REVIEW OF THE BALANCING MARKET

Final report

15 JULY 2022

CONTENTS

1 Executive Summary

2 Introduction

3 Overview of key rules of relevance

4 Drivers of high costs

5 Evidence of behaviour inconsistent with rules

6 Feedback from stakeholders

7 The case for intervention

8 Annex: Market rules

9 Glossary

1

EXECUTIVE SUMMARY

ESO COMMISSIONED A REVIEW OF THE BALANCING MARKET (BM) FOLLOWING VERY HIGH COST DAYS

THE REVIEW HAS BEEN STRUCTURED AROUND THREE WORKSTREAMS WITH A FOCUS ON TEN HIGHEST COST DAYS IN THE BM. THE BM REVIEW TEAM HAS CARRIED OUT AN INDEPENDENT REVIEW WITH INPUT PROVIDED BY ESO AS REQUIRED

Main workstreams

Current behaviours

A data led review of the bids and offers into the balancing market on highest cost days between 1 September and 31 December 2021. The focus of the review has been on BM data from ten highest cost days, though we have also examined intraday and day ahead market data

Market rules

Review of existing market rules as set out in the Grid Code and Balancing and Settlement Code and their effectiveness, including assessing consistency of behaviour with those rules

Note: this excludes consideration of REMIT or competition law

Stakeholder engagement

Obtain insights on behaviours and effectiveness of rules from market participants

BM review team

Frontier Economics has led the review and coordinated the input across the different workstreams

LCP has led the data analysis related to the 10 high costs days in the BM

Cornwall Insight has led the stakeholder engagement - organising the stakeholder events and feeding insights into the review

OUR ANALYSIS OF WHAT HAPPENED ON THE HIGH COST DAYS FOCUSES ON THREE QUESTIONS (1)

1

HOW DID BEHAVIOUR OF MARKET PARTICIPANTS DRIVE COSTS?

- The system was tight, or expected to be tight, which led to market participants (in particular coal and CCGTs) offering power at prices up to £4,000/MWh in the BM.
- Analysis of the day ahead and intraday prices shows price spikes at peak consistent with an expectation of scarcity (though at lower levels than BM offers). On around half of the days, expectations of scarcity appear to have increased intraday prices relative to day ahead prices.
- The high price BM offers were accepted across a large volume of coal and CCGT capacity on most of the days.
- The size and inflexibility of the relevant units (embodied by declared dynamic parameters) meant ESO had to accept offers up to £4,000/MWh across multiple hours just to cover the peak.
  - With regard to coal plants, offers had to be accepted for the full minimum non-zero time (MNZT), typically around 6 hours.
  - With regard to CCGTs, their minimum zero time of around 6 hours combined with a plan to desynchronise in the afternoon, often meant the ESO had to delay their planned desync to ensure they were available for the peak, resulting in accepted offers much earlier in the day.
- As expected, the duration of high prices observed in the BM contrasts with the intraday market where peaks in prices were confined to peak periods.
- While our analysis of BM bidding behaviour was not exhaustive, our analysis has found no evidence that movements in dynamic parameters in this period were a driver of high costs.

OUR ANALYSIS OF WHAT HAPPENED ON THE HIGH COST DAYS FOCUSES ON THREE QUESTIONS (2)

2

DID ESO DISPATCH THE CHEAPEST PLANT AVAILABLE?

- On all 10 days, the system did not end up being as tight as ESO forecast it to be. During the 10 days, we observe repeated under-forecasting of wind and over-forecasting of demand by ESO.
- Some degree of forecast error is inevitable, and errors are likely to be greater on days with extreme conditions such as these. In addition, we note that:
  - there is evidence from the intraday market that on some of the days the market expected greater tightness early during the day than it did closer to real time (although some of this may be driven by participants relying on ESO's forecasts)
  - there are restrictions in the Grid Code which limit ESO's ability to take price response into account in its demand forecasts, which may have been especially important on such high price days.
- While lower priced offers were available in the BM which ESO did not end up accepting, it is not reasonable to assume these could all have been accessed because to do so:
  - assumes perfect foresight – on the basis of ESO's forecast, it expected to need all inflexible and flexible capacity at the time it had to accept offers from inflexible capacity
  - ignores the fact that some of this lower priced capacity would have been required to maintain reserve
  - assumes that the owners of this capacity would not have changed their prices if the CCGTs were not running.
- It is difficult to identify an appropriate 'best practice' benchmark for forecast accuracy. That said, it remains the case that more accurate forecasting could have led to reduced balancing costs.
- Under-procurement of STOR relative to target capacity is unlikely to have fundamentally affected the overall supply demand balance on the system. However, it may have been a further driver for the ESO to lock-in inflexible capacity early to ensure sufficient reserve would be available at peak.

