THE ECONOMICS OF PUMPED HYDRO STORAGE DEPENDING ON GRID FEES AND FULL-LOAD HOURS

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Overview

At present, mainly pumped hydro storage plants are used to balance electricity generated from variable renewable sources. Worldwide 96% of installed power capacity and 99% of storage energy volume is provided by pumped hydro storage [1]. Austria is in an advantageous position due to its topography. To build additional capacities might, however, increase the investment costs due to high demands on possible project sites in terms of topography as well as environmental aspects. For this reason. it is essential to discuss other economic aspects of operating pumped hydro storage plants beside the possibly increasing investment costs, such as the arbitrage profits based on which market-based storage systems generate revenues. In addition to the previously outlined arbitrage profits of pumped hydro storage, it is worth noting that pumped hydro storage is also well suited for frequency regulation, particularly automatically and manually activated frequency restoration reserve, where high revenues could be generated through the provision of reserve capacity and the activation price when they are required [2].

Methods

Our approach is based on: (i) a literature review, (ii) an economic discussion on the revenues of storage operators (iii) calculations on the cost of new pumped hydro storage capacities and (iv) an analysis of grid fees, see equation (1) and the CO_2 price.

$$\max \Pi_t = \sum R_t - C_t = \sum (P_{H_t} - C_{gf_t}) \cdot D_t - (P_{L_t} + C_{gf_t}) \cdot \frac{D_t}{\eta_t} - IC_0 \cdot CRF - C_{OM_t} = 0 \quad (1)$$

With

Π_t… Profit of storage operator
R_t… Revenues of storage operator
C_t… Costs of storage operator
P_{H_t}… High price of electricity on the market
P_{L_t}… Low price of electricity on the market
C_{gf_t}…Costs of grid fee
D_t… Demand of energy
η_t… Storage efficiency
IC_0… Investment costs of a storage
CRF…Capital recovery factor
C_{OM_t}…Costs of operation & maintenance of the storage

Results and conclusions

When analyzing the arbitrage profit hence price spreads, see Figure 1, it is expected that these will increase with a further rapid expansion of variable renewables. On the other hand, the number of days with negative prices will equally increase. Another problem that can be seen is that with every additional installed storage capacity, when renewables are not expanded at a higher rate, price spreads will decrease („self-cannibalism of storage“). In theory, every additional storage capacity will have fewer full load hours than all previous ones.

Additionally, storage operators are considered electricity producers as well as consumers, in which case grid fees, electricity taxes and other fees may have to be paid by the storage operators, see Figure 1 (right). It shows the expected overall profit with 2000 full-load hours per year, including a grid fee of 1.5 cents/kWh, in comparison to Figure 1 (left), the profit is substantially lower. According to an EU survey, fees for storage power plants are levied at the transmission level in 8 countries. However, there has

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been a recent change in the grid tariff principles and these include an exemption or reduction from the network tariff for offtake and injection under certain conditions [3].

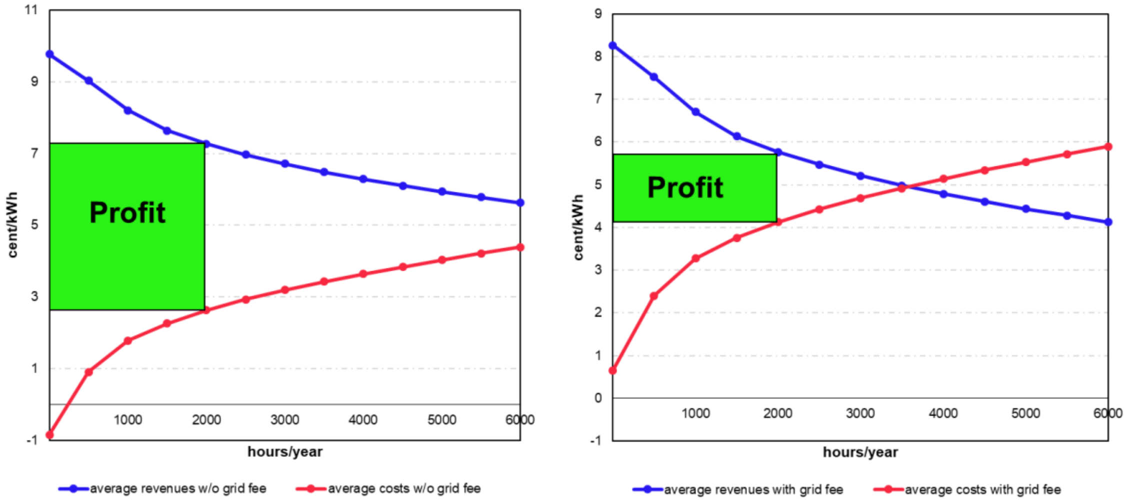

Figure 1: Profits, costs and revenues of existing pumped hydro storage depending on full-load hours per year without grid fees (left) including grid fees (right) (Data for Austria in 2020, EXAA)

In Figure 2, the costs and revenues of newly installed pumped storage systems are analyzed. Without including the previously mentioned grid fees, the systems could already be cost-efficient with 1500 full load hours per year.

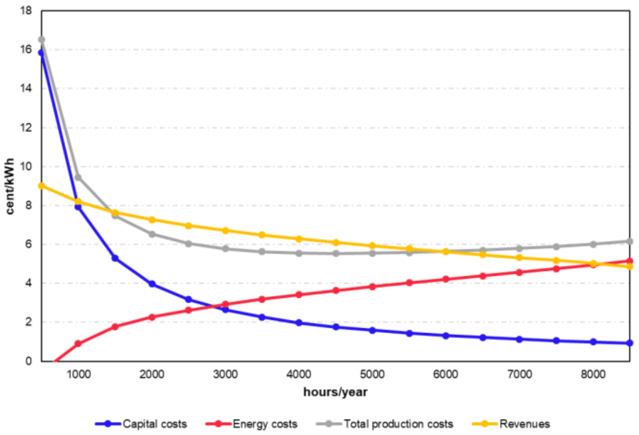

Figure 2: Overall costs and revenues of new pumped (Data for Austria in 2020, EXAA)

Pumped storage is currently, and will be in the coming decades, the most cost-efficient technology for electricity storage. Besides the discussed factors such as decreasing full load hours and price spread, also the potential for large-scale projects is limited due to topography. The most economical sites are already taken, hence retrofitting existing plants should be a priority. Another important point will be the decisions on how storage operators will be classified in the electricity system in terms of grid fees, as well as the discussion on CO_2 prices and how they affect the economic performance.

Referenzen

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