Unlocking the value of the Balancing Mechanism for renewable energy projects

The Balancing Mechanism (BM) has played a fundamental role in keeping the GB power system stable since its introduction in 2001. By paying participants to increase or reduce their generation or demand, the BM makes small adjustments on top of the wider wholesale market and balances the electricity market in real-time.

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The BM sees a wide range of participants, from traditional fossil fuel peaking plants to more recent flexibility players like batteries and demand side response units. It is mandatory for transmission-connected wind farms to register as a BM unit, but in recent years the BM has also opened up to smaller, distribution-connected projects.

Natural Power is a leading independent asset manager and, through our 24/7 ControlCentre and PerformanceCentre, manage over 2.5 GW of renewable energy projects in GB. In this paper we share some of our unique insights into how these assets interact with the BM, and where we see opportunities for renewable operators to access more value.

BALANCING MECHANISM TRENDS AND TERMINOLOGY

As renewable penetration increases, the GB electricity market is becoming more volatile. While wind and solar generation is cheaper than conventional power sources on a wholesale basis, the intermittency of the wind and solar resource means that the BM has to work harder to balance supply and demand. **Figure 1** shows the relative contribution to total generation (excluding interconnectors) from 2018 – 2022. There is a downward trend in overall generation; however, the contribution from renewables has been increasing.

Each BM unit has to submit Physical Notifications (PNs) forecasting the amount of power the unit expects to import or export in the 30 minute "settlement periods" ahead. Each unit also has to set a bid and offer price, which is the amount the unit will be paid to flex up (offer) or flex down (bid)[1] if they are accepted.

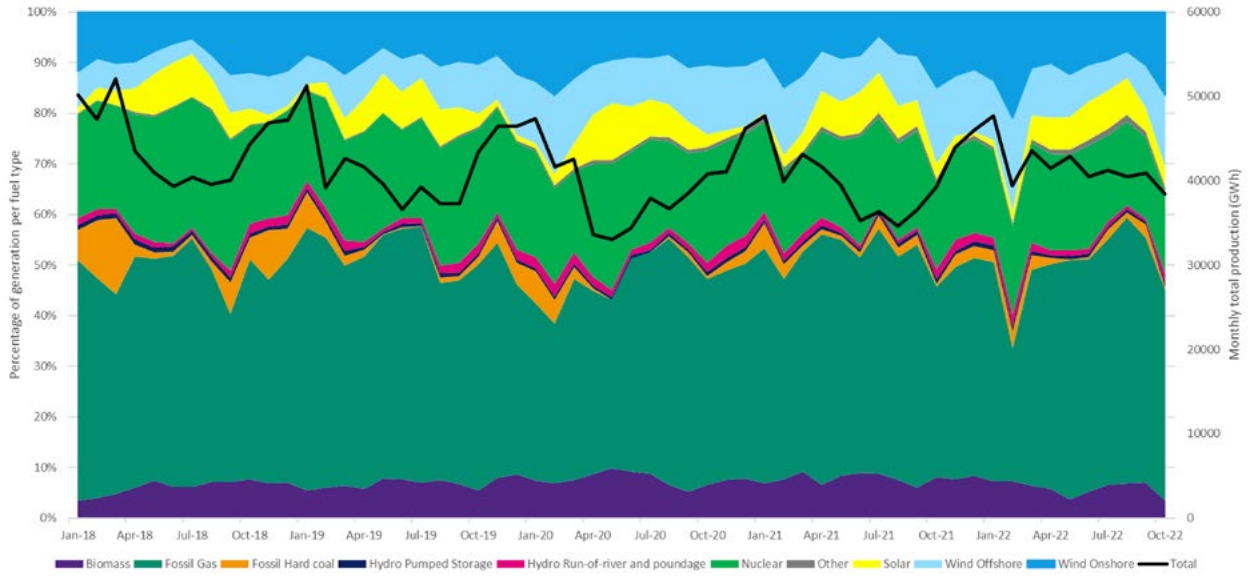


Figure 1: Evolution of the GB electricity mix, 2018-2022

[1] This description applies to generators. For demand side units, a bid / offer means increasing / reducing demand.

At any point in time, wind farms generally operate at the maximum power that the current wind speeds allow. Wind farms therefore normally only submit bids into the BM (not offers) - it is easy to curtail their generation, but typically not possible to ramp up their output.