OUR ANALYSIS OF WHAT HAPPENED ON THE HIGH COST DAYS FOCUSES ON THREE QUESTIONS (3)

3

HOW DO THESE 10 DAYS COMPARE TO (RECENT) HISTORY?

- Late 2021 saw a cluster of days with tight system conditions. Similar conditions, in terms of tightness, were observed in late 2020 and 2021.
- There was some similarity in bidding behaviour in late 2020/early 2021 with that on the high cost days. But the key driver of high balancing costs in late 2021 has been the greater consistency with which some coal and CCGT plants offered into the BM up to levels around £4,000/MWh on very tight days.
- We identified the profile of PNs as an important driver of costs on the high cost days.
  - The relevant Physical Notification (PN) profile driving cost in the high cost days (positive in the middle of day and zero over the evening) is not new behaviour and does not always result in offers being accepted. But it was more frequent in Autumn 2021
  - The increase in this behaviour when combined with dynamic parameters has contributed to increased costs, but it may simply reflect wholesale market behaviour.
- We also identified the importance of the values of MNZT and minimum zero time (MZT) as cost drivers:
  - the average values of MNZT and MZT observed are broadly consistent with those seen historically – a material change in the average level does not appear to be a driver of costs on the high cost days
  - the level and variability of historical values of dynamic parameters for individual plants suggests that they may not have been set to reflect absolute technical minimum on and off times
  - this could be consistent with them being set on a technical basis (i.e. to recover associated with the operating characteristics of a plant over a generation cycle)
  - since Ofgem's letter (published on 29th September 2020), for numerous plants, values for MNZT appear to have stabilised at a level above the lowest levels seen historically (at least for some plants)
  - the consistency of this behaviour with Ofgem's guidance remains an open question

BASED ON THE INFORMATION AVAILABLE TO US, WE HAVE NO CLEAR EVIDENCE OF BEHAVIOUR INCONSISTENT WITH THE MARKET RULES

DYNAMIC PARAMETERS

- Ofgem's guidance states plant should **judge dynamic parameters technically rather than commercially.** We do not have the evidence to judge basis on which generators have historically applied these parameters.
- The analysis suggests that key parameters (MNZT, MZT) may not be being set to pure technical minimums.
- But given the need to recover some non-variable costs over a generation cycle, there remains an open question as to the extent to which this behaviour can be considered inconsistent with Ofgem's guidance.

PHYSICAL AVAILABILITY

- **Movements in PNs** during high cost days do contribute to high balancing costs.
- This is consistent with the rules provided PNs reflect updated expectations of output and contracted position.
- We do not have evidence to judge if movements were inconsistent with this.

PRICING (BID-OFFERS)

- The rules do not place any restrictions on the level of bid and offer prices.
- We note that rational behaviour in a pay as bid market would entail:
  - participants increasing offers up to their expectations of the marginal accepted offer
  - in periods of scarcity, participants increasing offers potentially to Value of Lost Load (VoLL)

STAKEHOLDER ENGAGEMENT HAS BEEN A KEY PART OF THE BM REVIEW

THIS FINAL REPORT IS AN UPDATE OF THE INITIAL FINDINGS REPORT PRESENTED ON A WEBINAR HELD ON 29TH MARCH. IT TAKES INTO CONSIDERATION FEEDBACK RECEIVED BY STAKEHOLDERS DURING AND AFTER THE WEBINAR, INCLUDING VIA QUESTIONNAIRE, ROUND TABLES AND BILATERAL ENGAGEMENT.

01 → 02 → 03 → 04

01 LAUNCH WEBINAR

A launch webinar open to all interested stakeholders was hosted on 9 February 2022, with 135 individually identified attendees.

During the event 52 queries were raised.

02 PRELIMINARY FINDINGS WEBINAR

A webinar was hosted on 29 March 2022 with 155 identified attendees.

Frontier Economics and LCP presented preliminary findings. It was recorded and circulated via email to registered parties following the meeting.

03 QUESTIONNAIRE

A questionnaire was sent to test stakeholders' views on the preliminary findings.

The questionnaire was open between 5-22 April 2022 and received 7 responses.

04 ROUND TABLES AND BILATERAL ENGAGEMENT

Seven sessions took place between 5-19 April 2022, lasting between 30-90 minutes. There were 27 participants from 19 organisations, with parties grouped by theme.

Some parties undertook bilateral engagement, rather than joining a group in a round table discussion.

THE ANALYSIS AND EVIDENCE PRESENTED SUGGESTS THERE IS A CASE FOR CONSIDERING POTENTIAL REFORMS

ESO BEHAVIOUR

- While the impact on high cost days is quite uncertain and may be limited, there is merit in ESO continuing to review its forecasting and STOR procurement methodologies.

