Boosting flexibility (II) – the role of battery storage

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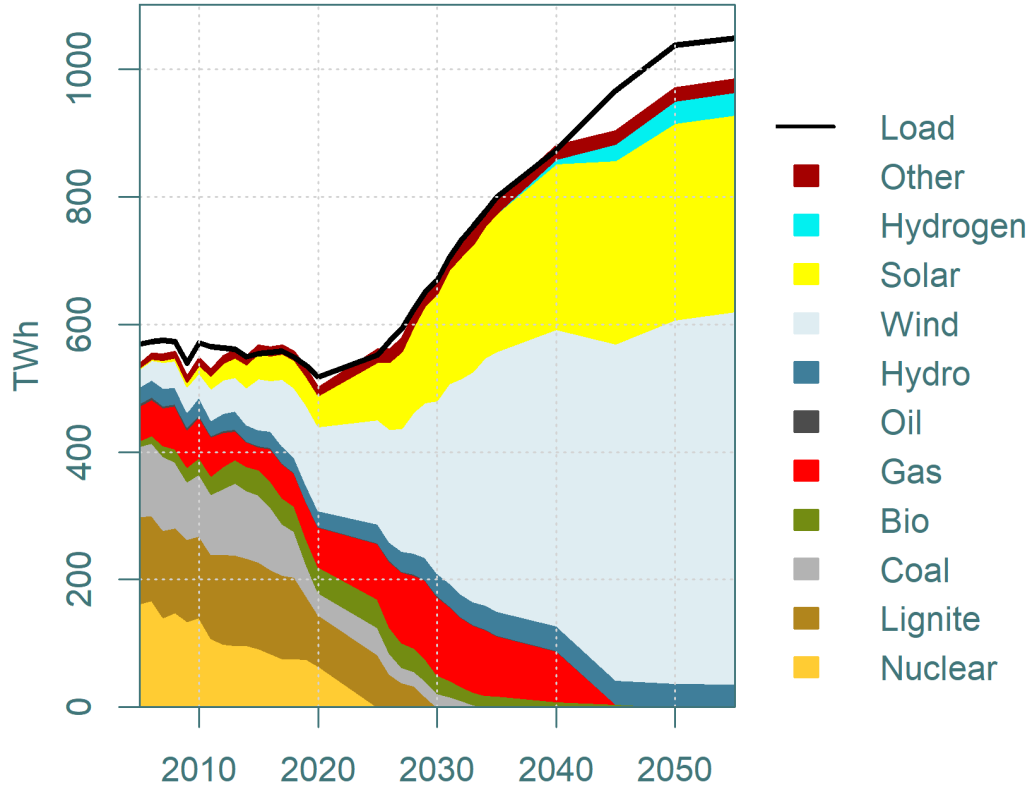
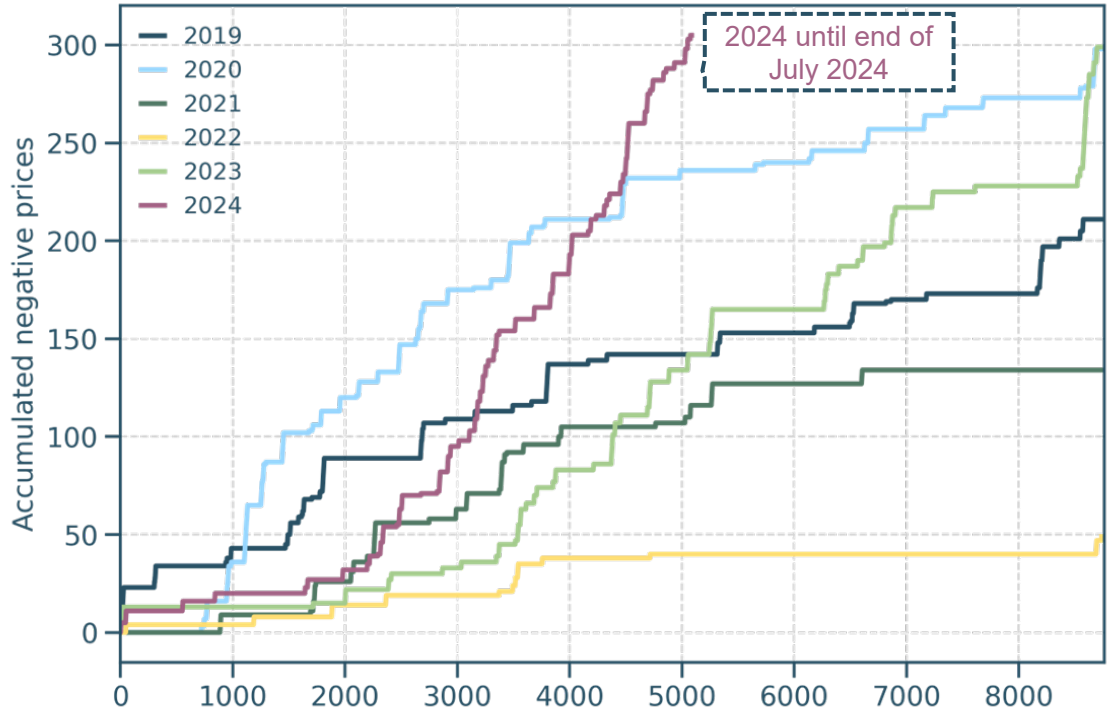
Why are we talking about Flexibility?

