Profitability of stationary battery storage in day-ahead trading considering uncertainty, degradation, and the changing market environment

Energieerzeugung/-infrastruktur und Netze
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Motivation

Increasing shares of renewable generation require additional flexibility options in power systems. Battery energy storage systems (BESSs) can provide this flexibility and recover investment costs by participating in day-ahead spot market trading. However, [1] state that historically, trading could only cover up to 25% of the BESS's cost. As spot market prices have been subject to significant volatility in the past year, this study investigates the profitability of day-ahead BESS trading in the current German market environment. As degradation and uncertainty have been often neglected in previous studies, we incorporate an XGBoost forecast and the SimSES battery degradation modeling framework.

Methodology

We evaluate the profitability development of BESS day-ahead trading from January 2020 to August 2022. Price uncertainty is modeled using an XGBoost forecast. For each investigated month, the forecast algorithm is trained using weather, prices and type-of-day features from the previous 365 days. Then, based on the day-ahead forecast for each day, the BESS is charged in the hour with the lowest price and discharged in the subsequent hour with the highest day-ahead price, if a profit margin, i.e., a difference of at least 25% between the lowest and highest price, is reached. Each month's resulting battery operation pattern is then used as input for the SimSES battery simulation framework with a Sony/muRata 1MWh battery with Lithium-Ion cells and Lithium-Ferrophosphate Cathodes [3]. The SimSES framework uses data from underlying real-world degradation experiments. To evaluate if the spot market prices of a month would allow a profitable BESS operation, a five year simulation is run. The resulting degradation after five years is interpolated to 20 years due to limited computing resources. Finally, based on a 0.65 End-of-Life (EOL) criterion [4] and battery costs of 350€/kWh [5] the BESS's resulting lifetime and amortization time are calculated.

Results

The results are illustrated in Figure 1. Assuming the price structure of January 2020, the BESS would reach its EOL after 17.5 years but would need to be operated 106.1 years to be profitable. In October 2021, the expected battery life (18.65 years) exceeds the amortization period (18.61 years) for the first time (when considering uncertainty). Since March 2022, the lifetime exceeds the expected battery-life in almost every month. Conditions were best in August 2022, where the amortization period amounts to 7.57 years and the lifetime lies at 17.63 years. Assuming a perfect foresight significantly overestimates BESS profitability. For instance, in August 2022 the amortization period lies at 5.49 years, which is 26.6% lower than the XGBoost-based equivalent.

In summary, the study shows that with current market prices, day-ahead trading with BESSs can be profitable in a real-world scenario with uncertain prices, day-ahead forecasting and a realistic battery degradation model. The BESS's profits could be even increased further when additional revenue streams are added, such as participation on reserve markets. Furthermore, the study shows that current XGBoost electricity price forecasting models are

sufficient for profitable BESS market operation. However, by improving forecasting models, amortization periods could be lowered further.

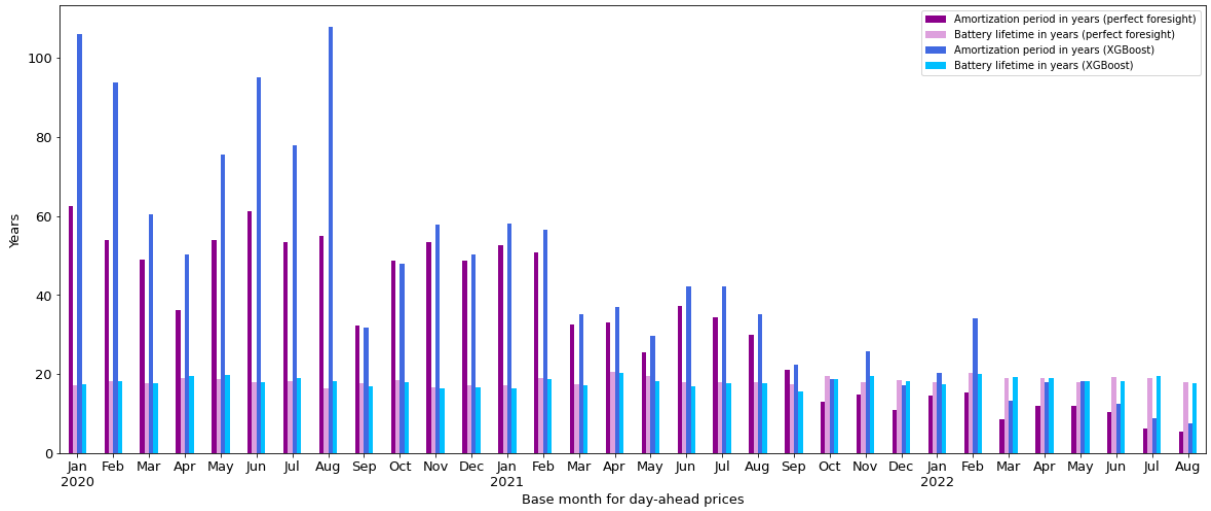

Figure 1: Comparison of the BESS's amortization period and battery life time in the respective monthly day-ahead prices(perfect foresight vs. XGBoost forecast)

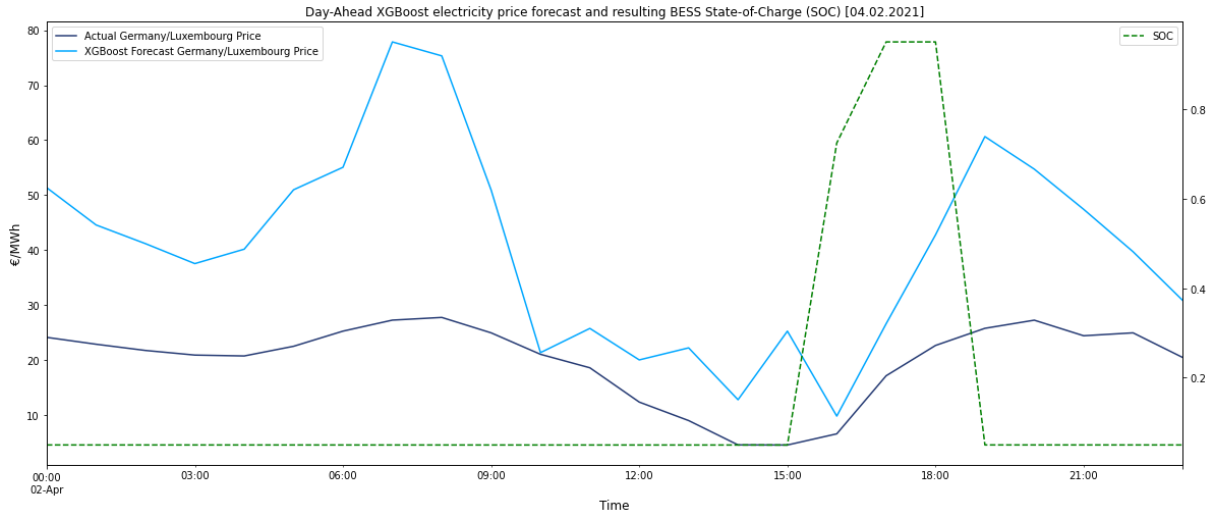

Figure 2: Exemplary daily electricity price forecast compared w. real prices and resulting battery State-of-Charge (SOC).

Literatur

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