BIDDING BEHAVIOUR

- In the shorter term:
  - There may be merit in interventions to change bidding behaviour. They have the potential to have a high impact (and could be implemented quickly). However, if pursued, design needs to balance the scale of impact against the risk of unintended consequences (may imply preference for "code of practice" over caps).
  - A "softer" measure such as enhanced market monitoring could be implemented in the short term, though its impact is uncertain. For example, if used to enforce technical minimums of MNZT and MZT its impact could be large, though it would depend on the scale of any resulting changes to offer prices.
- In the longer-term, there is merit in considering reliability options as part of government's on-going Review of the electricity market arrangements (REMA).

BIDDING RULES

- ESO should consider alternative bidding rules - analysis indicates inflexibility plays a key role, motivating broader consideration of alternative bidding rules that enable systems' physical flexibility to be more fully communicated to ESO.

SCARCITY

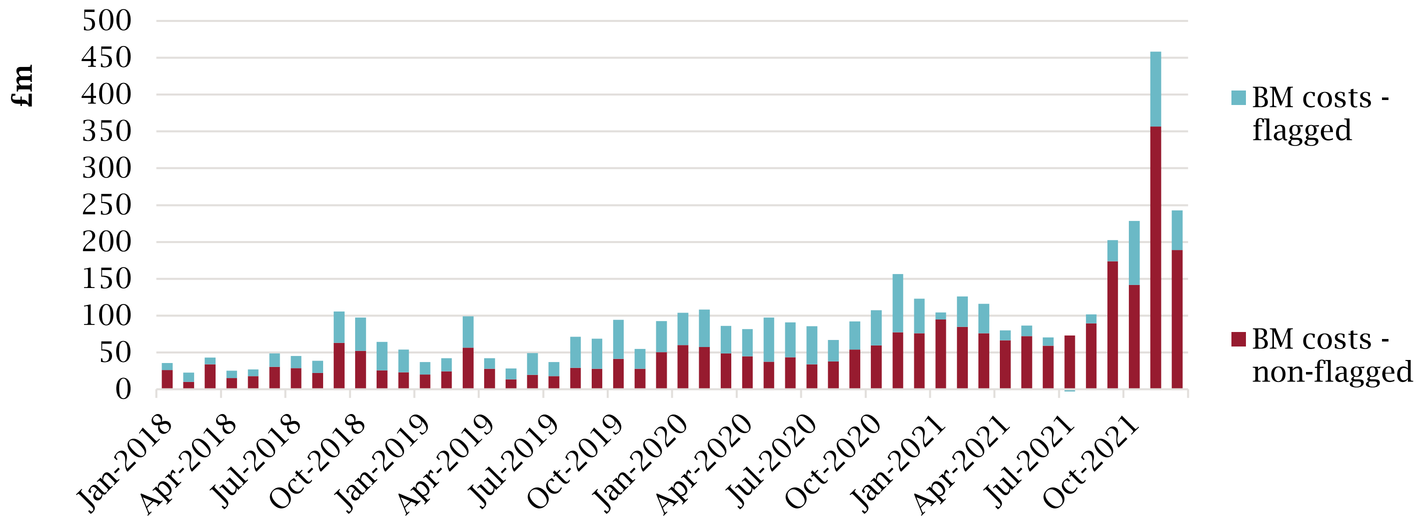
- Finally, there is a question for:
  - Government to consider regarding the tightness at which it wishes the system to operate; and
  - The ESO to consider regarding its methodology for setting target CM capacity.