Germany already has a high share of renewables, and the share and volumes are expected to increase. Solar power is also largely non-responsive to prices

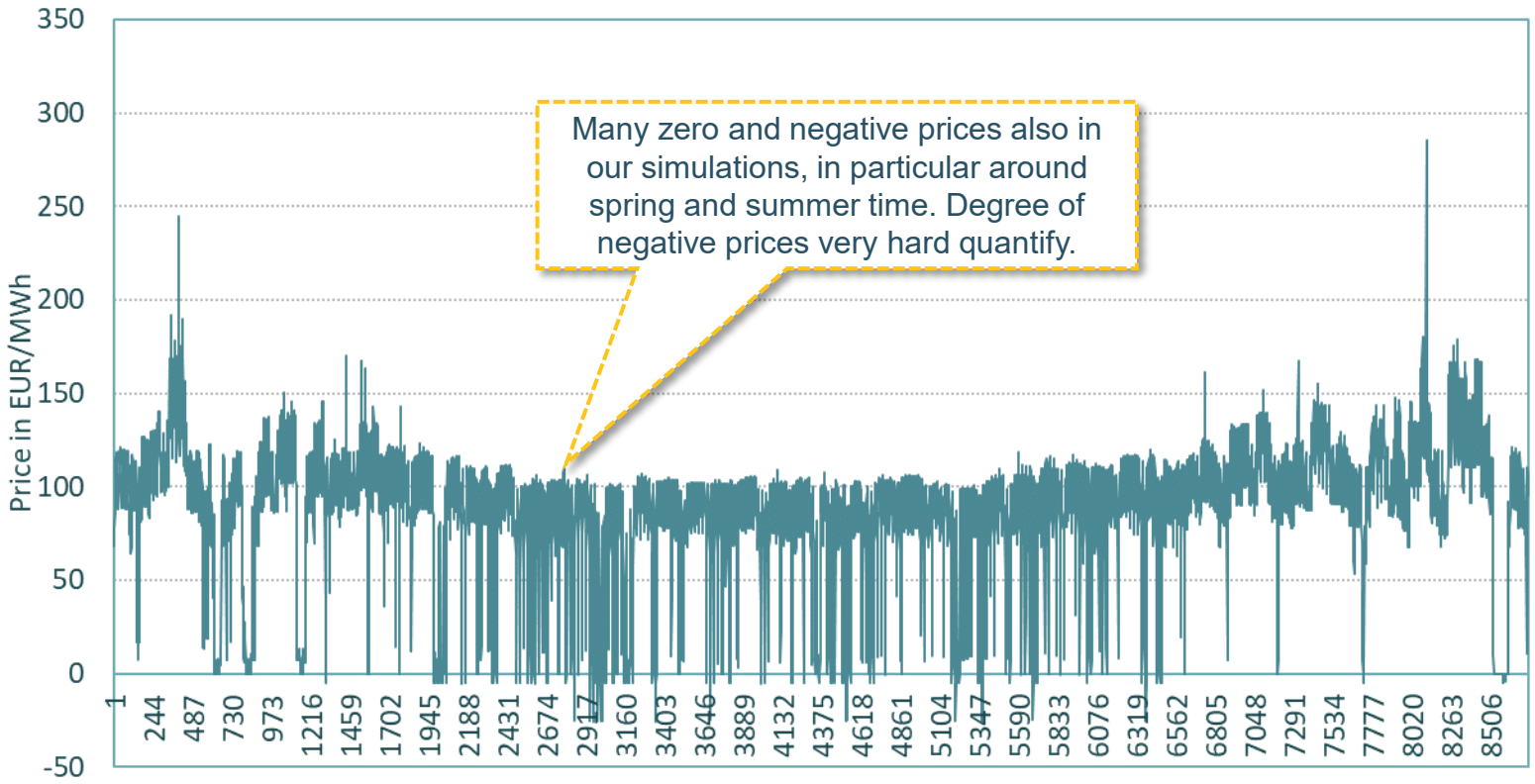


This leads to volatility and negative/zero prices: The figure below shows aaccumulated negative prices in Germany over past years



In our Base case for 2025, we expect many hours with zero or negative prices for Germany and Austria - preliminary results; official update 30-09-2024*

German power prices in Base case 2025



Commentary

- In our simulations we observe many negative and zero price hours. In particular in summer and spring time, frequency of zero and negative price hours increases
- The observed market volatility is even higher, but the model results clearly indicate the issue, i.e. many hours with large surplus that imply curtailment of RES resources and/or negative price hours
- Solar PV, with a very concentrated form of generation, is the main contributor to this phenomenon
- Many solar installations (ca. 70%) are not responsive to price signal. This also applies to installations in neighbouring countries, where solar PV is also growing
- To put data into perspective: In Germany we will have around **90 GW solar PV online in 2025**. **Peak demand** (typically in winter-time) is also at that level of around **90 GW.**

** Preliminary results – Official Update 30-09-2024 with release of THEMA market outlook*

The *TheMA* model covers all European markets

Using the TheMA power market model, we tested what effect batteries would have on price volatility

The key to our analysis is our *TheMA* model, a highly advanced and internationally recognised power market simulation model

Continuously updated

Easy to use, transparent

Back-tested, validated

Large, active user-group

We used our TheMA market model with data for 2025 to simulate the effect of additional batteries. We added gradually more and more battery capacities (with 2h storage) in Germany and neighbouring markets. The simulations are meant to illustrate the effect, and do not necessarily reflect a realistic scenario. Numbers below show added values.