The overall volumes of balancing actions on the UK grid are shown in **Figure 2**[2]. While overall, offers represent a more significant proportion of the balancing mechanism activity, there has been an increasingly large contribution from bids.

For each half-hourly settlement period, the BM determines whether the system is "long" (too much generation) or "short" (too much demand). Depending on the nature of the imbalance, the BM will then accept an appropriate number of bids or offers to balance the system. Individual bid and offer acceptance prices are aggregated into an overall system price. The BM is administered by Elexon, who publish comprehensive data on how the BM operates. An example is shown in **Figure 3**. where the distribution of system prices can be seen for January – April 2023.

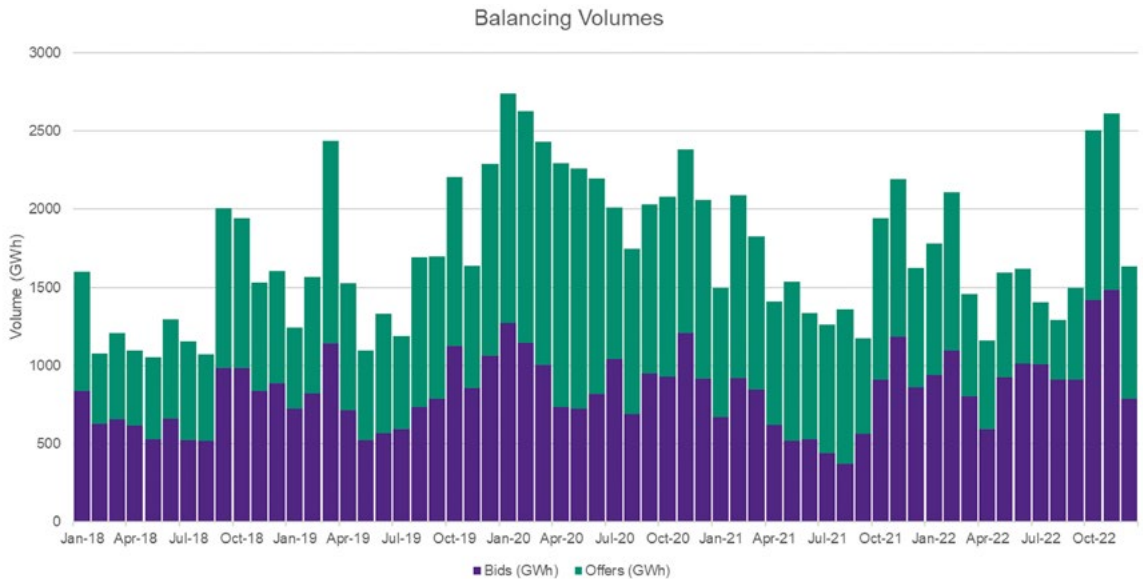


Figure 2: Volumes of Bids and Offers in UK BM, 2018-2022

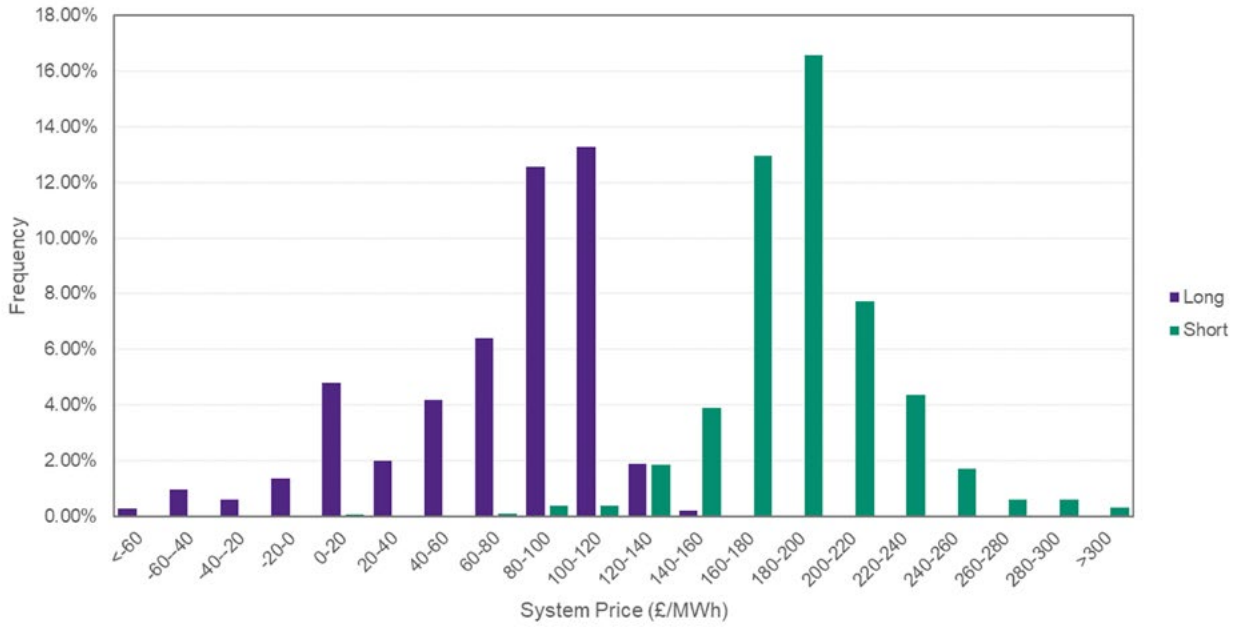


Figure 3: Distribution of system prices and system state, Jan-Apr 2023

[2] Note that BM volumes are derived from forecasted wind generation and may differ from the actual production that could have been delivered in the relevant period

It can be seen in **Figure 3** that prices are generally higher when the system is short and generation has to be increased. Nevertheless, there is also significant value that wind farms can access by curtailing their output when the system is long.

Figure 4 shows the accepted bid volume by fuel type across 2018-22. While there are a range of technologies that can help when the system is long, wind, alongside gas, dominates the accepted bids. It can be seen that there is significant wind curtailment especially in the winter months. Overall, the whole curtailment levels have been increasing in recent years, with winter 2021 seeing record volumes of wind curtailment and winter 2022 showing record overall curtailment volumes.

