

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

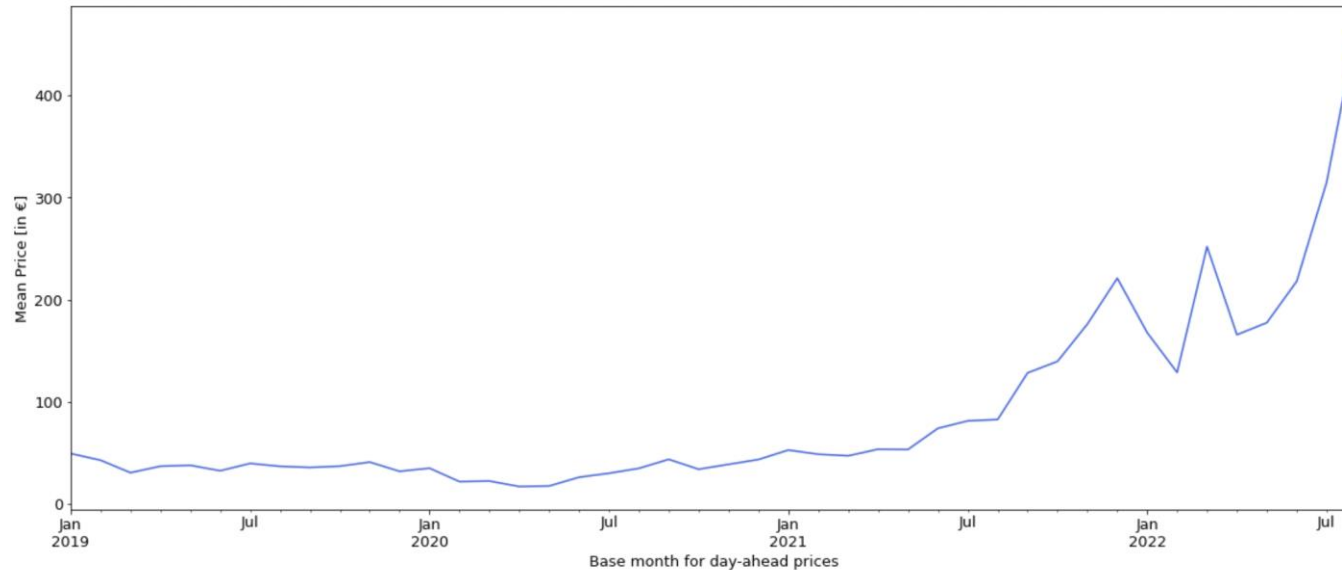
13. Internationale Energiewirtschaftstagung an der TU Wien  
16.02.2023, Leo Semmelmann



Picture source: Fluence Energy, <https://ir.fluenceenergy.com/news-releases/news-release-details/worlds-largest-storage-transmission-project-announced-fluence>

- BESS are necessary for transition to 100% renewables-based energy system [1, 2]
  - Hence: increased profitability of BESS would send a strong market signal for more installations, accelerating the way to a carbon-free energy system
- However, Battery energy storage systems (BESS) are considered unprofitable in spot market trading cases, especially in the day-ahead market [3, 4]
- Hence, multiple battery revenue streams, such as peak shaving and participation in reserve markets, must be combined to reach profitability [5]

# Motivation



Changed day-ahead market electricity prices in Germany due to the Russian invasion in Ukraine [6]

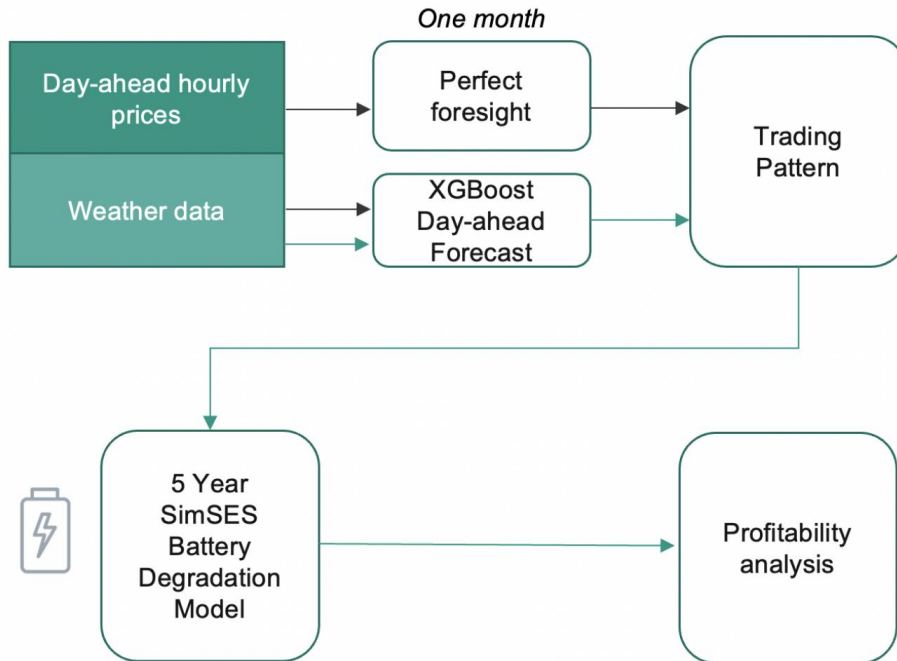
*RQ: What is the impact of elevated electricity price levels on profitability of BESS participating in the day-ahead market?*

