LCPDelta

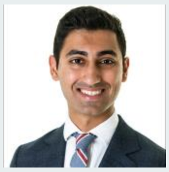
Weathering the Changing Power Market: Gusts and Gains

Managing an increasingly volatile GB system

June 2024

Contents

Authors



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Wind generation in GB has increased by over 180% since 2015 and is expected to more than triple by 2035, as the power market decarbonises in line with government targets. As we approach these targets, the intermittency of wind will pose an increasing challenge for the market. With a general increase in volatility, alongside increasingly frequent events such as negative pricing and storms, an accurate view of future wind is imperative to optimise the grid and create an efficient and economic system.

In this report, we explore recent wind trends over 2015-2024, including the increasing level of curtailment, the impact on pricing and market outturns during extreme weather events.

Introduction:
GB wind penetration is continuing to grow

Wind generation in the GB power market has seen remarkable growth in recent years, but to reach net zero by 2050, this will need to continue at an accelerated pace. Monthly wind outturn[1] has increased at an astonishing rate (Figure 1), from around 1.4TWh in April 2015 to 6.5TWh in April 2024. This peaked in December 2023 at 8.9TWh, representing a record 37% of the country's total demand that month. This proportion is set to grow, with LCP Delta's Central scenario projecting that by 2030, 60% of demand will be met by wind (still below ambitious government targets).

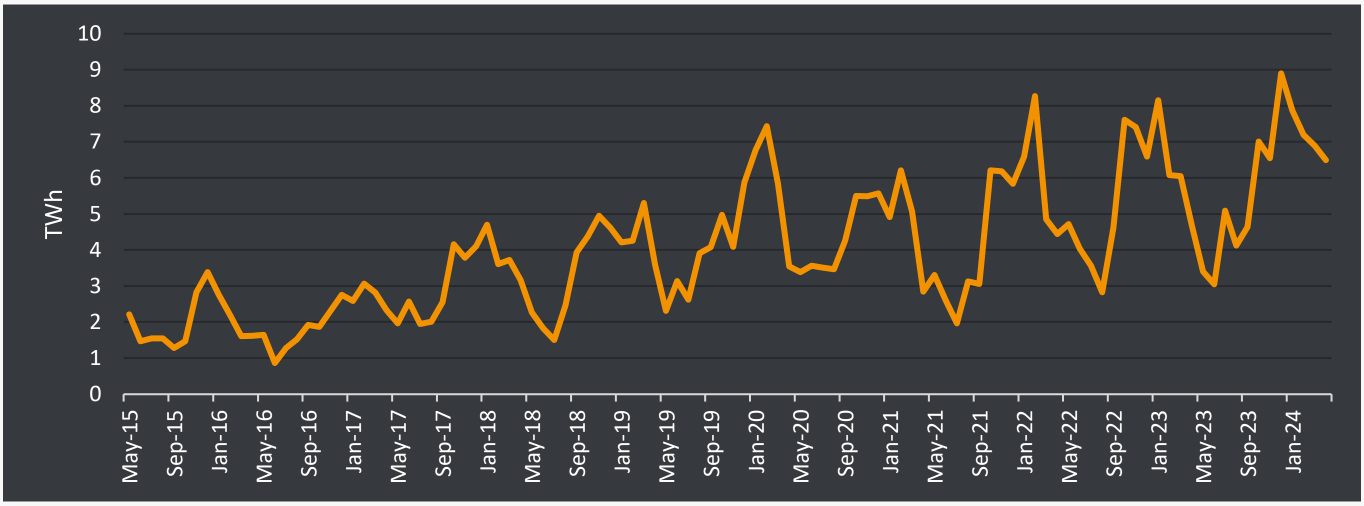


Figure 1: Total monthly GB metered wind outturn from May 2015 to April 2024

As wind deployment increases, the daily variability in wind output also rises, significantly contributing to the challenges of managing systems with high levels of wind penetration. Within-day generation spread has risen by almost 220%, from an average of 2.1GW in 2015 to 6.5GW in 2024 (Figure 2). The proportional increase in daily variability and wind output is a key driver of changes in market dynamics, such as the reform to the frequency response markets.

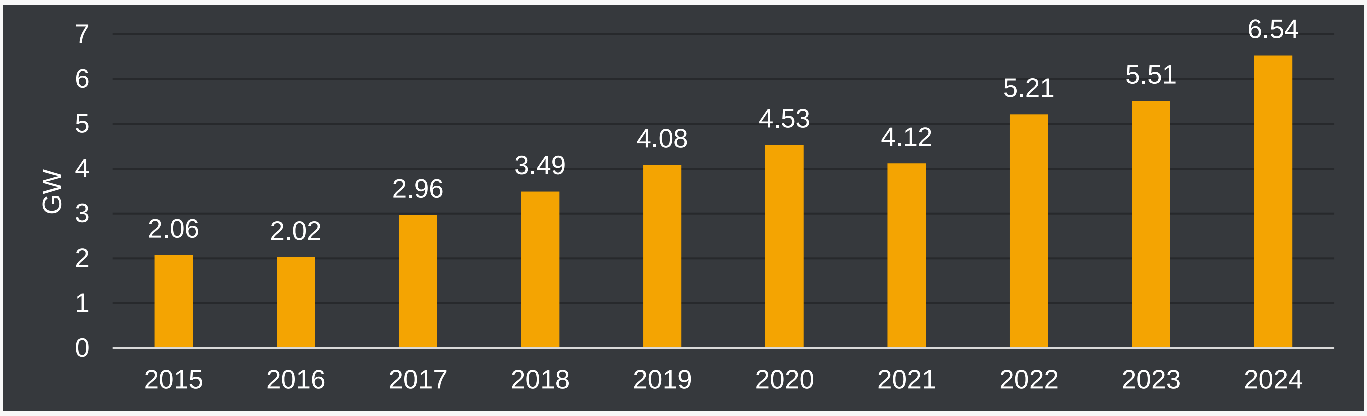


Figure 2: The average within-day spread of wind generation from 2015 to 2024

[1] Based on figures of operationally metered assets via Enact.

Looking ahead:
The future of GB generation will be increasingly reliant on wind

Despite within-day wind volatility increasing proportionally with wind output, the growing presence of wind assets in the generation mix has heightened the impact of its volatility. Wind assets constituted 8% of the generation mix in 2015. This increased to 17% by 2019 and reached 25% in 2023 (Figure 7).