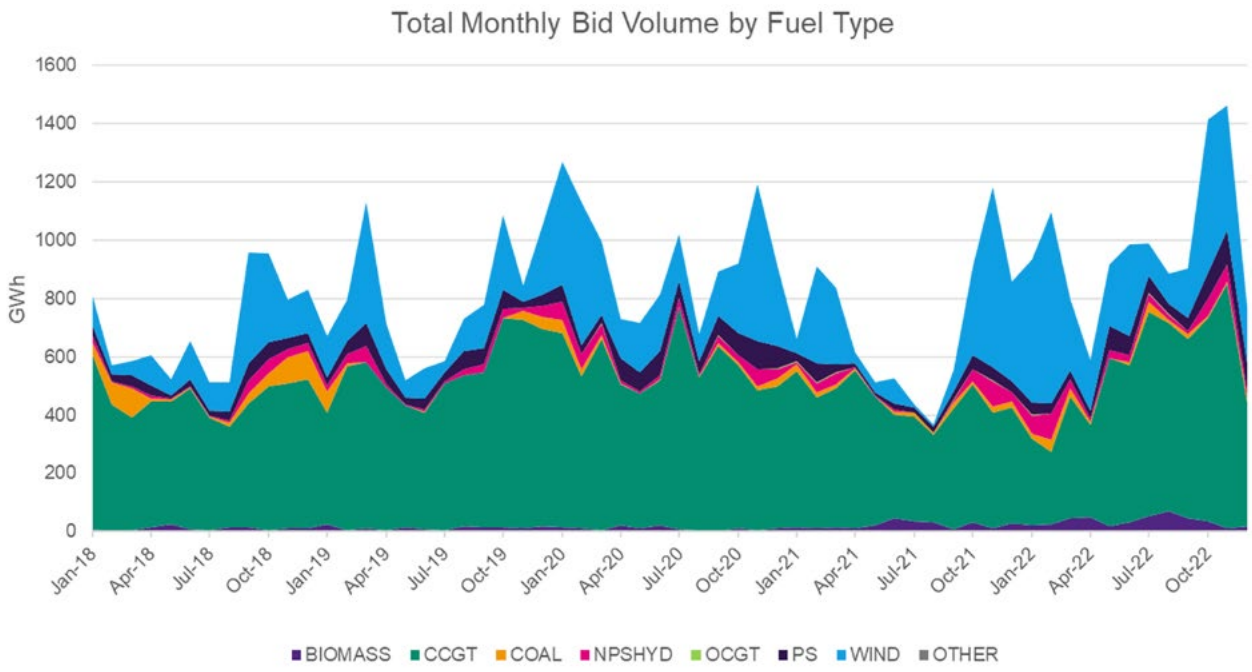


Figure 4: Bid volumes by fuel type, 2018 - 2022

BALANCING MECHANISM STRATEGY FOR WIND GENERATORS

BM bid pricing approach varies significantly between technologies, depending on factors such as fuel costs, subsidies and technical ability to ramp up and down in short timescales. For wind farms, specific bidding strategies will also be dependent on the Power Purchase Agreement in place between a project and an offtaker.

The achieved bid price and standard deviation of accepted bids for wind generators is shown in **Figure 5**[3]. Despite the overall volume of curtailment increasing, wind farms were on average paid less to curtail in 2021-2022 compared to 2018-2020 on a per MWh basis. At the same time, the spread of pricing has increased, with extreme high and low bid prices accepted for some periods. This variability can be attributed both to the increased volatility of the wider electricity market, and to wind farms pursuing more dynamic BM pricing strategies.

The need to curtail wind farms and other generators is not only linked to balancing supply and demand, but also to grid constraint management. A large proportion of the GB wind fleet is located in Scotland, and the generated electricity has to be transported south to where demand is located. Constraint management costs are primarily incurred during the winter months when wind speeds are high and wind farms have to be paid to curtail. Location can therefore play a key role in determining which wind farm's bids are accepted.

[3] This is typically linked to nuances of these wind farm's PPAs, contractual arrangements and operations within a wider mixed generation portfolio.