Evaluation of BESS profitability in German day-ahead electricity markets

Consideration of uncertainty and battery degradation

Analyzing the impact of forecasting accuracy on BESS profitability

# Framework



Trading decisions based on perfect foresight and XGBoost forecast [7]

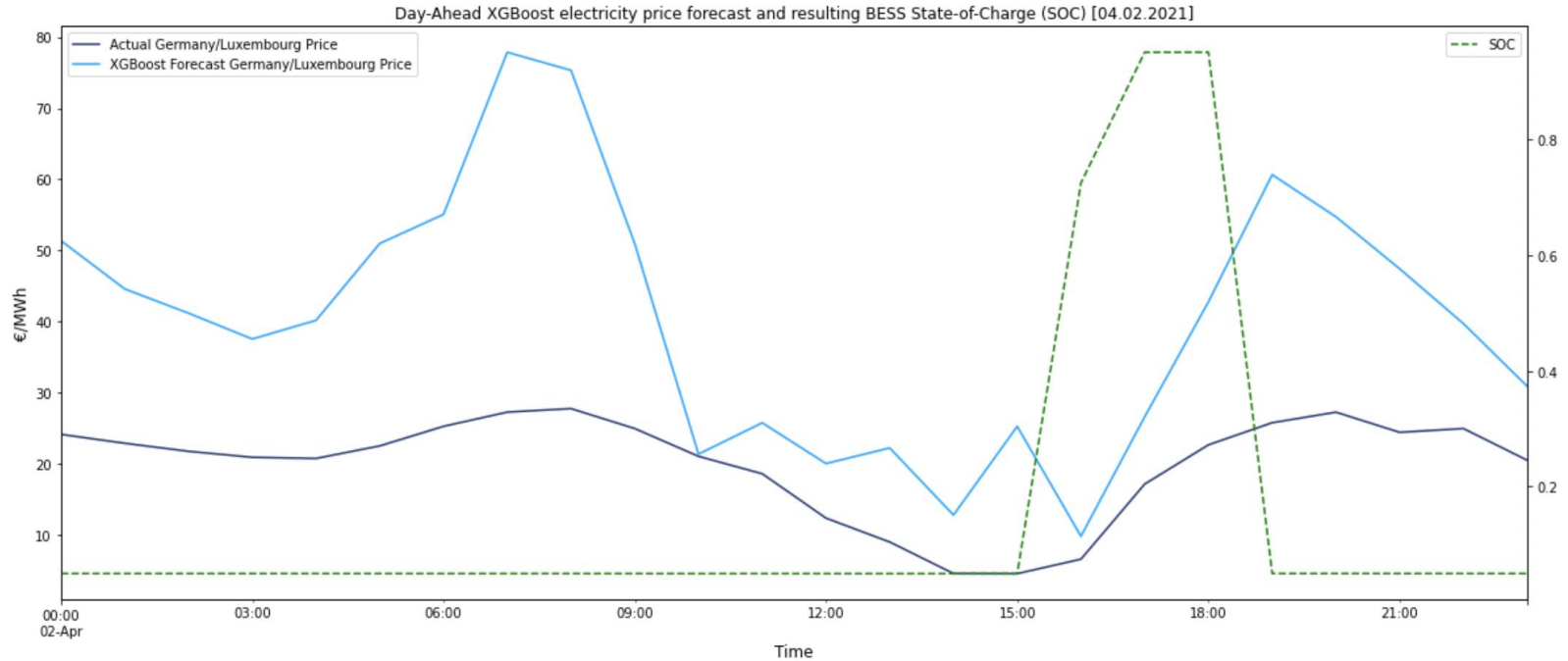
Battery operation and degradation simulation with SimSES [8]

