Profitability of pumped-hydro and Li-ion energy storage.

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Motivation and central question

Recent events in the electricity market such as the renewable generation increase and integration of new market players (prosumers), influenced the development of new flexibility measures. One of these measures is energy storage systems, but their profitability and economic viability in comparison to some other measures (demand response, ancillary services) are still questioned. This paper analyses pumped-hydro and Li-ion energy storage economics, used for price arbitrage in the electricity market. The paper answers the next questions:

- Does the profitability of energy storage systems increase with the increasing shares of generation from renewable energy sources?
- How do electricity prices influence the profitability of energy storage systems?

Method

Analysis of the energy storage systems' profitability is conducted with the optimization technique where profits are maximized from hourly price arbitrage. For analysis, the study case of Austria and Bosnia and Herzegovina is used, since these two energy power systems have similarities in the terms of interconnection with other countries and geographical locations for the development of pumped-hydro storage systems, but also differences concerning installed capacities of renewable energy sources.
Considering: the yearly price spread from two different electricity exchanges EPEX and HUPX, used in Austria and Bosnia and Herzegovina respectively; the different storage capacity of pumped-hydro storage and Li-ion battery; different full load hours and total costs of the energy storage for the assumed full load hours, profits are given. The next equation describes the proposed linear optimization model of energy price arbitrage:

$$\max \prod_t = \sum R_t - C_t = \sum_{t=1}^{8760} (P_{Ht} \cdot D_t \cdot \eta - P_{Lt} \cdot D_t) - C_t \qquad (1),$$

Where:
P_{Ht} is selling (high) price of electricity in the market at hour *t* in €/MWh,
D_t is the demand for energy in MWh,
η is storage efficiency,
P_{Lt} is buying (low) price of electricity in the market in €/MWh,
C_t is the total cost of operating energy storage for one year in €

Besides equation (1), energy storage power limitations are considered. Since full load hours impact the total costs of energy storage systems, three scenarios are calculated as low, moderate, and optimal.

Results and Conclusion

Profitability analysis of energy storage systems in two different electricity markets brings interesting outcomes. Although it is expected for Austria, as a country with high shares of renewables in the energy mix and already installed pumped-hydro storage power plants, to have high profits from energy storage arbitrage, results indicate differently. Profits from the electricity price difference are higher for the Bosnian scenario, as electricity prices in the HUPX exchange are higher than in EPEX. Figure 1 shows results for both markets, with 2000 full load hours. The influence of weather conditions of Western Balkan countries on HUPX exchange can be interpreted as an arbitraging opportunity for the development of energy storage systems in this region. Profits for Li-ion batteries are negative in both markets (Figure 2) for all three scenarios of full load hours, hence cost-effectiveness of this technology is unjustified for price arbitrage. Characteristics of the electricity market and power system in which energy storage operates influence final profits. Bosnia and Herzegovina as a thermal dominant power system, contrary to hydro-dominant Austrian, has investment potential for pumped-hydro power plant developments. For Austria, the economic benefits of arbitraging pumped-hydro storage are justified in the context of a new flexibility measure, but constraints are still available locations for the installation of new capacities.