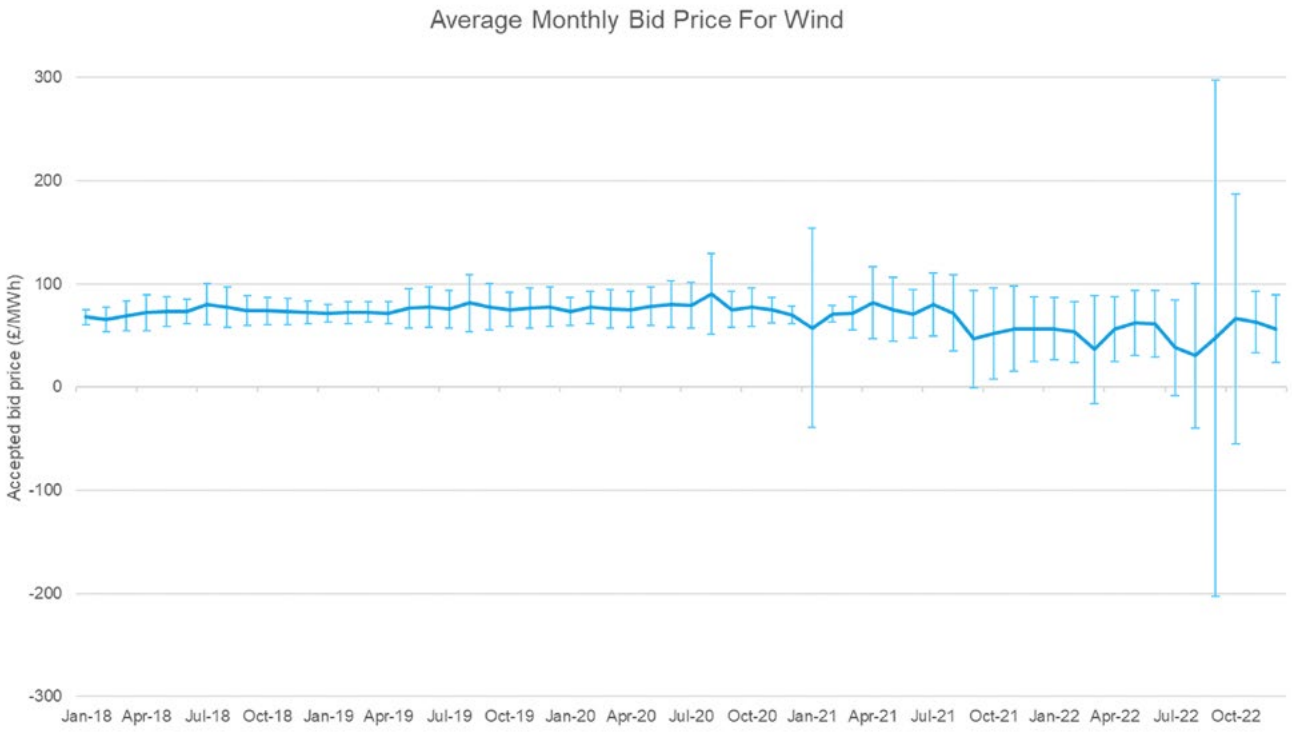


Figure 5: Accepted wind Bid Prices (average and standard deviation)

WHY WIND FARMS ARE MISSING OUT ON BALANCING MECHANISM VALUE

Historically, large wind farms have benefitted from the Renewables Obligation Certificate (ROC) subsidy, which provided a fixed payment per MWh on top of any base revenue achieved by selling electricity via a power purchase agreement (PPA). If a wind farm's bid to curtail its generation is accepted on the BM, it will lose out on its base revenue and ROC revenue.

As of 2021/22, each ROC was notionally worth approx. £55, with offshore wind farms receiving 2 ROCs per MWh and onshore wind farms 0.9 ROCs per MWh. Taking into account typical PPA prices (50-70 £/MWh), this means that wind farms are usually better off sticking with their usual route to market, rather than playing the BM.

In fact, the majority of GB wind farms that are obligated to participate in the BM simply choose to set a fairly high bid price (in excess of their ROC value) which ensures they are rarely accepted for a "turn down" action.