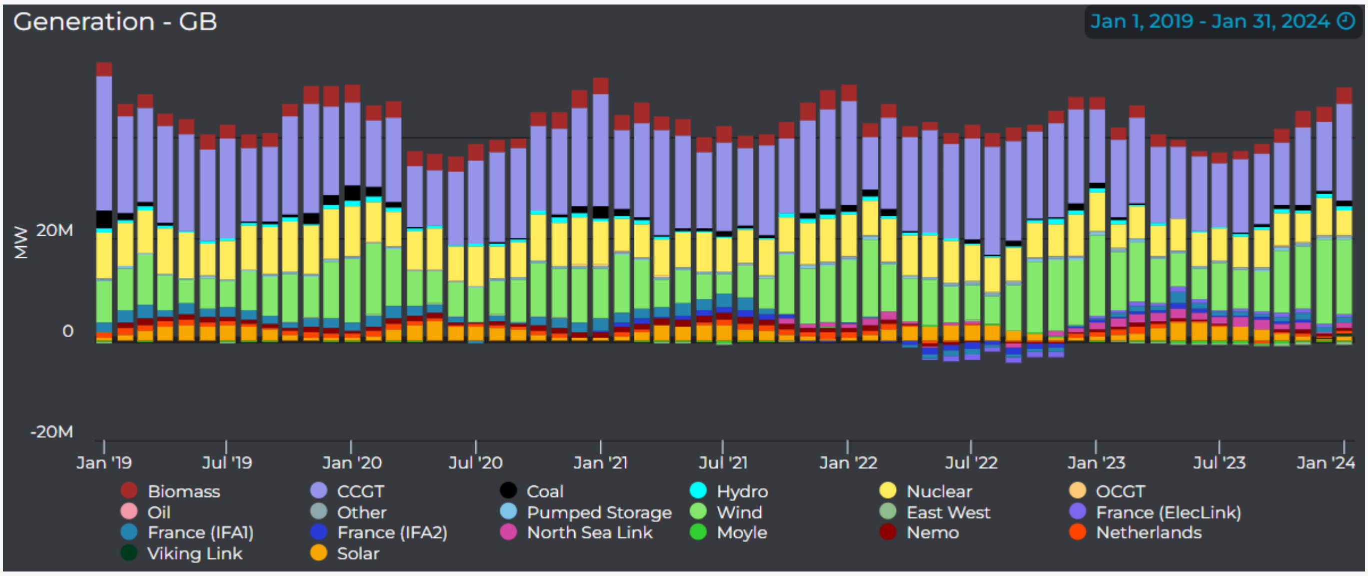


Figure 7: The GB generation mix by fuel type from January 2019 to January 2024 (source: Enact)

The UK government has committed to 50GW of offshore wind capacity by 2030 – more than triple the capacity currently on the grid. In the latest government DUKES publication[1], offshore wind capacity only increased by 2.6GW from 2021 to 2022 reaching a total installed capacity of 13.9GW. This fell short of the average 4.5GW per year required to meet the 50GW target by 2030. LCP Delta's Central scenario assumes this target won't be met, falling short by 13GW.

With minimal offshore wind capacity added in 2022/2023 and no offshore wind procured in Allocation Round 5 (AR5), progress towards the 50GW goal has been limited. While there is technically sufficient capacity with connection agreements to build the additional 25 GW required, only 7GW has the necessary planning consent, and with only up to three Contracts for Difference (CfD) auctions remaining before 2030, time is running out to achieve this target.

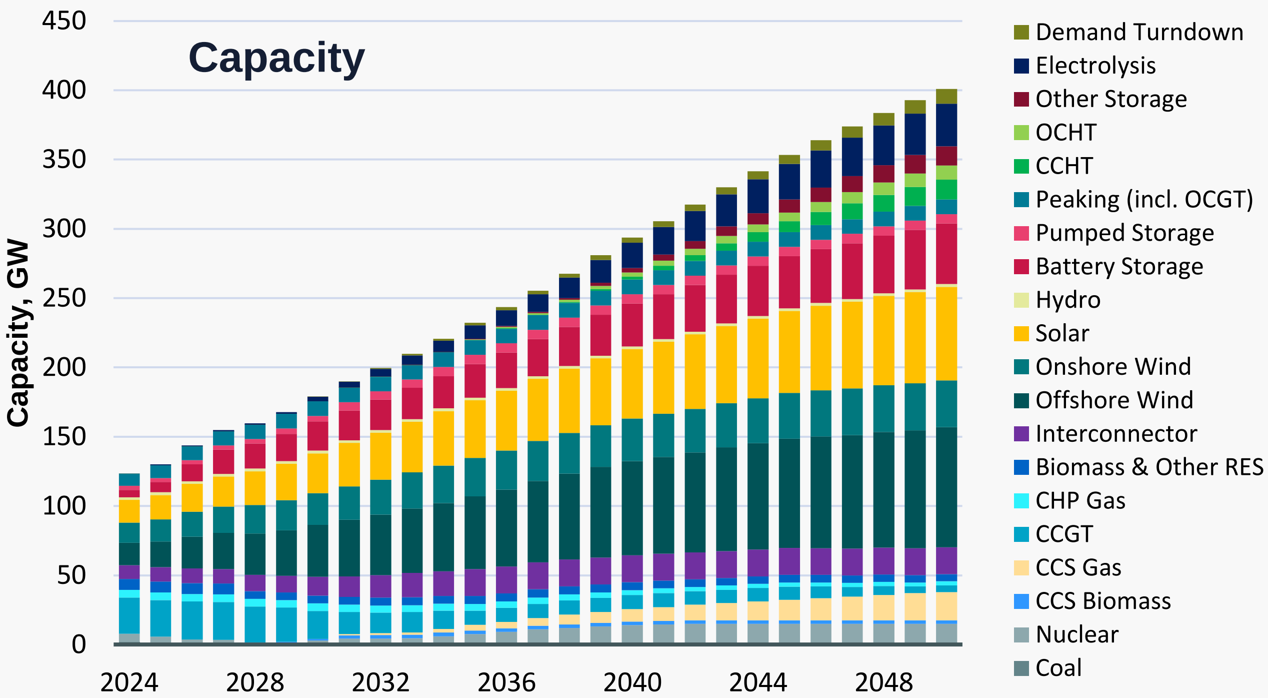
Similarly, from 2021 to 2022, onshore wind capacity increased by 0.3GW to a total of 13.4GW in 2022[1], significantly below the rate of 1.5GW needed to meet the current ambition of 30GW by 2035 (Figure 8).

Nonetheless, 1.4GW of onshore wind secured contracts in AR5, 0.5GW more than in AR4. Moderate changes to planning rules have also been made, allowing locations suitable for new wind farms to be identified by local planning authorities (LPAs) in numerous ways, rather than only in the area's development plan. Despite this subtle change, it remains uncertain how much these changes will affect build levels. Achieving 30GW of onshore wind by 2035 appears possible, given the success in the last two CfD auction rounds. However, it's uncertain if the changes to planning rules in England announced in September 2023 will be effective to enable the required levels of build, as not all capacity can be located in Scotland if this goal is to be achieved.