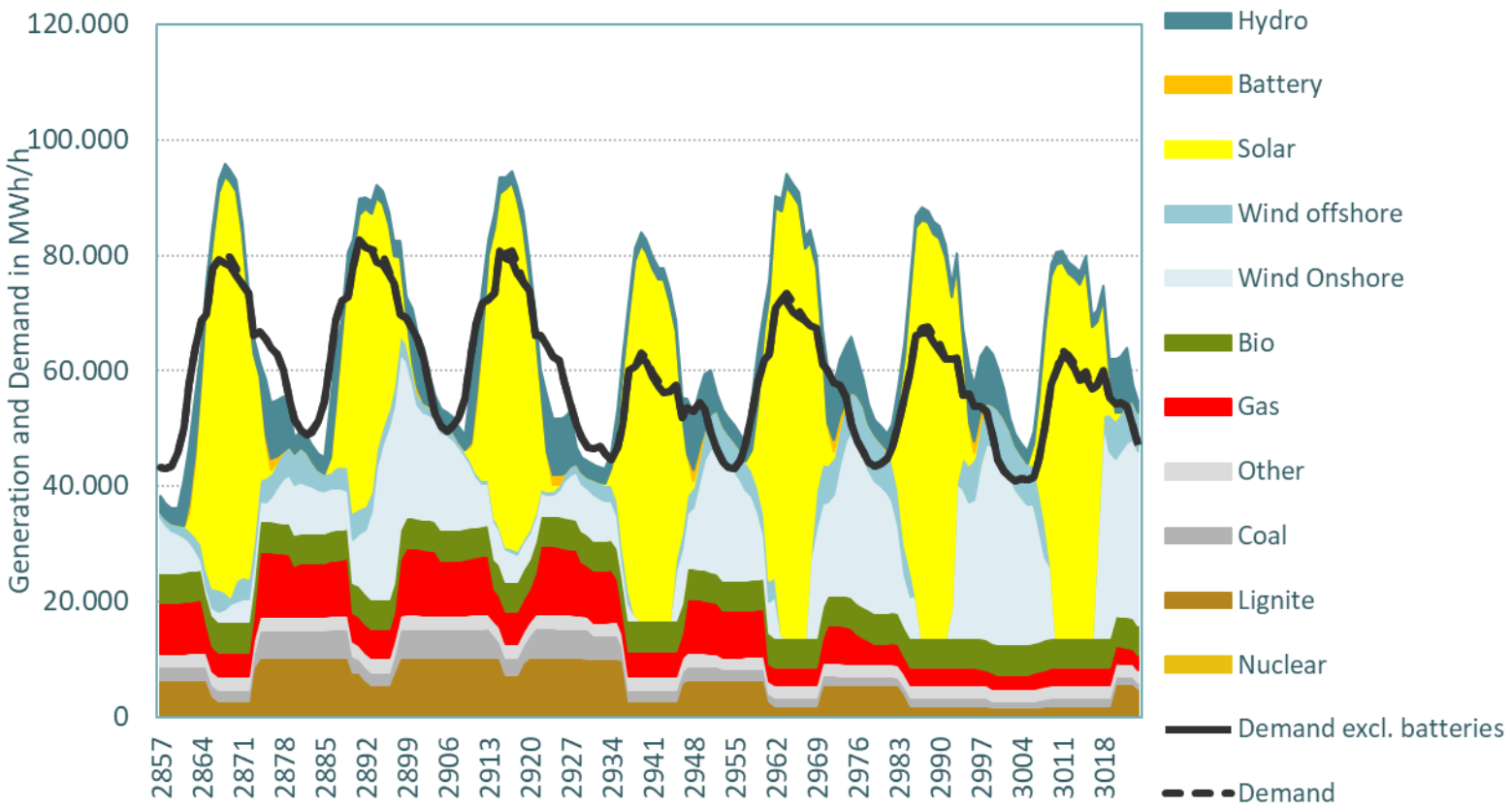
Results are preliminary – New market outlook due 30-09-2024

	+5 GW DEU	+10 GW DEU	+15 GW DEU	+20 GW DEU	+25 GW DEU	+30 GW DEU	+35 GW DEU	+40 GW DEU	+45 GW DEU	+50 GW DEU
Germany	5 000	10 000	15 000	20 000	25 000	30 000	35 000	40 000	45 000	50 000
Neighbouring markets total*	3 666	7 331	10 997	14 662	18 328	21 994	25 659	29 325	32 991	36 656
Total add	**8 666**	**17 331**	**25 997**	**34 662**	**43 328**	**51 994**	**60 659**	**69 325**	**77 991**	**86 656**

** Neighboring markets in which capacities are adjusted are France, Netherlands, Belgium, and Austria*

The “problem” becomes evident when looking at hourly dynamics

Hourly Generation after curtailment and demand dynamics week 18 in 2025* - Base case