There are several reasons why this is changing:

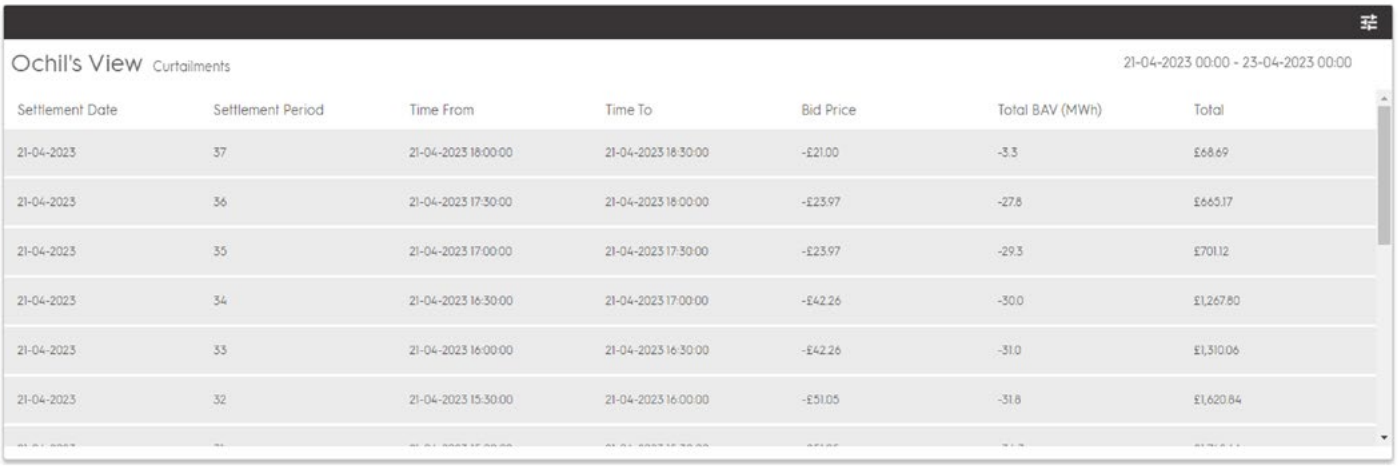
- Firstly, the ROC subsidy was closed to wind farms commissioned after 2017 and many onshore wind farms are now being built on a subsidy-free basis. At the same time, older wind farms are coming to the end of their 20-year ROC subsidy period. Without ROC income, the threshold at which BM prices become attractive is considerably lower.
- Secondly, some wind farm owners are starting to pursue a more merchant strategy where all or some of the generated electricity is sold on the wholesale market, rather than via a PPA that provides a fixed £/MWh revenue. This requires much more dynamic decision-making, as wholesale prices are becoming increasingly volatile.
- Thirdly, advances in wind farm monitoring, analysis and forecasting are enabling owners and operators to implement smarter maintenance planning.