[1] Based on figures from government DUKES publication. Data for 2023 is not yet available.

Below are two charts from LCP Delta's Central scenario of future capacity and generation. We assume that, although the government's 2030 target is not met[1], over 60% of demand will still be met by wind generation, approximately double that of today. This value is projected to increase to 75% by 2040.

a)



b)

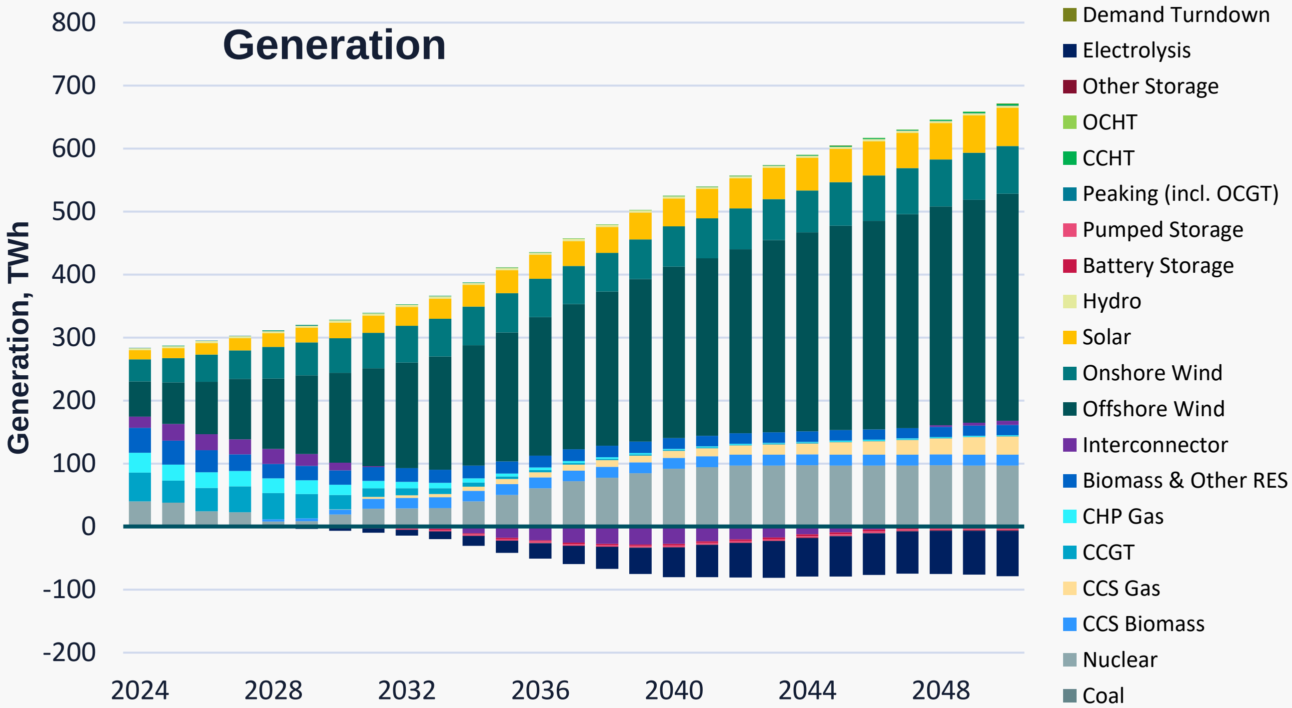


Figure 8: The projected a) capacity mix and b) generation mix of GB from 2024 to 2050

Source: LCP Delta Q2 2024 Market Forecasts report

[1] Discussed in the GB Power Market Outlook

Assessing the impact:
Constrained networks leading to increased wind curtailment

The increase in wind assets connected to the transmission network has led to a significant rise in the total wind generation turned down (or curtailed) by the ESO in the Balancing Mechanism (BM). The total volume of wind bids accepted (turn down actions) in the BM have risen 240%, from 1.3TWh in 2015, to 4.3TWh in 2023 (Figure 5). In 2023, the average daily cost of turning down wind was approximately £874k, representing a 250% increase from £250k in 2015 (Figure 6).

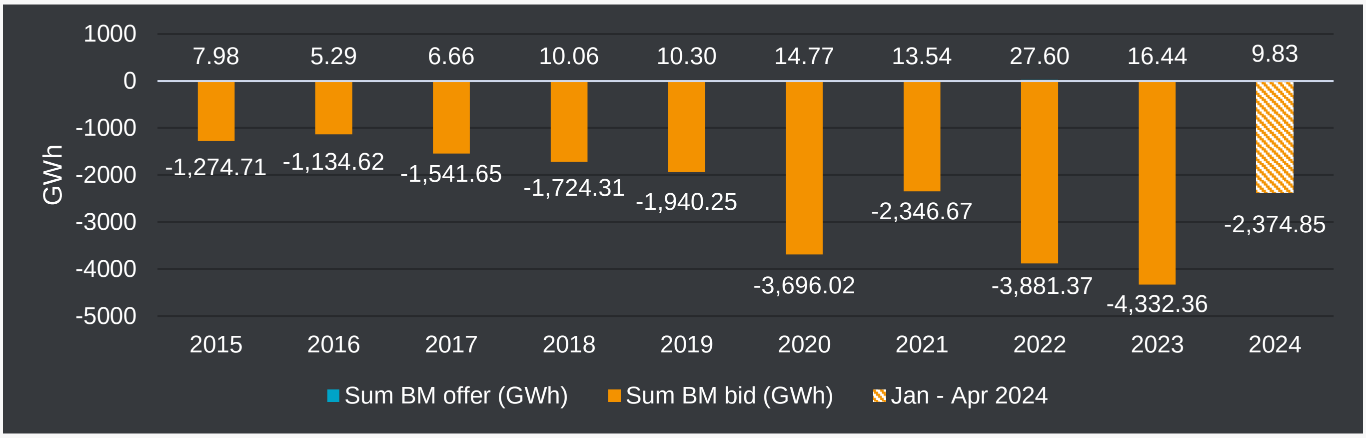


Figure 5: Annual accepted Balancing Mechanism bids and offers of wind assets from 2015 to 2024