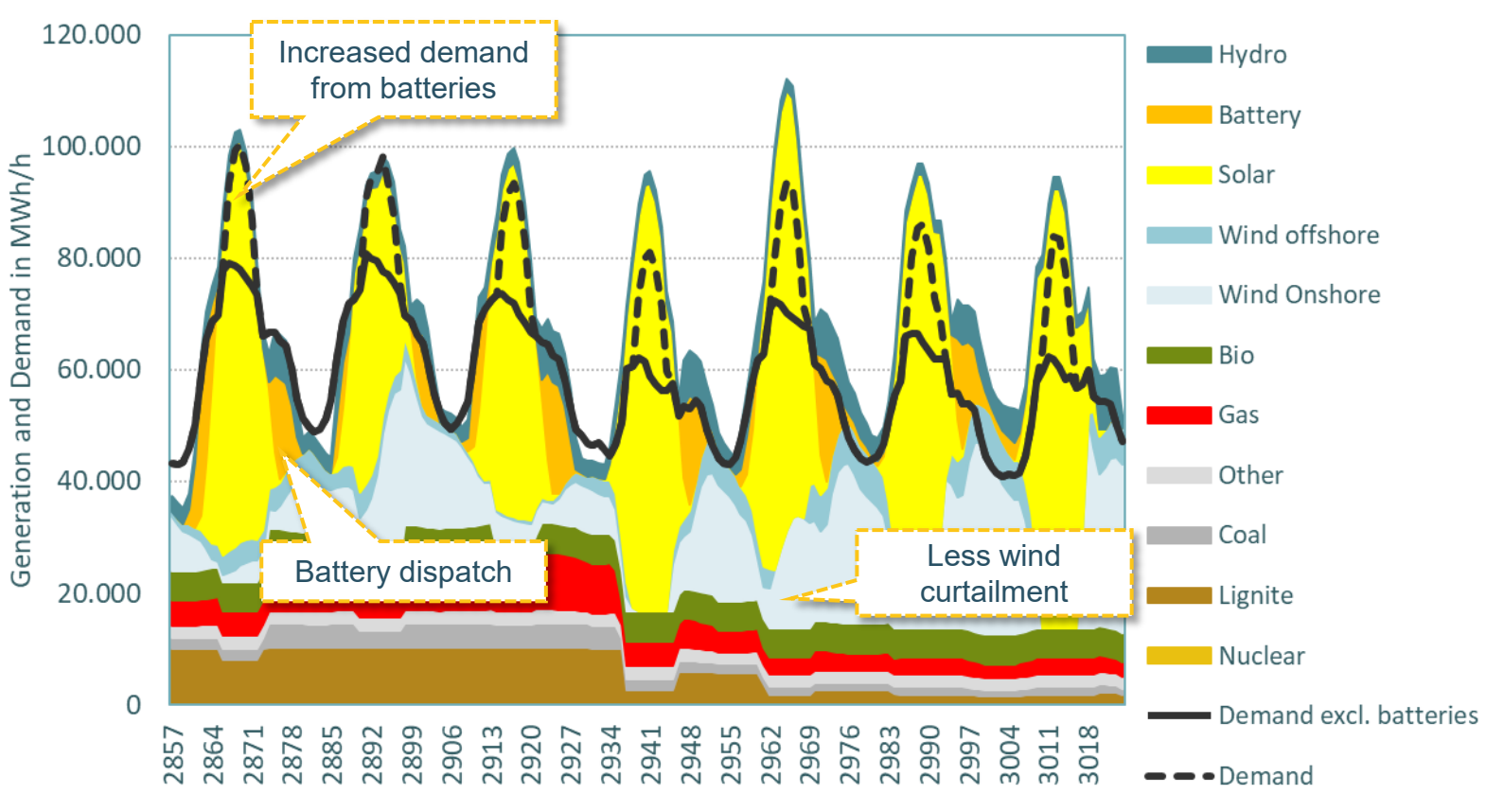
Commentary

- The issue becomes evident when studying hourly dynamics
- The figure to the left shows hourly demand and generation in Germany simulated for 2025 in the Base case
- **At mid-day, solar PV alone is covering more than demand**. In addition, some other remaining base-load units in CHP setup or other feed-in regimes continue to produce
- **In many hours, wind has to be curtailed**. This is illustrated by wind dropping to zero in the figure, which is due to curtailment, not little wind
- A similar picture is observed in neighbouring markets, so trade cannot solve the issue at hand

** Preliminary results – Official Update 30-09-2024 with release of THEMA market outlook*

Batteries can change the dynamics in the market considerably

Hourly generation after curtailment and demand dynamics week 18 in 2025* - With 50 GW Batteries in Germany and additional battery capacities in Central-West Europe

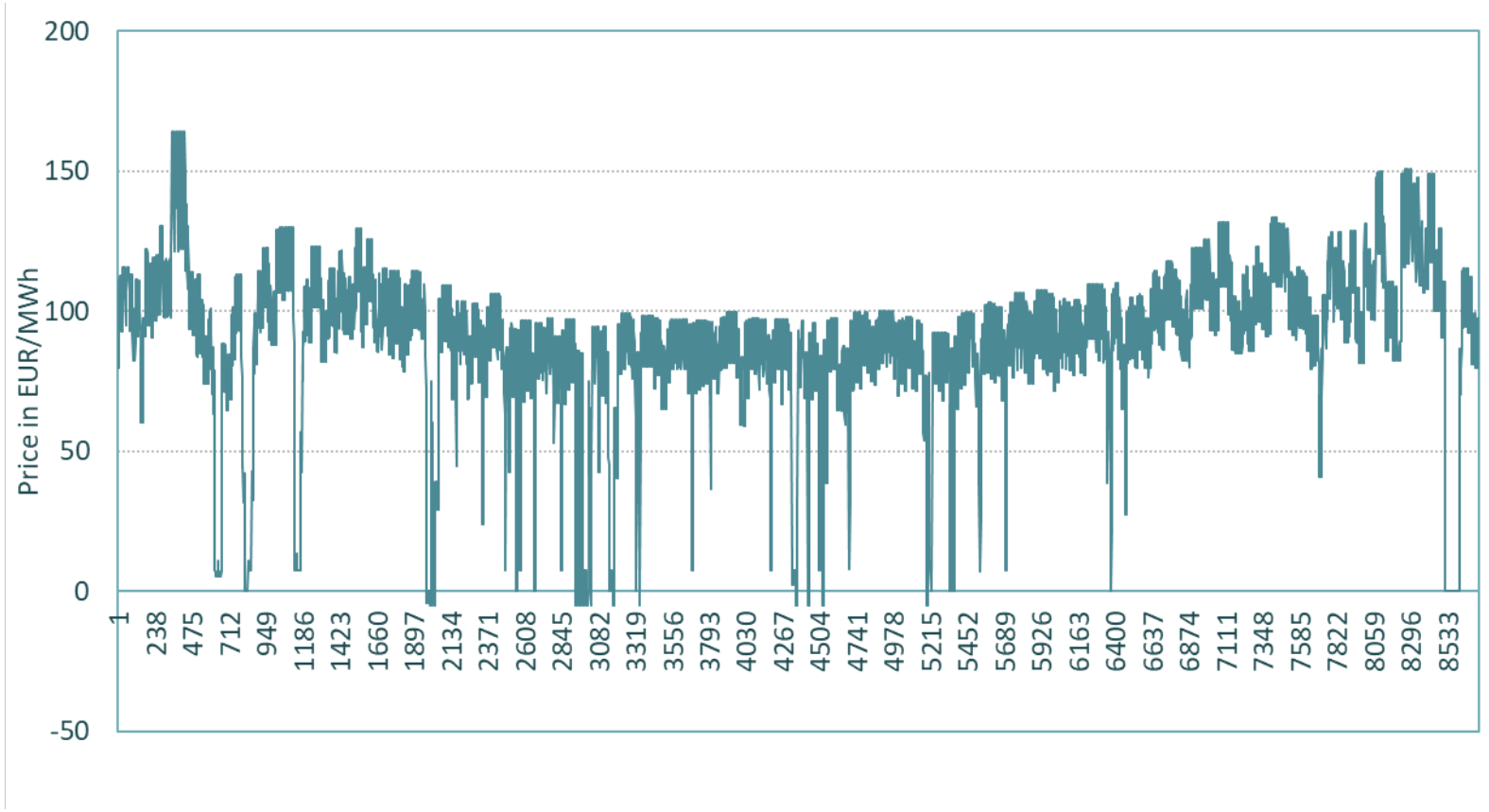


Commentary

- **Batteries have a clear impact on hourly demand and dispatch**, and can also reduce curtailment of RES resources
- Typically, a battery would charge when there is lots of surplus (typically mid-day when sun is shining and prices are zero or negative), and discharge in the more expensive peak hours in morning and evenings
- The behaviour is somewhat similar if one attached a solar park to a battery and wanted to sleeve generation output. But note that in such setup the value of battery and solar in combination cannot exceed the value of battery and solar in separation (from a strictly economical and optimisation perspective)