Analyzing payback period and battery lifetime

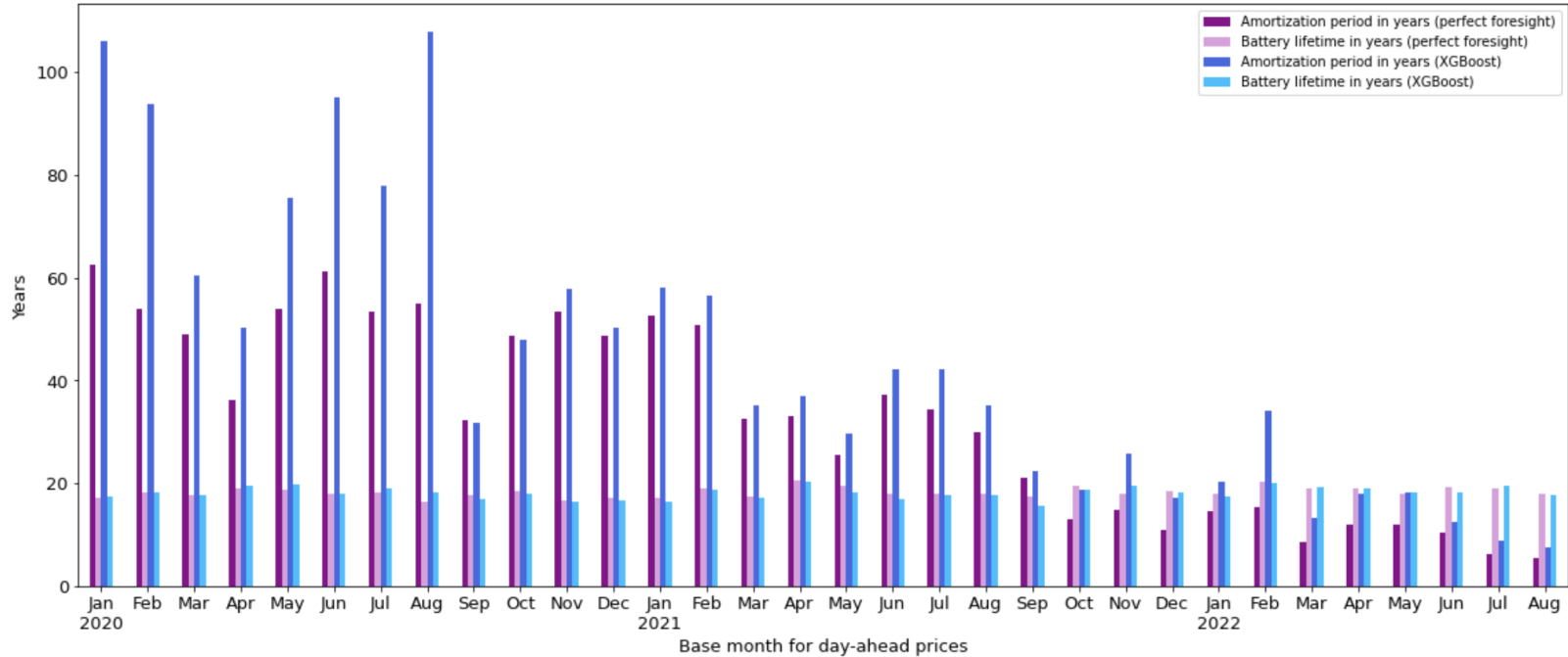
# Case study

- Day-ahead market prices from the German/Luxembourg price zone January 2020 – August 2022 [6]
  - January to December 2019 price data used for training of XGBoost model
- Weather data from five stations and respectively four weather data points
  - Stations: Frankfurt, Kiel, Konstanz, Cologne, Munich
  - Data: Temperature, precipitation, wind speed and solar radiation
- Simulating Sony/muRata 1MW/1MWh battery with Lithium-Ion cells and Lithium-Ferrophosphate Cathodes [8, 9]
  - Assuming price of 350€/kWh and 0.65 end-of-life criterion (EOL) [9]

# Results



# Results





# Sensitivity Analysis

Value	-25%	-10%	Base case	+10%	+25%
BESS Cost [350€/kWh]	5.68	6.82	7.58	8.33	9.47
Minimum Profit Margin [25%]	7.58	7.58	7.58	7.58	7.58
End-of-Life Criterion [0.65]	25.81	20.91	17.63	14.35	9.44

*Table 1: Sensitivity analysis for amortization period and battery lifetime (in years) with August 2022 prices, based on XGBoost day-ahead forecast*

# Discussion

Results subject to underlying price levels

Only one simple use case and forecasting algorithm regarded

Battery aging mainly calendric

# Conclusion & Future works

BESS day-ahead trading profitable in investigated case

Improving forecasts can further improve profitability

Implementation of more complex trading strategies, e.g. intraday

Consideration of multiple use cases

# Sources

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- [3] Komorowska, A., Olczak, P., Hanc, E., & Kamiński, J. (2022). An analysis of the competitiveness of hydrogen storage and Li-ion batteries based on price arbitrage in the day-ahead market. *International Journal of Hydrogen Energy*, 47(66), 28556-28572.
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- [7] Chen, T., & Guestrin, C. (2016, August). Xgboost: A scalable tree boosting system. In *Proceedings of the 22nd acm sigkdd international conference on knowledge discovery and data mining* (pp. 785- 794).
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# Thank you for your attention!

■ Looking forward to your questions 😊