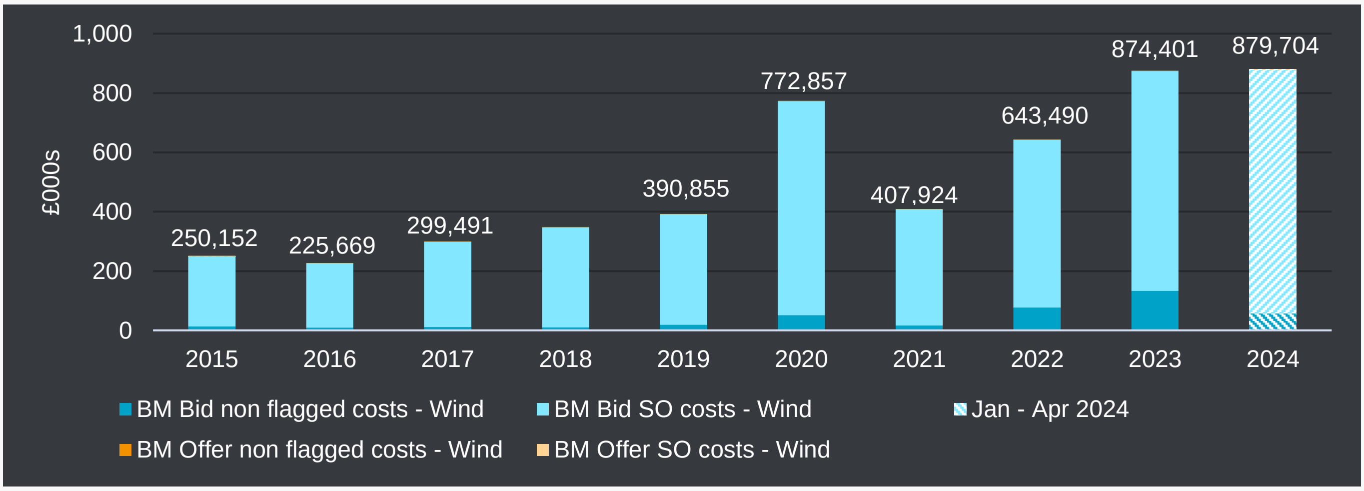


Figure 6: The average daily cost of all wind accepted bids and offers in the Balancing Mechanism including non-flagged and flagged (SO) costs

Currently, 196 wind assets – accounting for 24.6GW of electricity capacity – are connected to the transmission network. However, 11.4GW (67%) of this capacity is located in Scotland, where only 9.8% of consumer demand was recorded in 2022. The majority of demand in the UK is situated in England (81%), leading to large flows across the B6 (Scotland-England) boundary. This flow often exceeds network capabilities, creating bottlenecks that lead to thermal constraints. These system constraints require the ESO to take action, typically by using the BM to turn up/down assets and pay generators in constrained areas (often wind in Scotland) to reduce their generation, while paying those in high-demand areas (usually gas in southern England) to increase their generation. Thermal constraint costs are currently the most significant component of balancing costs for the ESO, contributing 40% of total balancing costs in 2023/2024 compared to 36% in 2022/2023. These costs are projected to rise further by 2030 as more assets become operational and the network becomes increasingly congested.

Assessing the impact:
Negative pricing will cause more volatility in the future

Negative pricing periods (NPP) have a dampening effect on wind outturn by dictating the generating patterns of assets holding certain Contracts for Difference (CfD) contracts.

When the IMRP (Intermittent Market Reference Price) - a volume weighted average between the EPEX and N2EX day ahead markets - is negative for six hours or more, assets with CfD contracts from Allocation Rounds (AR) 2 and 3 do not receive any payment for their generation during this period. This often leads to these assets turning off which reduces the amount of wind generation available during the NPP. This rule was introduced by the UK government to discourage generation practices that are unhelpful to the overall system.

For assets that obtain a CfD contract in AR4 onwards, this rule will be stricter still, applying to any hour where the IMRP is negative. We are yet to see the true effect of these as there are currently no AR3, AR4 or AR5 assets online,

Drilling into an example, on March 23rd 2024, the IMRP was negative from 9am to 3pm GMT, reaching a low of -£8.12/MWh at 1pm (Figure 9). This NPP resulted in plants that secured a contract in AR2 switching off, reducing wind outturn from 17.1GW before the NPP to a low of 14.7GW at 2pm (Figure 10).

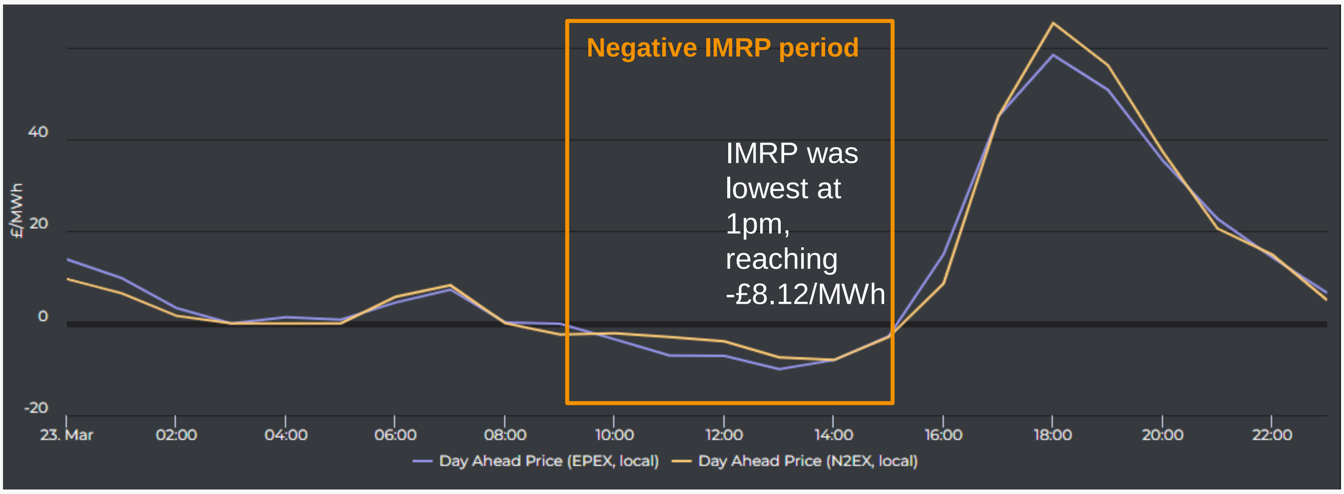


Figure 9: The day ahead prices from the EPEX and N2EX markets on March 23rd 2024 where the Intermittent Market Reference Price was negative from 9am to 3pm GMT