And prices would be much flatter, with less number of hours with negative or zero price hours

German power prices with 50 GW Batteries in Germany and additional battery capacities in Central-West Europe (CWE)

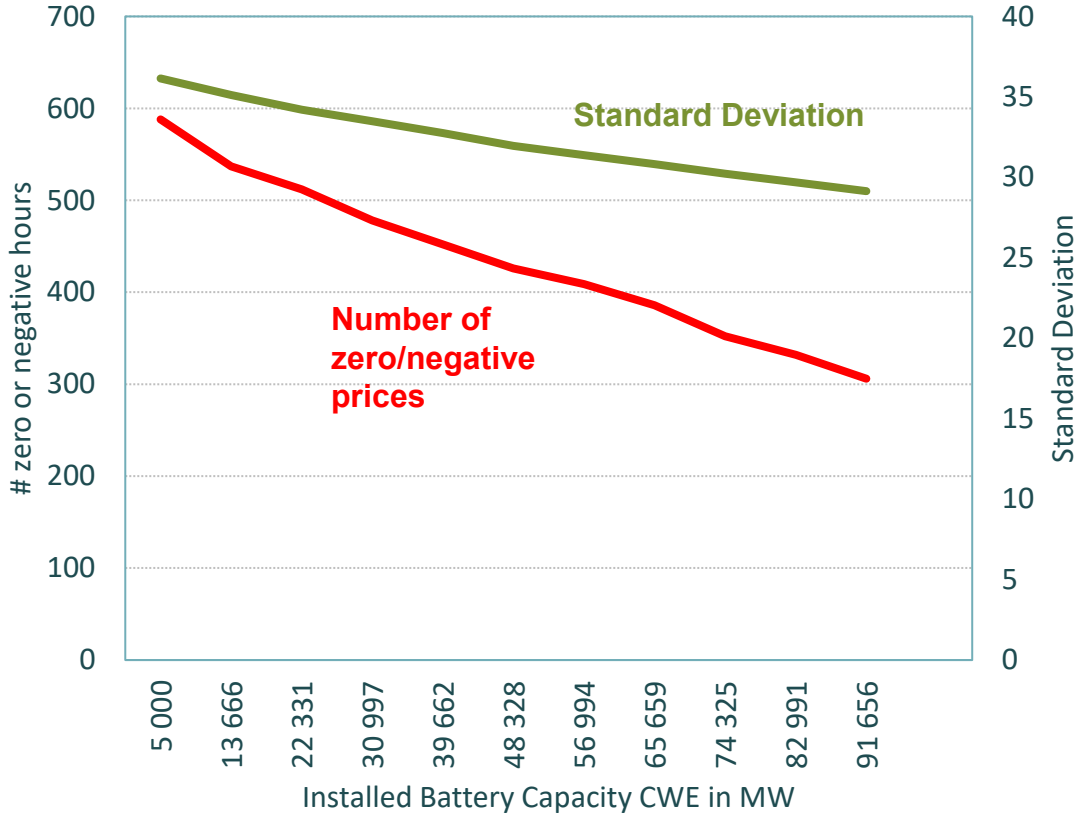


Commentary

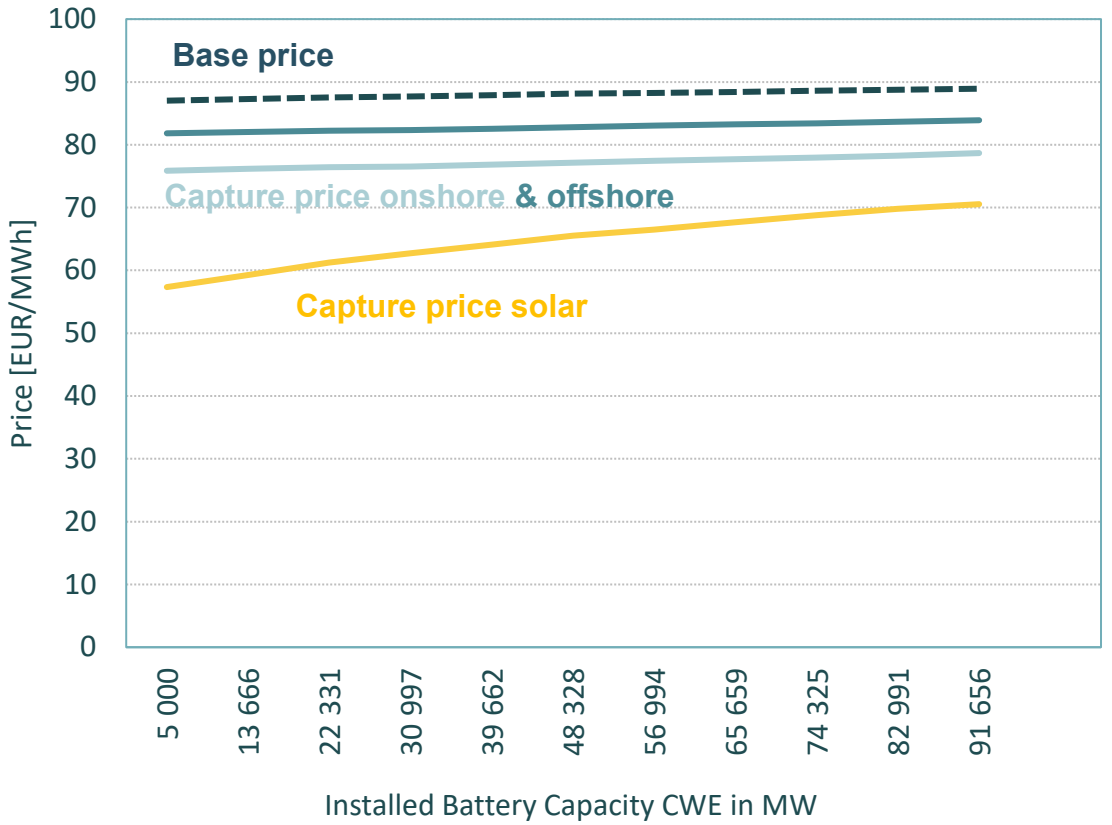
- In consequence, prices would become much “flatter” and the number of zero and negative price hours would decrease substantially
- But, even with 50 GW in Germany and close to 40 GW of batteries in markets around Germany, **prices would still be volatile in 2025**. And 90 GW of capacity is an unrealistically high number for 2025.
- And this is in a 2025 perspective. The solar ambition for **Germany alone by 2030 is 200 GW** (compared to 90 GW 2025) – in which case much more flexibility would be needed to smoothen prices
- So, **batteries can contribute to smooth prices, but price volatility will remain**, and will likely increase in the period to 2030 with additional solar PV becoming operational

