing share of fluctuating renewable energies such as wind and solar also influences the market dynamics (Gaudard and Romerio, 2014). Thus, an increase in renewable energies implies chances as well as threats for HP. One the one hand, flexible technologies such as HP will be needed to balance generation and demand and to provide reserves. This could provide additional incomes for HP plants. On the other hand, the new renewable energies influence the merit-order and consequently the electricity prices. Thus, HP profitability may be decreased due to lower spot prices. In Switzerland for example many HP plants are currently not profitable any more. Since the share of new renewable energies will further increase in the future, HP needs to change its operation strategy to adapt to a changing market environment and new dynamics. In order to analyse short-term HP operation options under varying market conditions we developed a short-term model framework for HP operation that allows us to incorporate different flexibility aspects (Barry et al., 2015).

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 Day-Ahead and Intra-Day markets and the reserve markets (and potential new flexibility markets for future scenarios) given the technical characteristics of the plants (i.e. turbine, pumping and storage characteristics), the hydrological constraints of the system (i.e. inflows and cascaded structure), and regulatory constraints (i.e. residual flow restrictions). The model is formulated as MILP and coded in GAMS.

Furthermore, the short-term HP operation model which was developed in this work is based on a modular design. This allows to flexibly adjust the model to different technical and environmental aspects such as different plant types, plants topologies, generation units or case specific flow constraints. In addition, the modular design enables the consideration of different economic aspects such as market designs or trading options. The model framework is applied to a case study in the Swiss canton Valais. In order to simulate future electricity prices and the effect of the new renewable energies on the electricity spot prices the electricity market model Swissmod developed by Schlecht and Weigt (2014) is used.

Results

First results for the case study under historical data indicate potential optimization and market opportunities for HP. Comparing the historic operation of the HP plant with the optimized operation of our model shows that there is still room to improve the short-term operation of the HP plant. As shown in Figure 1 revenues in the Day-Ahead market in 2010 could be increased by 10% due to optimization of the short-term operation. However, since spot market prices dropped between 2010 and 2014, the Day-Ahead revenue in 2014 under optimized operation is still 20% lower than in the past. Since electricity prices will most likely not increase in the near future HP plants may have to enhance their participation in additional markets to increase their revenues. As shown in figure 2 revenues in 2014 of the underlying HP plant could be increased by 25% due to participation in the primary (PRL), secondary (SRL) and tertiary (TRL+ and TRL-) reserve markets. For the underlying case study especially the PRL and SRL markets seems to be profitable. However, since our model is deterministic and thus the HP plant operators know for sure how much of their capacity bid into the market they have to deliver over the tender period, the uncertainty of getting called up gets lost. Thus, the market potential is overestimated. To take this into account, we introduced a varying security time which indicates for how many hours of the tendering period the plant operator needs to be able to fully deliver its awarded capacity. As shown in figure 2 the reserve markets becoming less attractive the higher the uncertainty.

However, the attractiveness of the individual reserve markets also depends on the type of the HP plant as well as its storage capacity. Since our case study is a relatively small plant with little storage capacity, an increase in the security time strongly reduces the flexibility of the plant and its ability to participate in the energy-only markets. Thus, with an increase in the security time the HP plant decreases its participation in the reserve markets while increases its participation in the Day-Ahead market. However, even under a security time of 24 hours participating in the reserve markets still increases the revenues compared to pure Day-Ahead market participation.

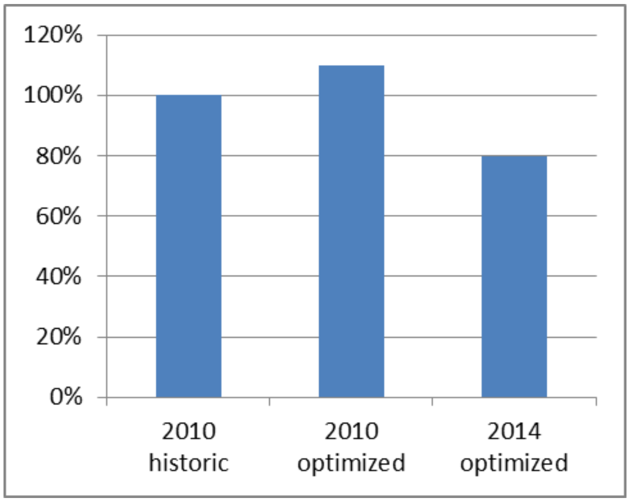

Figure 1. Revenue Day-Ahead market relative to 2010 historic values.

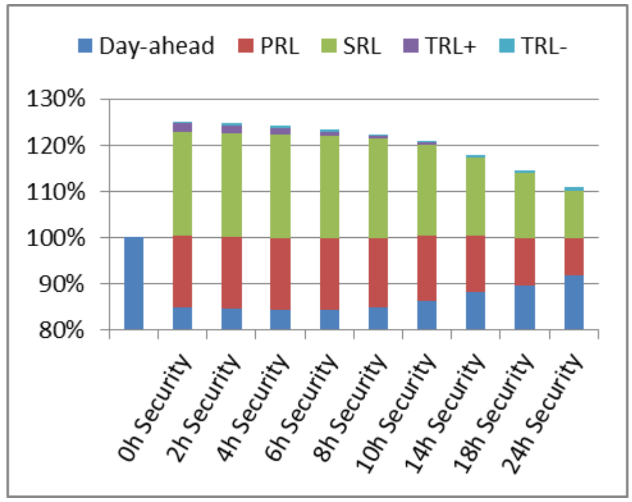

Figure 2. Relative revenue Day-Ahead and reserve markets under varying security time.

Conclusions

For many countries HP will become even more important with an increasing share of new renewable energies. However, in countries like Switzerland HP is currently making losses. While there is still room to optimize short-term HP operation the decrease in electricity prices negatively affects the profitability of HP. However, preliminary results indicate an increase in profits for HP plants by going beyond selling energy in the spot markets. Since HP plants, especially storage and pump-storage plants, are highly flexible they can profitable participate in the reserve markets and thus spread their risk over different markets. However, the ability to profitably participate in the reserve markets depends on the underlying HP type and its case-specific characteristics. For smaller HP plants the uncertainty in the reserve markets may negatively influence their flexibility and their ability to participate in the energy-only markets. In the end, since the market design of reserve markets differs between countries the real effect on the HP profitability is case-specific.

References

Barry, M., Baur, P., Gaudard, L., Giuliani, G., Hediger, W., Romerio, F., Schillinger, M., Schumann, R., Voegeli, G., Weigt, H., 2015. The Future of Swiss Hydropower - A Review on Drivers and Uncertainties. SSRN Journal. 10.2139/ssrn.2663879.

Gaudard, L., Romerio, F., 2014. The future of hydropower in Europe: Interconnecting climate, markets and policies. Environmental Science & Policy 37, 172–181. 10.1016/j.envsci.2013.09.008.

Schlecht, I., Weigt, H., 2014. Swissmod – A Model of the Swiss Electricity Market. WWZ Discussion Paper 2014/04.