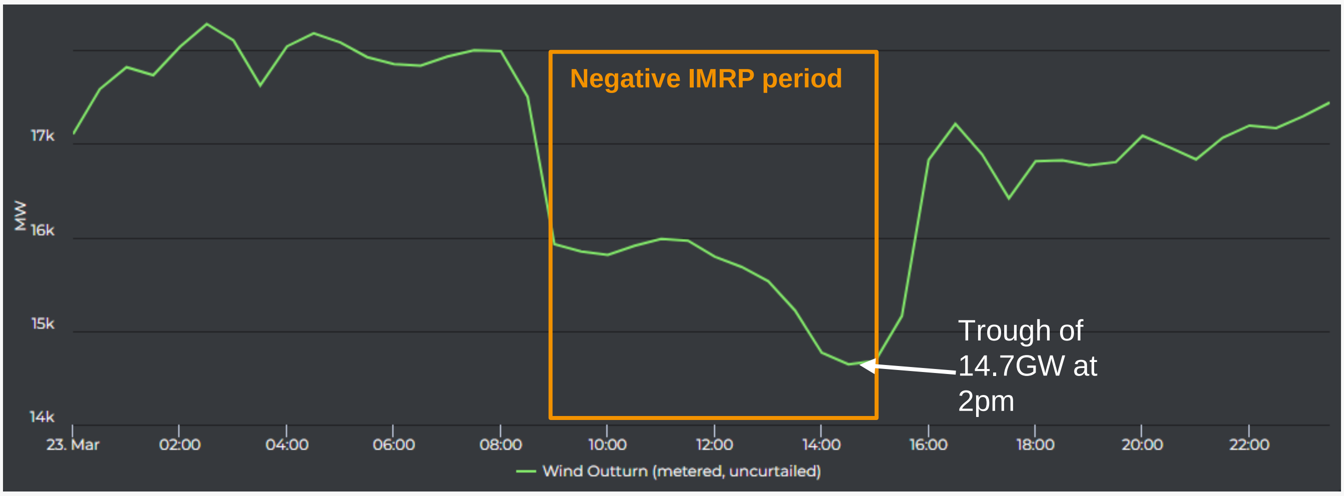


Figure 10: The wind outturn from March 23rd 2024, dipping during the negative price period from 9am to 3pm GMT

As more CfD-contracted assets become operational, the impact of negative pricing on wind outturn will likely increase. Currently, 3.2GW of AR2 wind assets are operational, meaning a six-hour NPP could result in a maximum wind downturn of 3.2GW. However, by 2031 all wind CfD contracts from AR3, AR4 and AR5 will be operational and could cause up to 8.5GW of wind downturn for any single hour of NPP, and an additional 8.9GW if the NPP exceeds six hours (Figure 11).

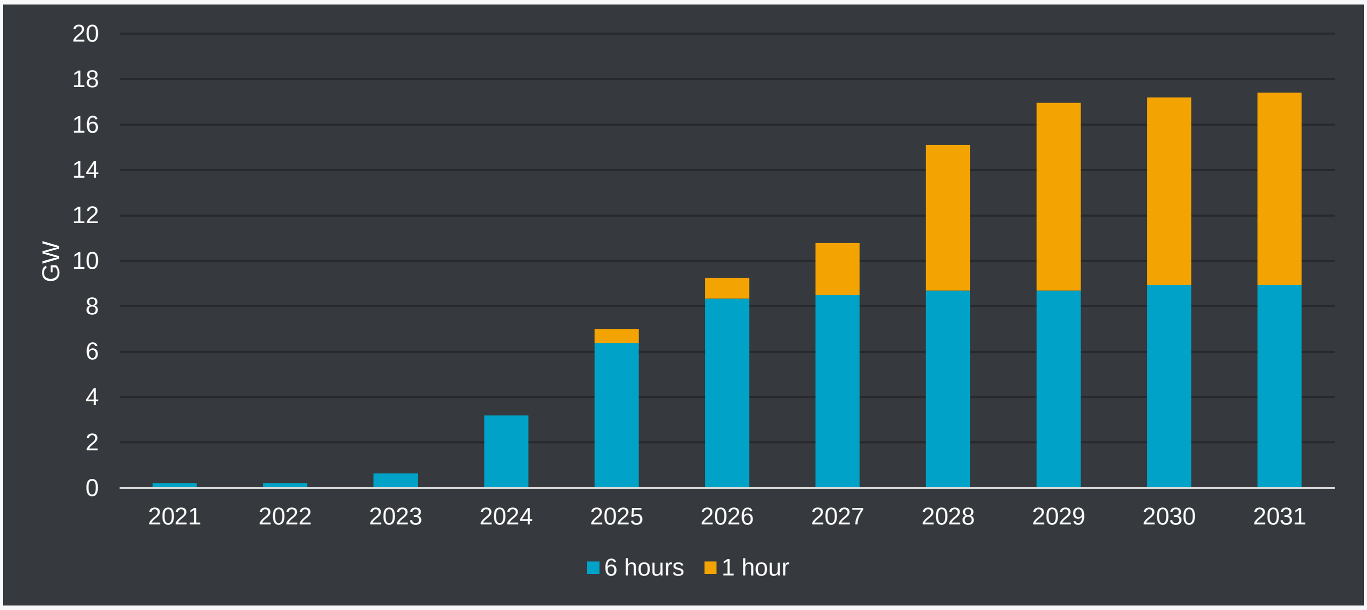


Figure 11: The potential power downturn caused during 6-hour and 1-hour negative pricing periods as AR3, AR4 and AR5 wind assets become operational

However, some assets do not behave as expected during NPPs. Taking April 7th 2024 as an example, the AR2 contracted wind farm, Triton Knoll, continued generating despite not receiving its strike price during a NPP (Figure 12). A possible reason for this could be the additional maintenance costs and risks associated with turning down a turbine, even when done so in a controlled manner. Triton Knoll may have therefore made the decision to continue generating during the NPP to minimise these effects.