This is also reflected in other KPIs, like zero price, standard deviation, or capture rates

KPIs for price volatility in 2025 with varying degree of battery capacity in CWE

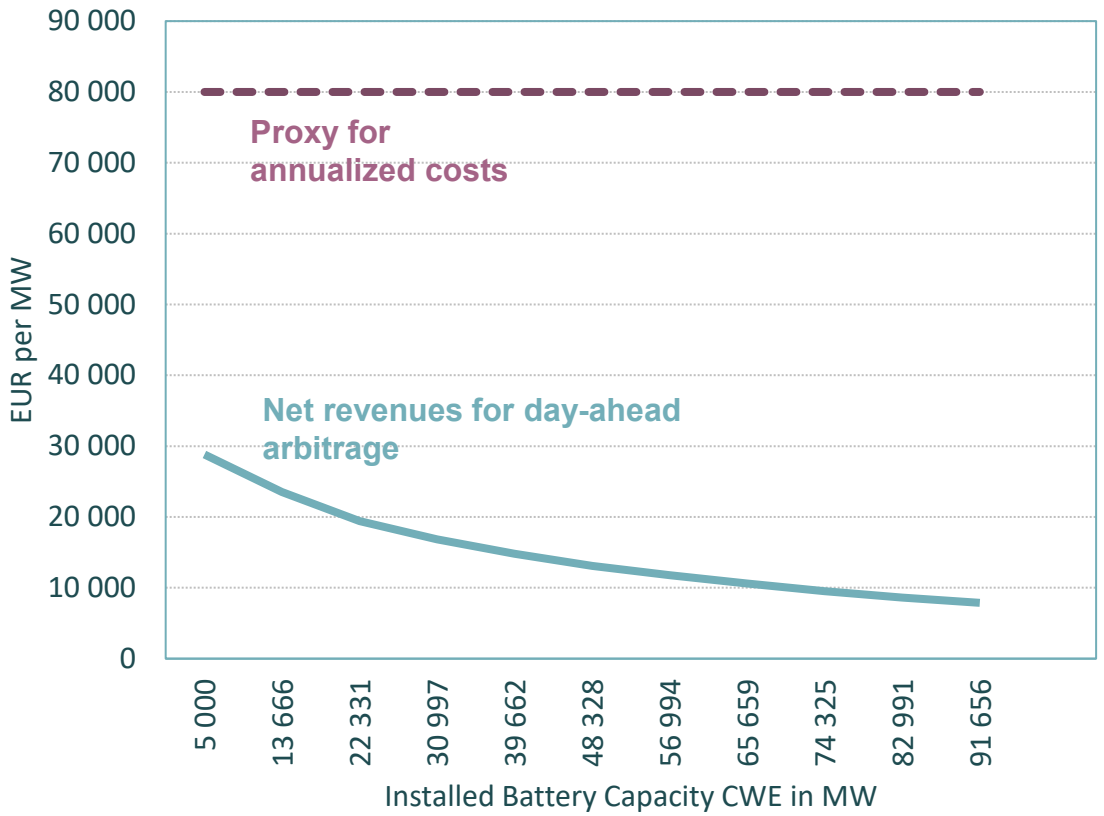


Capture prices in Germany in 2025 with varying degree of battery capacity in CWE



But, not only are 50 GW extremely high – they would also not finance themselves

Battery day-ahead market revenues from spot arbitrage and break-even proxy

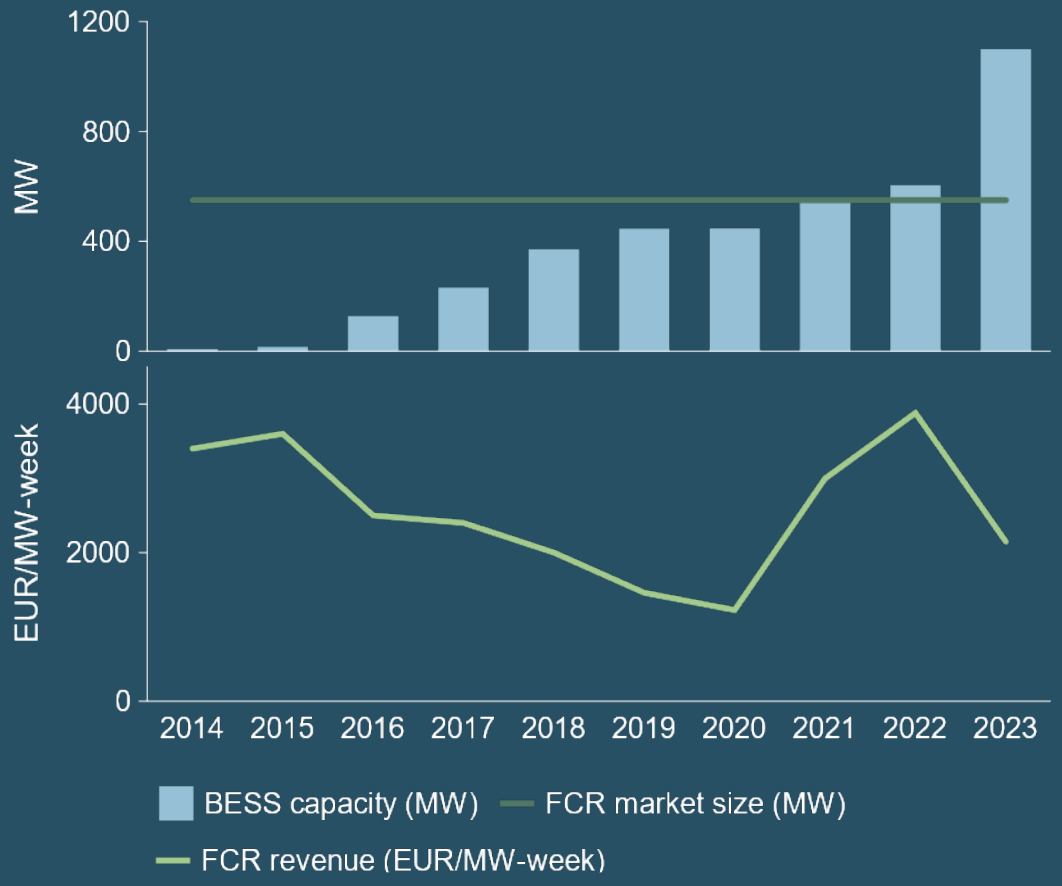


Commentary

- The main challenge is that day-ahead market arbitrage is not sufficiently attractive to finance battery investments
- We would see a **strong "cannibalisation":** The more batteries we have, the less is the price volatility and hence attractiveness of battery investments