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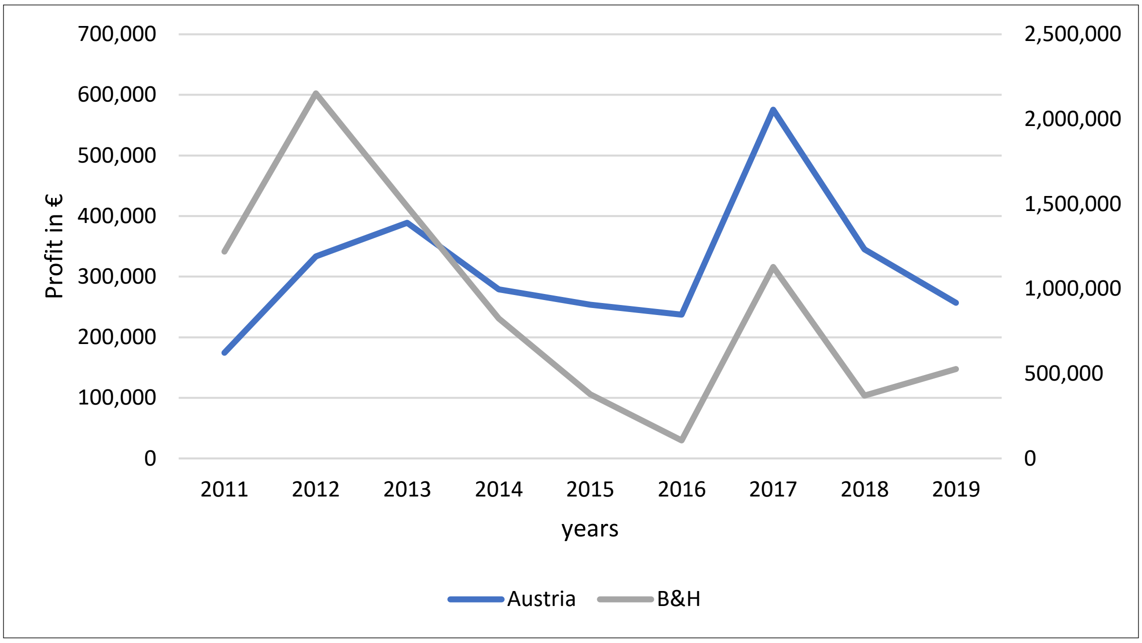

Figure 1: Profits of energy storage arbitrage for pumped-hydro storage for 2000 full load hours (Austria-primary axis).

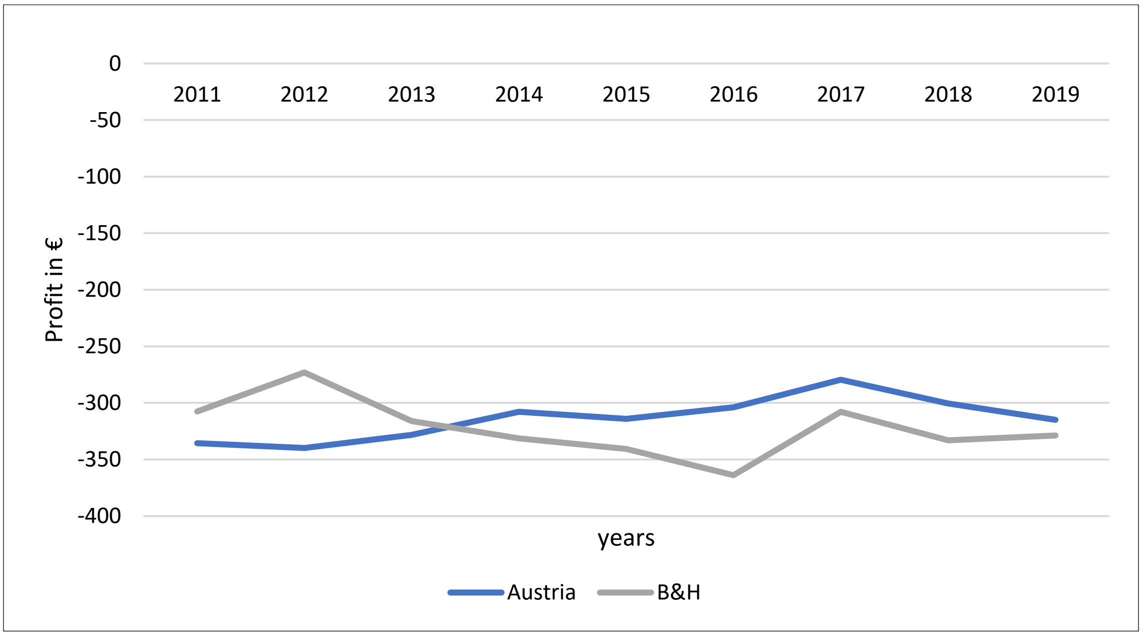

Figure 2: Profits of energy storage arbitrage for Li-ion battery for 2000 full load hours.

Literature

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