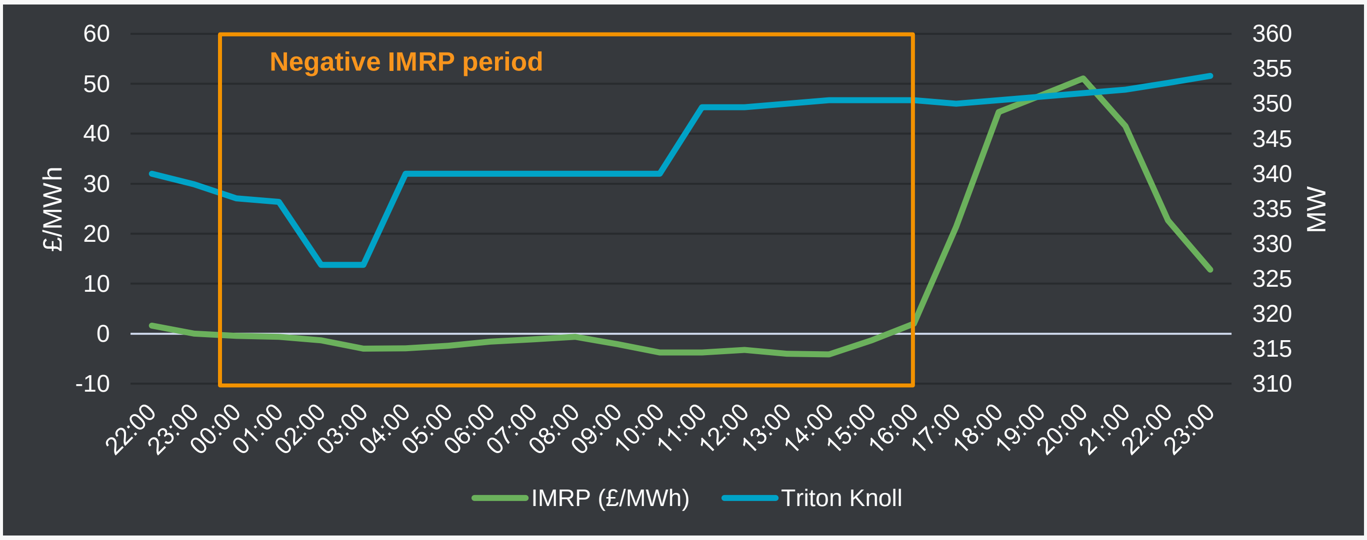


Figure 12: The metered output of Triton Knoll wind farm on April 7th 2024 when the Intermittent Market Reference Price was negative from midnight to 4pm GMT

There are also instances where AR2 sites initially switch off, but ramp back up before the NPP has ended. Larger wind farms typically ramp up/down at around 50MW/min, allowing quick adjustments in generating outturn. However, engineering constraints, especially during high wind periods, can necessitate longer ramp-up/down times. In one case, Hornsea turned off from 11am to 2pm GMT before gradually ramping up, reaching full capacity by the end of the NPP at 4pm (Figure 13). As the site began to ramp up during the NPP, it was not receiving any payments from its CfD contract. To generate further revenue, the site submitted more negative bids during this time, averaging -£131/MWh, compared to between -£92/MWh and -£113/MWh before and after the NPP.

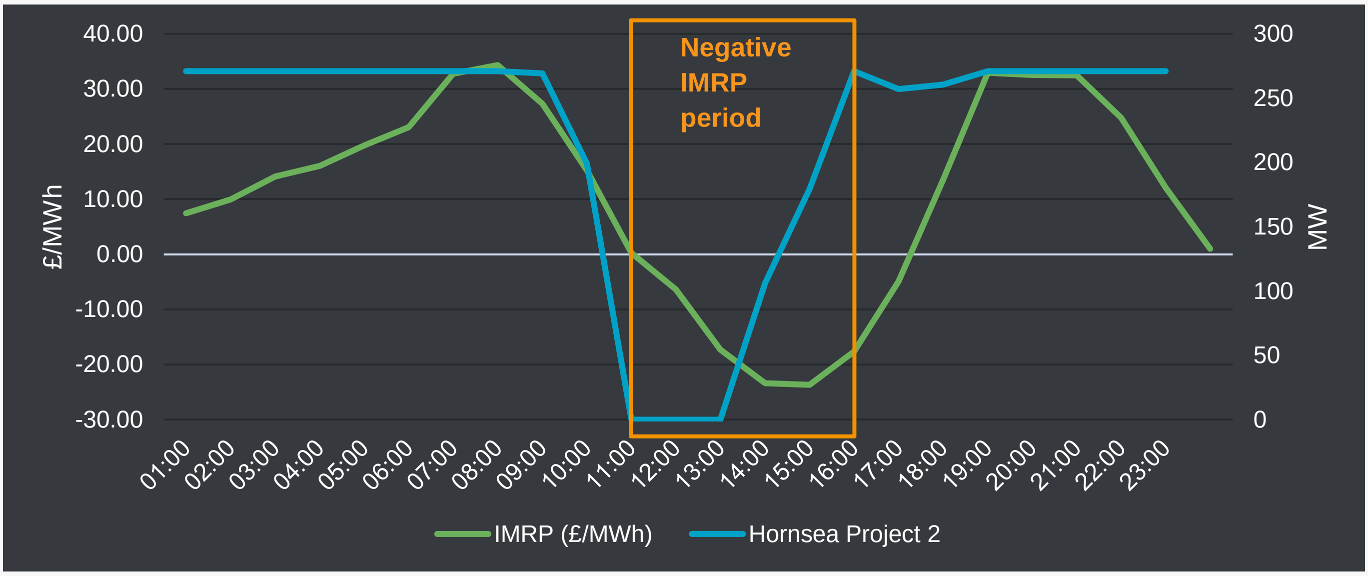


Figure 13: The metered output of Hornsea Project 2 Phase 1 on April 13th 2024 when the Intermittent Market Reference Price was negative from 11am to 4pm GMT

Additionally, there are instances whereby sites which are not subject to the negative pricing rule as part of their CfD contract, i.e. AR1 and Investment Contracts, switch off during these NPPs (Figure 14). In these instances, sites may have additional contracts in place alongside the CfD for part of the volume of the site, such as corporate power purchase agreements (CPPAs), that have contractual requirements that cause them to turn off during NPPs.

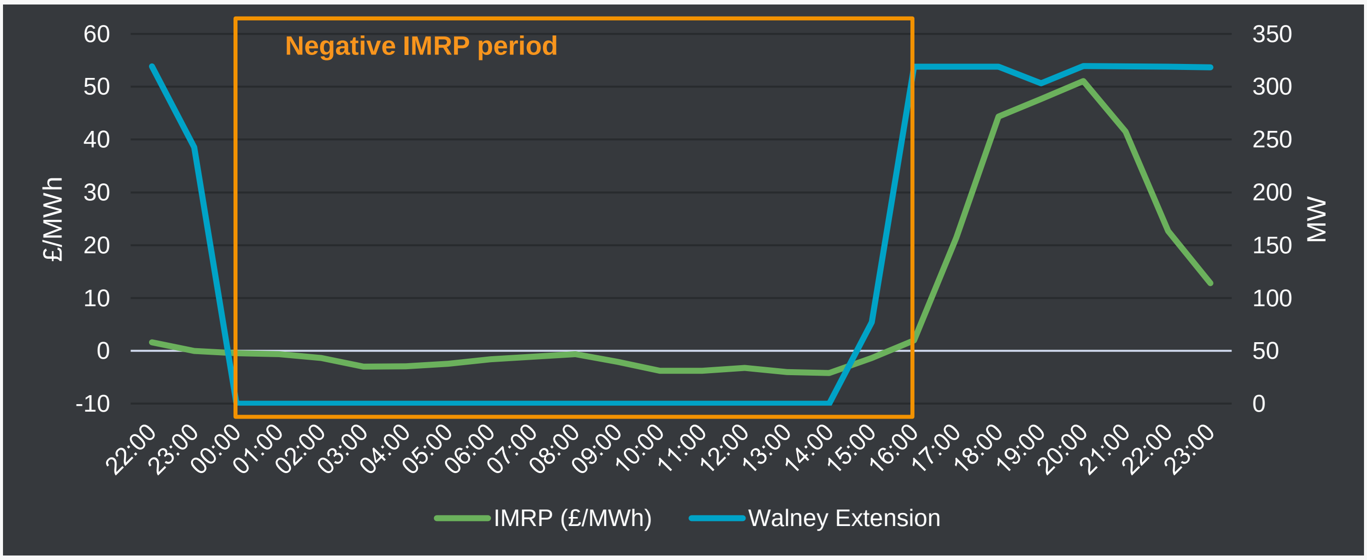


Figure 14: The metered output of Walney Extension Phase 2 on April 7th 2024 when the Intermittent Market Reference Price was negative from midnight to 4pm GMT