INTEGRATING BALANCING MECHANISM DATA INTO ROUTINE WIND FARM MONITORING

At Natural Power, we are working with our clients to provide more visibility of BM pricing and associated revenues, to ensure this can inform day-to-day wind farm operations. **Figure 6** illustrates how production losses due to BM curtailment are tracked over a user-defined period. Our automated algorithms calculate the production and revenue loss as well as the BM compensation at up to half-hourly resolution. This provides a simple means of evaluating the wind farm's BM strategy and making sure the curtailment compensation outweighs the reduction in base revenues. Owners can also track whether the submitted physical notifications are reasonably accurate.

Figure 7 shows a monthly summary of BM actions with associated bid pricing and bid accepted volume.

Figure 6: Tracking BM performance for an individual wind farm



Settlement Date	Settlement Period	Time From	Time To	Bid Price	Total BAV (MWh)	Total
21-04-2023	37	21-04-2023 18:00:00	21-04-2023 18:30:00	-£21.00	-3.3	£68.69
21-04-2023	36	21-04-2023 17:30:00	21-04-2023 18:00:00	-£23.97	-27.8	£665.17
21-04-2023	35	21-04-2023 17:00:00	21-04-2023 17:30:00	-£23.97	-29.3	£701.12
21-04-2023	34	21-04-2023 16:30:00	21-04-2023 17:00:00	-£42.26	-30.0	£1,267.80
21-04-2023	33	21-04-2023 16:00:00	21-04-2023 16:30:00	-£42.26	-31.0	£1,310.06
21-04-2023	32	21-04-2023 15:30:00	21-04-2023 16:00:00	-£51.05	-31.8	£1,620.84

Figure 7: Monthly BM performance summary for an individual wind farm

BENCHMARKING WIND FARM BALANCING MECHANISM STRATEGIES

In addition to tracking an individual project's BM revenues, we can benchmark how the wind farm is performing compared to its neighbours. Considering different operating regions, **Figure 8** shows there is significant variation in average bid prices and volumes of curtailments even within BM zones. Offshore wind sites have historically been compensated using a higher ROC coefficient and as a result these cluster at a significantly higher average bid price.