- This would also **impact pumped hydro storage assets in Germany and Austria**: In the case with +50 GW of batteries, we estimate a decline of more than 50% in revenues for a typical pump storage plant (compared to Base case)
- The problem is that batteries are still very expensive, and rather extreme price swings are needed to cover costs with day-ahead arbitrage alone

So far, batteries have been very active on the market for FCR…

Revenues in the FCR market are decreasing despite growing market volatility



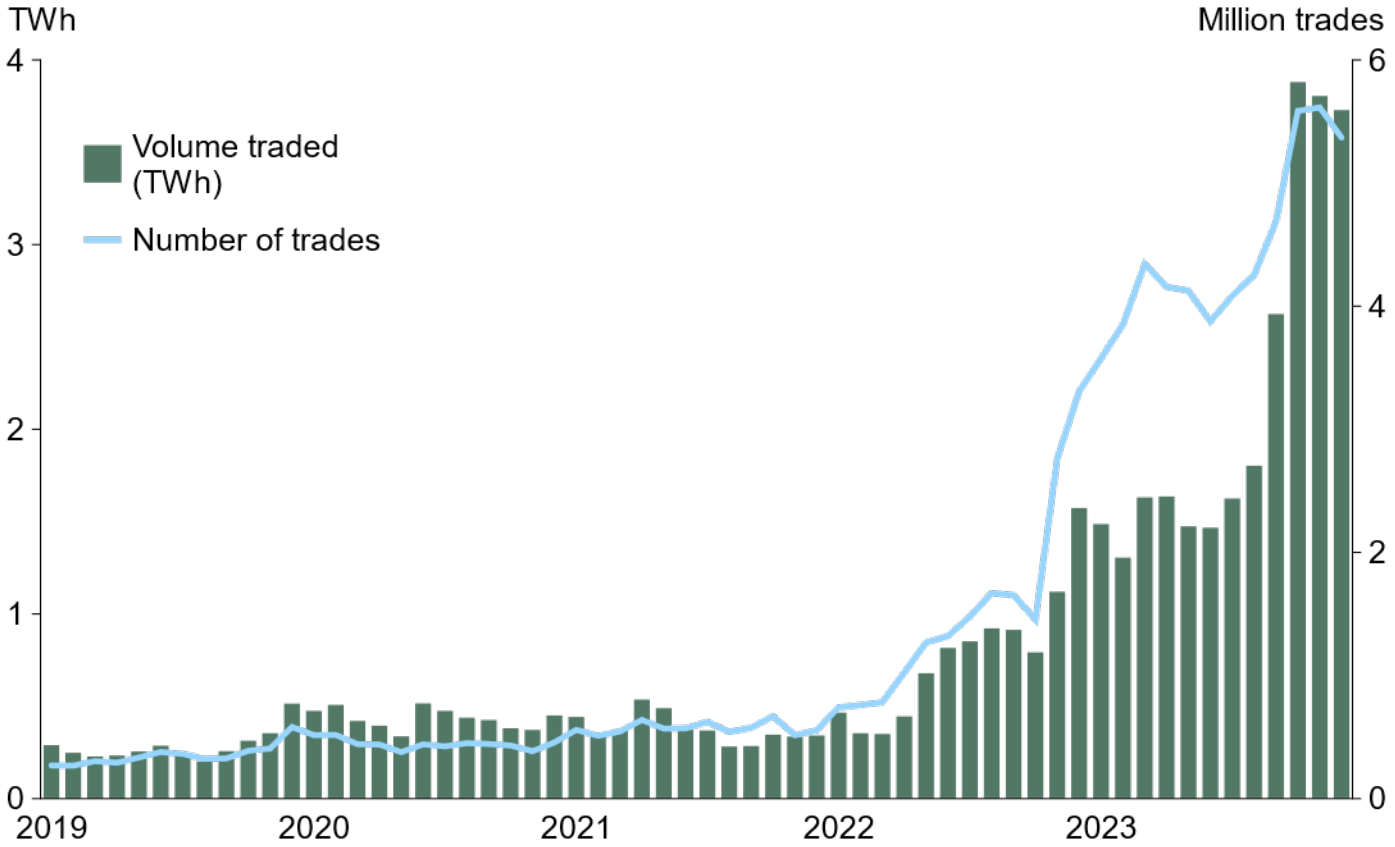
FCR = Frequency Containment Reserve

… but the "**F**requency **C**ontainment **R**eserve" market is too small to finance all new investments