Investigating the extremes:
Storms now have a large impact on the market

Another form of volatility in the market is the presence of high winds, which especially become an issue during storms. While initial analysis by Meteomatics doesn't indicate an increase in overall GB wind speeds in recent years, there is statistically significant increases in wind gusts (sudden and brief increases in wind speed).

High winds can pose engineering challenges for wind farms, impacting their operation and the speed at which they can ramp up or down. Wind turbines automatically cut off when wind speeds reach 24.6 m/s to protect the assets. According to the UK State of Climate report, while storminess has not increased over the past four decades when considering maximum gust speeds, the 2023/24 storm season has seen a record number of stormy days - 20 days as of April 30th - compared to a maximum of 16 days in the 2015/16 season.

Storm Gerrit – Case Study

From December 27th to 28th 2023, Storm Gerrit, centred in west Scotland, produced maximum wind gusts of over 81mph, causing turbines across the UK to cut out.

During the storm, gust speeds began increasing from around 10am GMT, causing wind outturn to decrease as turbines shut off (Figure 15). This trend later reversed as gust speeds fell, and wind outturn increased as turbines switched back on.

These dynamics illustrate the system's adaptability and safeguards to protect wind assets in extreme weather conditions. However, without an accurate forecast it represents a potential

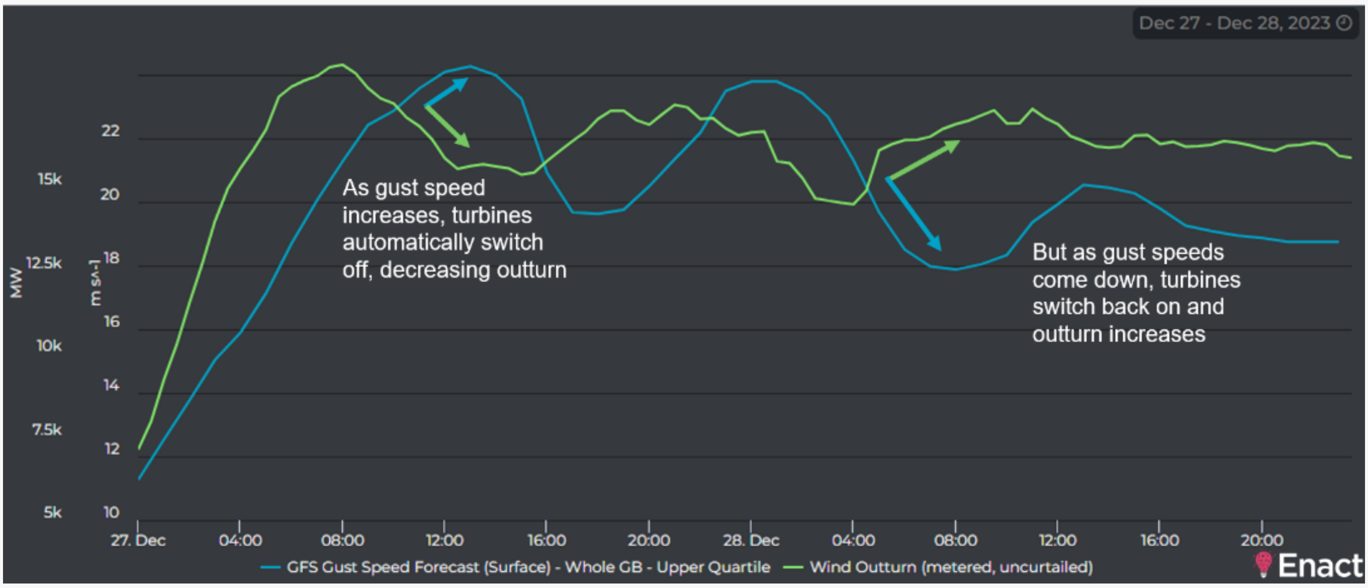


Figure 15: GFS gust speeds & wind outturn during Storm Gerrit on December 27th and 28th 2023

Storm Isha – Case Study

Storm Isha struck the UK on January 21st 2024, lasting for two days and bringing gusts of up to 99mph. This storm marked the most significant major wind event to impact the UK since Storm Eunice on February 18th 2022. Particularly noteworthy was how widespread the strong winds were, with few parts of the UK escaping wind speeds near cut-out thresholds or above.

The intensity of Storm Isha caused a substantial 8GW drop in wind generation as high winds forced wind fleets to shut down automatically for safety reasons. Additionally, constraints within the transmission network led the ESO to curtail a further 2.5GW of wind generation, predominantly in Scotland (Figure 16).

Wind cut-offs are volatile, and small variations in a wind speed forecast can make a large difference in your view of the GB wind fleet. Accurate forecasting is a necessity here.

On January 19th, two days before Storm Isha hit the UK, Enact's AI wind forecast predicted that the cut-off threshold of turbines could be reached. This presented a differing view compared to public forecasts, which did not predict a drop in generation. As the delivery period approached, improved Meteomatics wind speed forecasts led to more wind plants being affected, and the forecast came down further still (Figure 17). The Enact and Meteomatics forecast was, on average, 0.75% below the actual wind outturn recorded during Storm Isha. This compares to the public forecast, which averaged 7.58% above the actual wind outturn during the period.