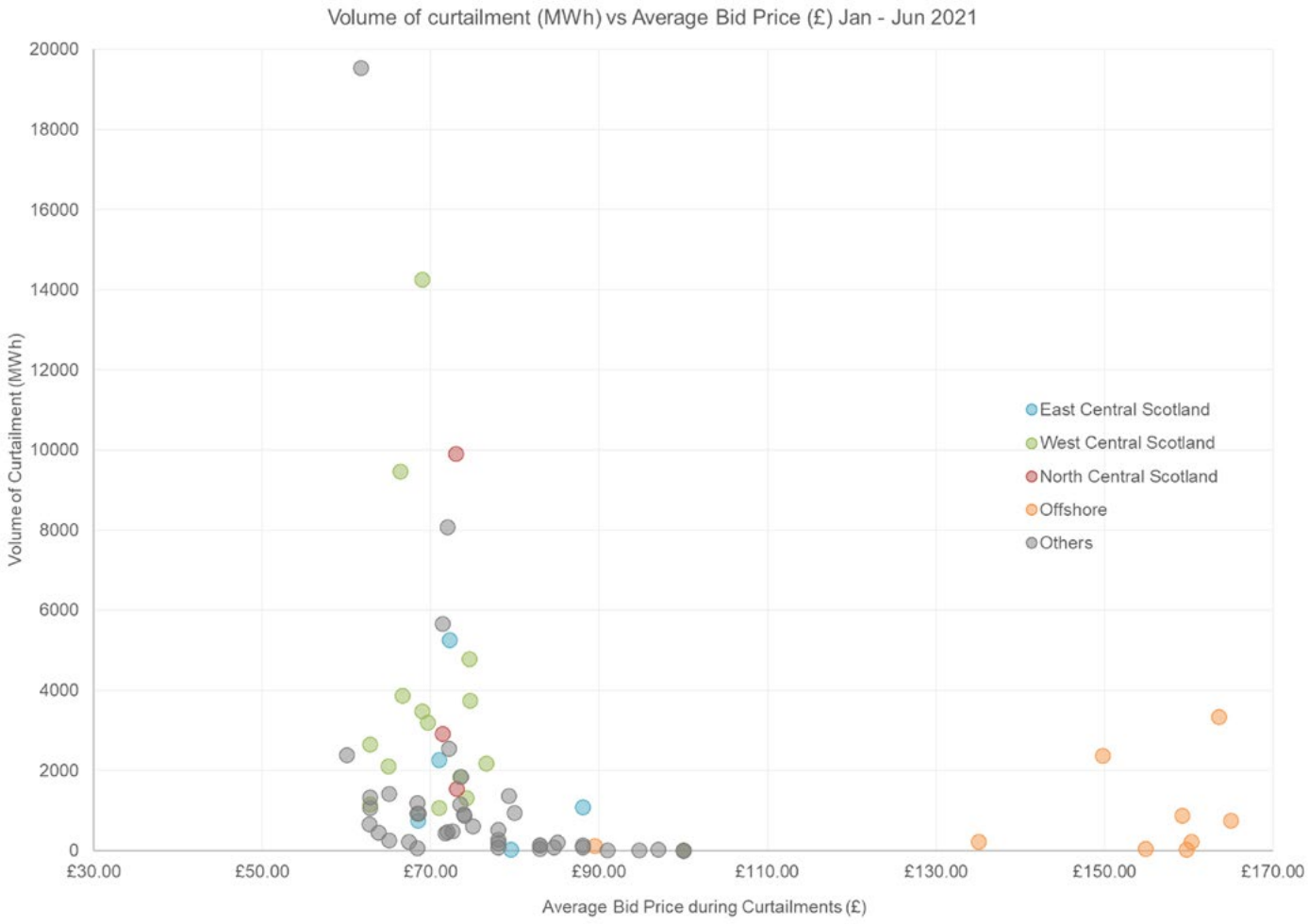


Figure 8: Illustration of individual wind farm BM strategies

Considering the West Central Scotland region, there is relatively high network congestion and a high resulting volume of curtailment. We have selected three wind farms in this zone that appear to be taking different strategies while achieving similar volumes of curtailment relative to their installed capacity. These are shown in **Figure 9**, where the points represent the average accepted bid price and the horizontal error bars correspond to the variation in accepted bid prices:

- Wind Farm A has a fixed pricing approach
- Wind Farm B has a highly variable pricing approach, and this results in a higher volume of curtailment but at a lower average price compared to Wind Farm A.
- Wind Farm C is curtailed at a similar magnitude to Wind Farm A, but achieves a higher curtailment price by having a dynamic pricing strategy that is less variable than Wind Farm B.

