The problem of diminishing storage profits from arbitrage

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Overview

Energy storage is a critical component in the transition towards net-zero carbon emissions, as it helps address the variability of renewable energy sources such as wind and solar, which are intermittent by nature. In its Ten-Year Network Development Plan (EntsoE, 2024), Entso-E estimates that 700 GW of solar and 500 GW of wind power will be deployed in Europe by 2030 and that 200 GWh of battery energy storage systems (BESS) will be built by that time.

This massive deployment of renewables and BESS raises the question of whether and to what extent it will affect electricity prices and, in turn, how this will translate into a change in BESS investment's profitability. This work investigates how the increase in renewable and BESS deployment will affect expected BESS profits from arbitrage in day-ahead markets in 2030, focusing on France, Germany and Italy.

Methods

To assess the profitability of BESS, a European market model has been developed to simulate the European day-ahead market coupling. The electricity network has been created using the reference Entso-E electricity grid and adding the planned expansion in 2030. Demand and generation capacity in each country have been obtained from the Pan-European Market Modelling Database (EntsoE, 2024). This includes generation from 13 different fuel types (geothermal, marine, run of river, biomass, waste, gas, hard coal, heavy oil, hydrogen, light oil, lignite, nuclear, and oil shale). To account for the stochasticity of wind and solar generation, a Monte Carlo approach has been adopted by building different scenarios to account for generation outages and climate variability. To properly account for pumped-storage and reserve-based hydro, the reservoir levels throughout the year have been modelled with a weekly resolution for dam-based hydro, daily for poundage, and hourly for both open-cycle and closed-cycle pumped storage. This model has been used to solve a market clearing problem for each Monte Carlo scenario to obtain the electricity market prices and the BESS charging and discharging patterns, which have been used to determine the BESS profit from arbitrage in the day-ahead markets.

Results

Preliminary results show that the amount of renewable and BESS deployed significantly affects storage profits. Figure 1 reports the profitability of storage from arbitrage in the day-ahead market in France, Germany, and Italy in 2030. The values of renewable and BESS labelled with 100% in the y-axis and x-axis, respectively, represent the amount of renewable and

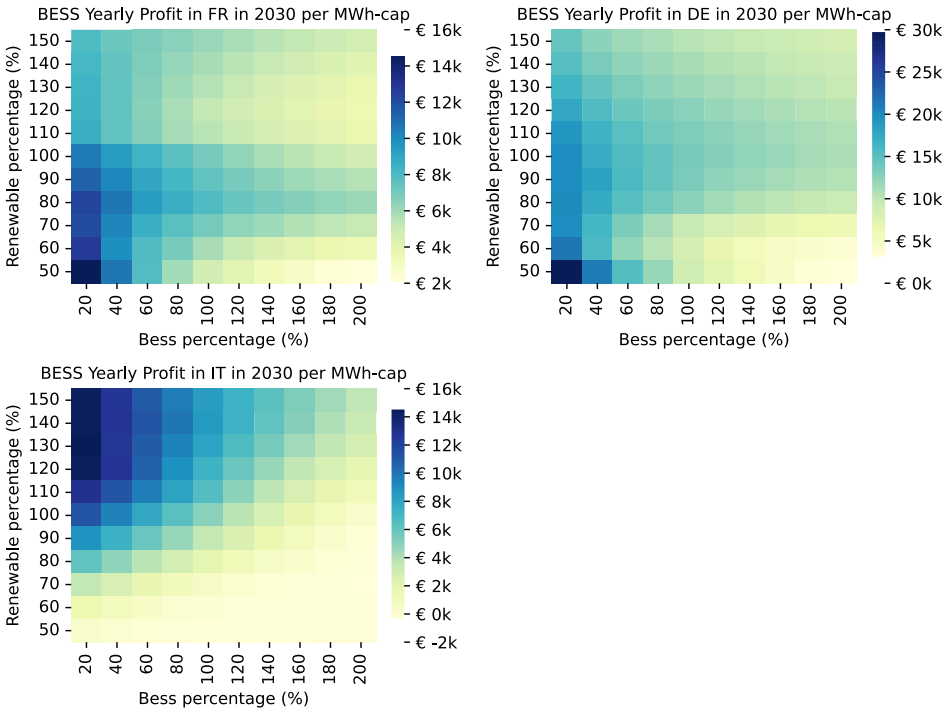

Figure 1 The Figure shows how the BESS profit per MWh installed in France, Germany and Italy chances as the deployment of BESS and renewable increases

BESS deployment that EntsoE expects in Europe in 2030. The figure shows how the increase in BESS deployment reduces the BESS profitability (profit cannibalisation), particularly in the Italian market. By contrast, the increase in renewable tends to increase BESS profits, countering this effect.

Figure 2 reports the distribution of electricity market prices in the day-ahead market in France, Italy, and Germany in 2030 for different levels of renewable penetrations, showing how the increase in renewable energy shifts the electricity price distribution towards zero, particularly in Germany. In France, this significantly increases the likelihood of nuclear power being the marginal power plant.

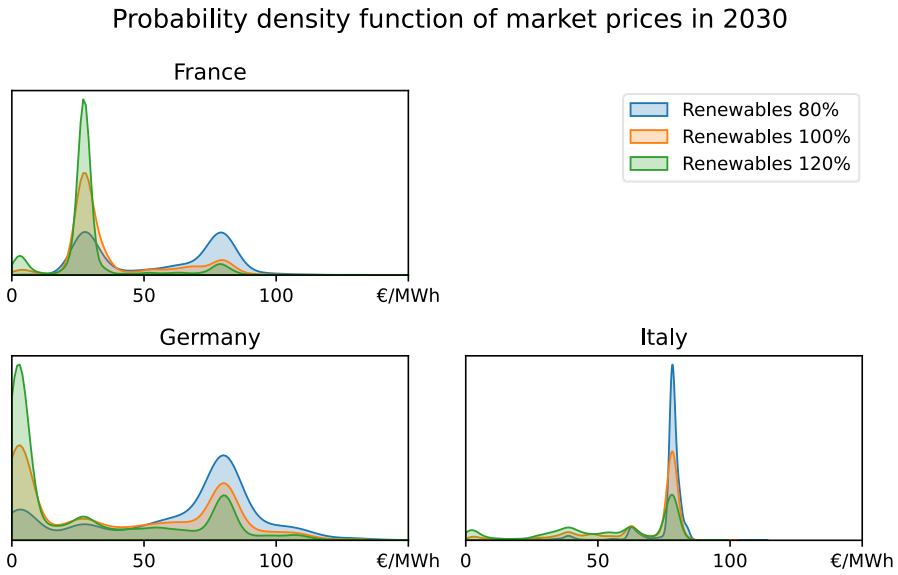

Figure 2 Distribution of electricity market clearing prices in the day-ahead in France, Italy and Germany in 2030 for different levels of renewable penetrations (the value of 100% represents the expected renewable deployment in 2030).

Conclusions

These preliminary results show that BESS profitability in day-ahead markets can be significantly affected by the amount of renewables and BESS present in the market. This suggests that storage investors may find it difficult to recover the required investment costs to reach net zero carbon emission unless additional revenues are earned from different market streams (such as ancillary services and capacity markets) or through subsidies.

References

EntsoE. (2024). *TYNDP 2024*. https://2024.entsos-tyndp-scenarios.eu/download/