- **Batteries are ideal for the FCR market**. They can switch on quickly:
  - FCR requires a start-up time of 30 seconds,
  - And a max operational time of 15 minutes.
- Activation on the FCR market is often limited → **Degradation and strain on the battery is also limited**
- Revenue by available capacity (MW), not delivered energy (MWh)

Intraday markets are of large interest to battery investors

The market has grown both in terms of traded volume and number of trades

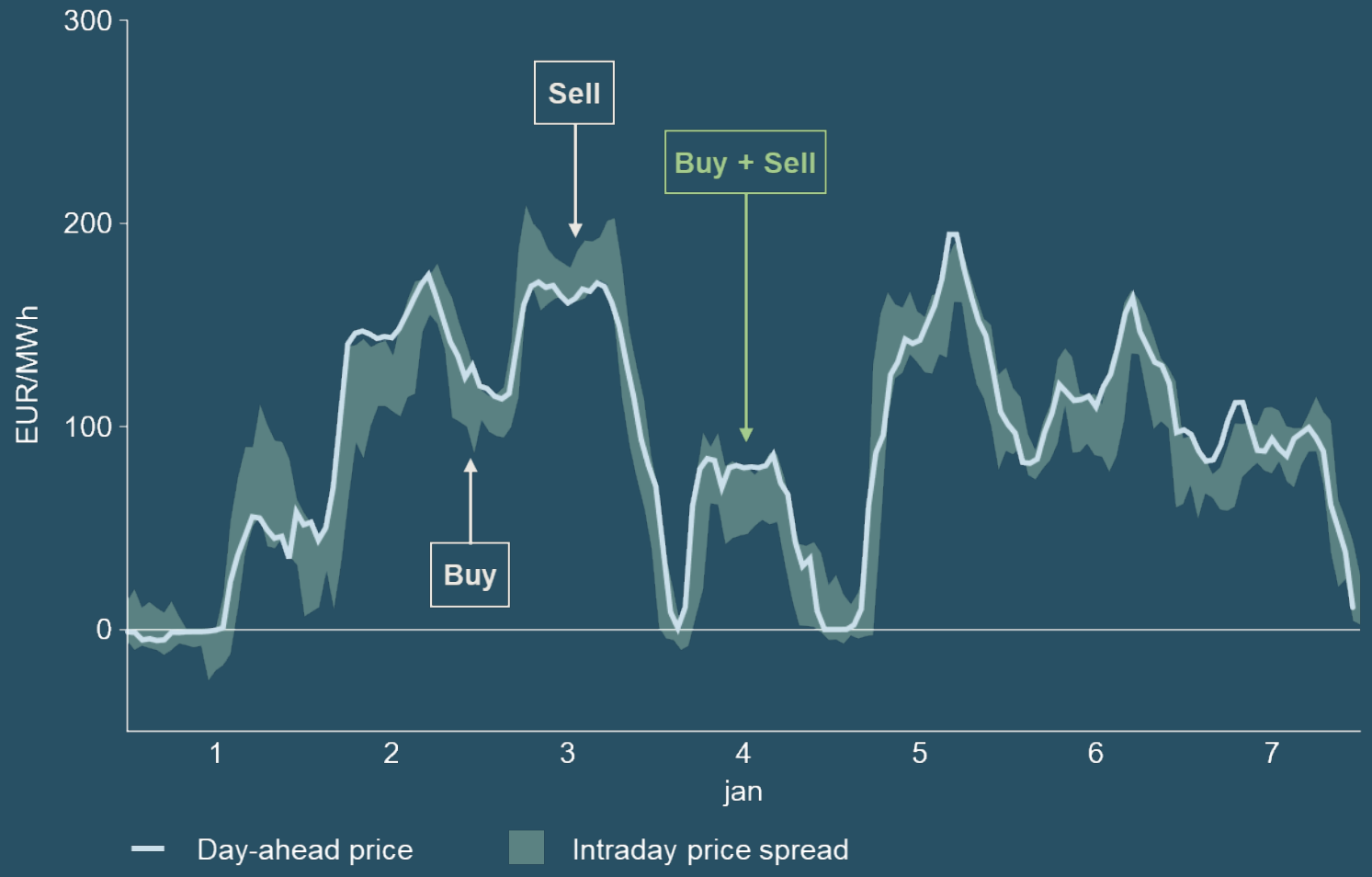


8-fold growth in traded volume, 6-fold growth in number of trades

The high number of trades indicates that algorithmic traders have entered the market

The intraday market offers battery-owners two advantages over the day-ahead market

Example week for Day-ahead vs Intraday markets in 2023



1

Higher price spread for arbitrage

- Buy power cheaper than in the day-ahead market
- Sell at higher prices than in day-ahead market

2

Asset-backed trading

- Buying and selling power within the same hour
- The **battery might not even run**, unless the battery operator fails to achieve a net-zero position

Key takeaways

- Batteries can help to smoothen prices, but batteries alone are not sufficient to get rid of all volatility.
- Batteries can also contribute to a reduction in RES curtailment, and higher capture prices (in particular for solar PV).
- The biggest challenge are dimensions and costs. Batteries are still expensive and cannot be financed by day-ahead arbitrage alone.
- Additional revenue streams are needed, but the question is whether other markets are large enough to accommodate very large battery volumes before also margins in these markets decrease.
- Also note that co-location will not improve the economics. The economic value of a co-location system cannot exceed the value of the individual components when individually optimised against day-ahead markets.

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