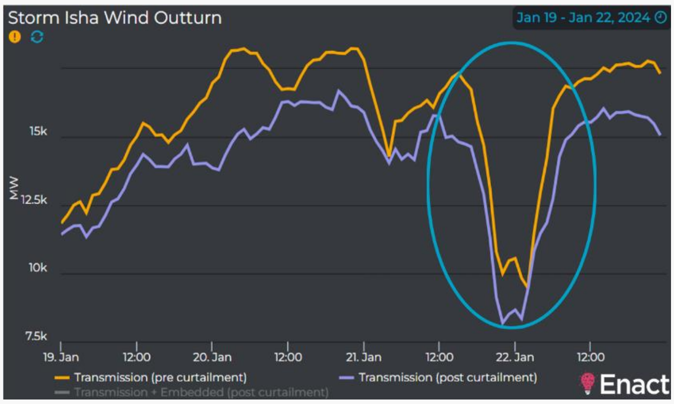


Figure 16: The wind outturn pre- and post-curtailment during Storm Isha from January 19th to 22nd 2024

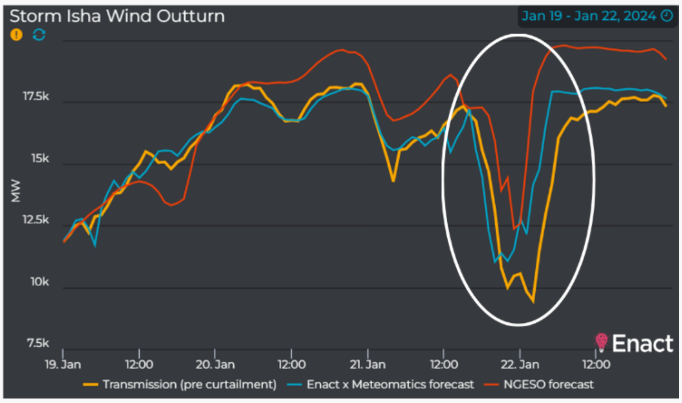


Figure 17: The uncurtailed wind outturn, NGESO forecast and Enact and Meteomatics forecast during Storm Isha from January 19th to 22nd 2024

Finding a solution:
Forecasting the intraday market means forecasting wind

As wind continues to make up a larger proportion of the GB generation mix, accurately forecasting the magnitude and pattern of wind outturn is vital in creating a decarbonised and affordable power market.

Improvements in wind forecasting will allow the Electricity System Operator (ESO) to anticipate and manage future imbalance, enabling more cost-effective actions to be taken to ensure supply meets demand. It also allows other market participants to better anticipate future intraday prices and volumes, better informing trading decisions. These last-minute supply/demand errors are now more often than not driven by an uncertainty in wind generation.

In its latest Annual Balancing Costs report, the ESO highlighted its increased forecasting capabilities helped it to better optimise its reserve holdings, contributing to an 18% fall in reserve costs from 2022/23 to 2023/24.

These improved forecasts are backed up; since 2015, public wind forecasts have been slowly improving, from a 24% RMSE to 9% in 2023. However, they continue to perform poorly over the autumn/winter periods where wind is the most volatile (Figure 4).

The improvements in public forecasting has been outpaced by the proportion of wind generation, which has tripled since 2015 - making up 25% of the GB generation mix in 2023. To trade in the intraday space, market participants need more reliable wind forecasting. LCP Delta have been working with Meteomatics to do just this, leading to our improved **Enact AI forecast**. This has been able to consistently outperform public forecasts, with a RMSE within 2% of the actual wind output (when looking 30 mins before delivery) (Figure 4).

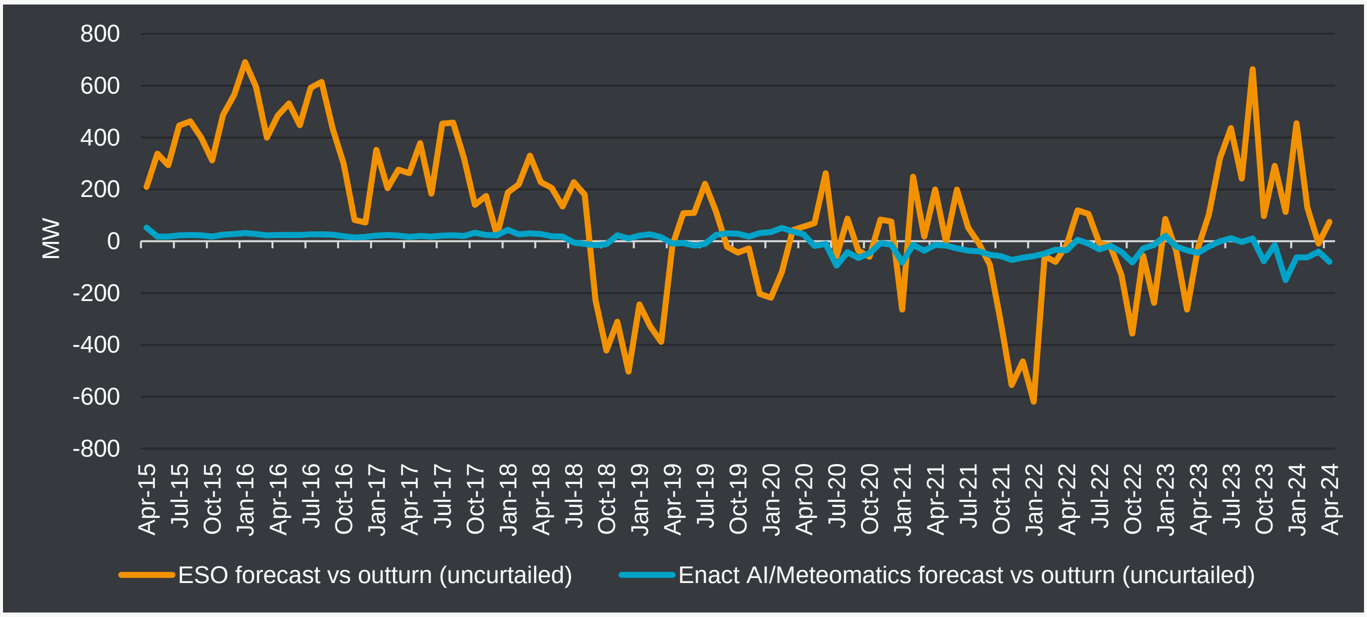


Figure 4: The root mean squared error differential in the ESO and Enact and Meteomatics forecasts against the actual wind outturn from April 2015 to April 2024 at 30 minutes before delivery

Weathering the Changing Power Market: Gusts and Gains

While the growth of wind generation in the UK represents a positive step towards a decarbonised power sector, challenges such as forecasting accuracy, capacity expansion, and managing intermittency remain.

Accurate forecasting, as demonstrated by the joint Enact / Meteomatics AI forecast, is crucial for helping market participants navigate this increasing volatility. Wind curtailment, negative pricing periods, and extreme weather events, such as storms, add complexity to grid management and predicting the market. However, recent events have indicated that this behaviour is predictable, and overcoming these challenges through technological, policy, and strategic measures is essential for maximising wind energy's potential and achieving government targets.

Webinar

This whitepaper was produced alongside a webinar, featuring LCP Delta's Shivam Malhotra: Senior Consultant, and Meteomatics' Rob Hutchinson: Meteorologist.

You can watch the recording here.

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Take a moment to explore some of our top recommendations:

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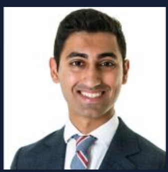

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