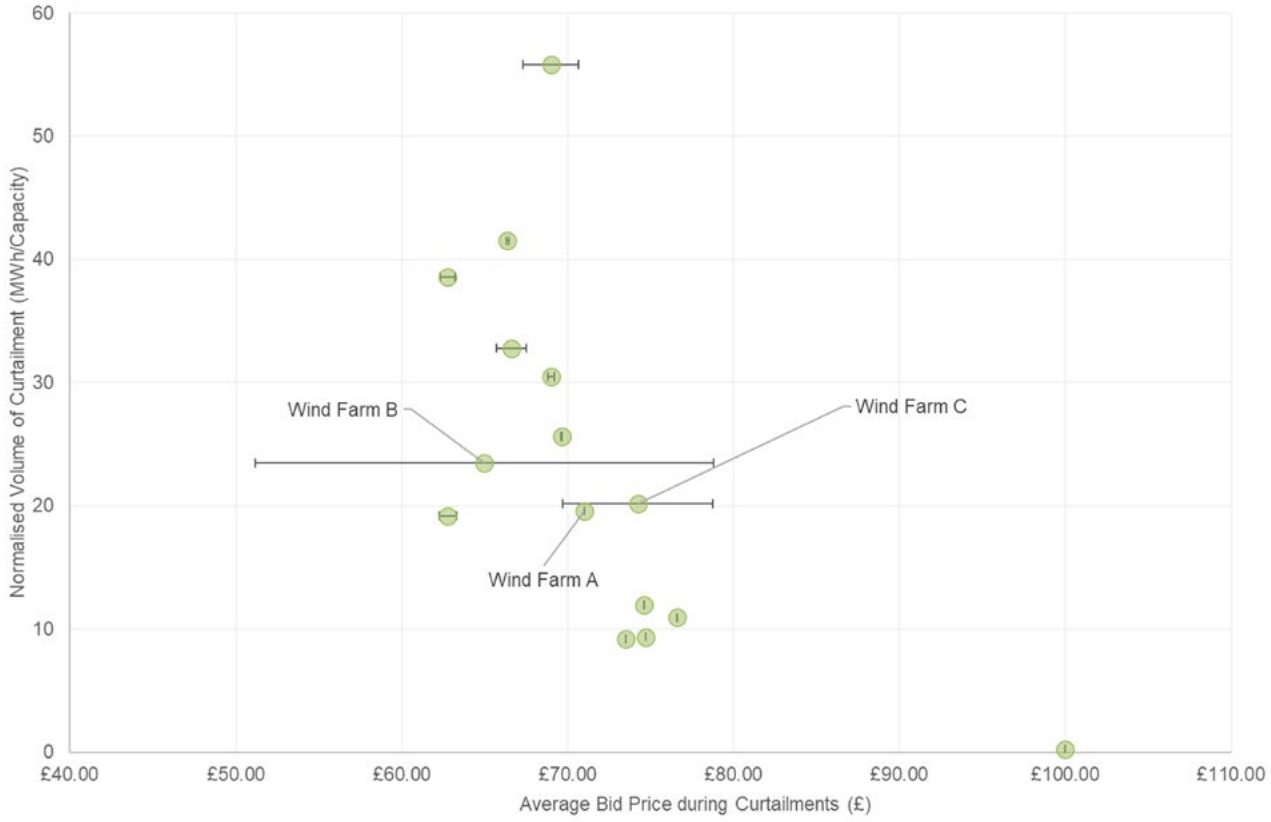


Figure 9: Differences between BM strategy for wind farms in the West of Scotland region

It should be noted that pricing is only one criteria by which the National Grid chooses which BM Unit to curtail - location, accuracy of forecast, capacity and ability to respond to requests all contribute to the final decision. However, our analysis clearly shows that even for wind farms located in the same region and of similar size (60-80 MW), different BM pricing strategies can result in very different outcomes.

This kind of analysis allows us to work with owners to improve their asset's BM strategy. Of course, this must be done in a holistic way and take into account the project's full revenue stack (e.g. ROC or CfD subsidies, PPA pricing structures, wholesale trading revenue), as well as any major operational constraints or maintenance requirements.

THE FUTURE OF THE BALANCING MECHANISM

The UK government recently ran a consultation in relation to widespread electricity market reforms (Review of Electricity Market Arrangements or REMA). The proposed changes could radically transform the way renewable generators operate in the GB power market and, as part of this, reform the BM. Consultation responses suggest that the BM is seen as an essential mechanism for unlocking and valuing flexibility, and that its role could be improved by allowing more participants access to the BM as well as disaggregating BM actions into individual system requirements (e.g. inertia).

Ultimately, it is in everyone's interest to maximise the use renewable generation and avoid the need for curtailment as much as possible. As more flexibility is added to the system (mainly in the form of battery storage), wind farm owners may question whether these assets will end up being the cheapest provider of balancing services and erode the value of the BM for wind farms. Batteries are already starting to displace fossil fuel peaking plants in the BM. While the GB market is still nowhere close to having enough flexibility to support a net-zero grid, renewable players are increasingly focused on hybrid projects that combine electricity generation, storage, and even power-to-X applications (where electricity is converted to another energy vector such as green hydrogen or ammonia).

It's an exciting time for the energy sector – and wind farm owners will have to get comfortable with the idea of diversifying their revenue stack and optimising the dispatch of their projects on a dynamic basis. In this paper, we have showed how wind farms may be able to unlock additional value in the GB Balancing Mechanism.

To find out more about our monitoring, control and optimisation services for wind farm assets contact:

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