2

INTRODUCTION

ESO COMMISSIONED A REVIEW OF THE BALANCING MARKET (BM) FOLLOWING RECENT VERY HIGH COST DAYS

Monthly cost of BM actions



£2.64 billion of balancing costs in 2021

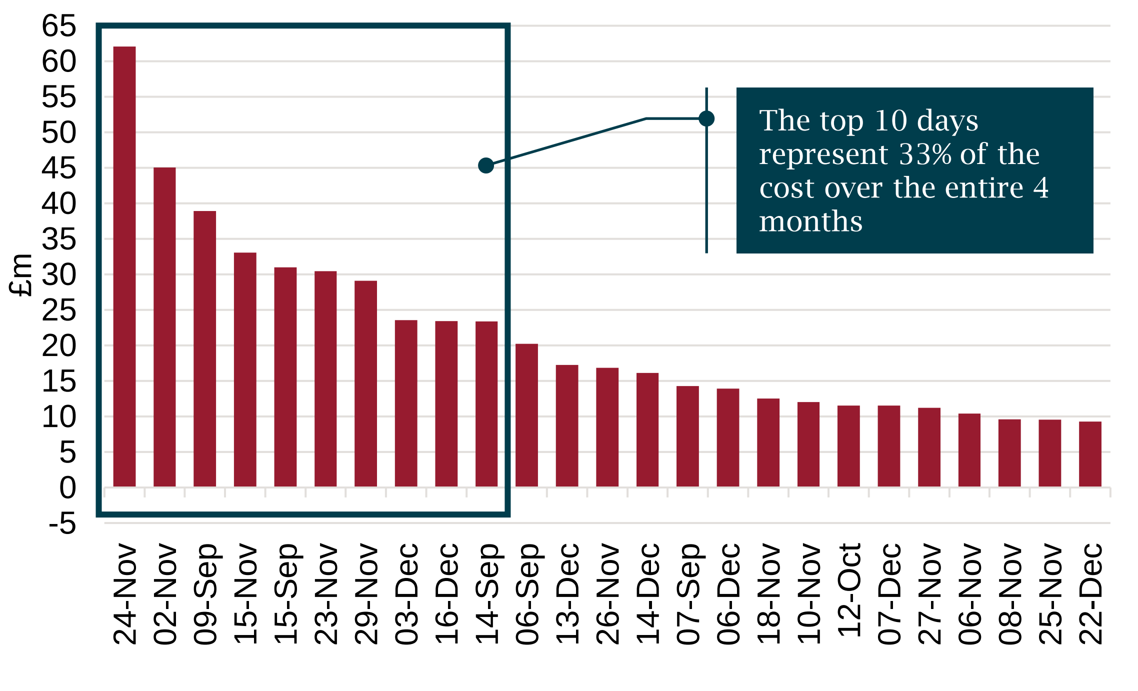
+48% year-on-year growth

54% of balancing costs in 2021 occurred between September and December

THE REVIEW HAS BEEN STRUCTURED AROUND THREE WORKSTREAMS WITH A FOCUS ON TEN HIGHEST COST DAYS IN THE BM

Key focus of the assessment

Non-flagged offer costs. Period from September to December 2021



Terms of reference

Current behaviours

A data led review of the bids and offers into the balancing market on highest cost days between 1 September and 31 December 2021. The focus of the review has been on BM data from ten highest cost days, though we have also examined intraday and day ahead market data

Market rules

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THE BM REVIEW TEAM HAS CARRIED OUT AN INDEPENDENT REVIEW WITH INPUT PROVIDED BY ESO AS REQUIRED

BM Review team

Frontier Economics has led the review and coordinated the input across the different workstreams

LCP has led the data analysis related to the 10 high costs days in the BM

Cornwall Insight has led the stakeholder engagement - organising the stakeholder events and feeding insights into the review

ESO commissioned the independent review, and has provided the access for the review team to all the BM data requested by the team and facilitated engagement with internal staff in order to share in-house expertise on different issues raised by Frontier Economics and LCP

THE STRUCTURE OF THE REMAINDER OF THIS REPORT

THIS FINAL REPORT IS AN UPDATE OF THE INITIAL FINDINGS REPORT PRESENTED ON A WEBINAR HELD ON 29TH MARCH. IT TAKES INTO CONSIDERATION THE FEEDBACK RECEIVED BY STAKEHOLDERS AFTER THE SESSION VIA QUESTIONNAIRE AND FURTHER ENGAGEMENT THROUGH ROUND TABLES AND BILATERAL ENGAGEMENT

SECTION 3	• We show a summary of **BM rules** in the Balancing Settlement Code and the Grid Code regarding dynamic parameters, physical notifications (PNs) and bid-offers. • Some further detail is provided in the **Annex** in Section 8.
SECTION 4	• We present quantitative analysis that explores the **drivers of BM costs** on the 10 highest cost days during the period between September and December 2021. • Following stakeholder engagement in response to the Initial Findings presentation, this section includes new analysis.
SECTION 5	• We draw conclusions as to whether there is any evidence of **behaviour inconsistent with rules** in the Grid Code and Balancing and Settlement Code.
SECTION 6	• We describe the different phases of the **stakeholder process**, and provide a summary of stakeholder views that we have received in response to our initial findings and more generally regarding the drivers of high costs and appropriate policy responses. • We also explicitly identify the additional analysis we have undertaken in order to incorporate stakeholder comments received in relation to the initial report presented on 29th March 2022.
SECTION 7	• We conclude by considering **potential reforms** that could address the key drivers of BM costs on the high cost days identified in this review. • Some of the potential reforms could be implemented quickly (short-term) and others are longer-term.

3

OVERVIEW OF KEY RULES OF RELEVANCE

THE KEY RULES GOVERNING PARTICIPANT BEHAVIOUR

DYNAMIC PARAMETERS	MAXIMUM EXPORT AND IMPORT LIMITS (MEL/MIL)	PHYSICAL NOTIFICATIONS (PNs)	BID-OFFERS
True operating characteristics of plant	Capacity which the unit wishes to make available	Users' best view of intended import/export	No restrictions on level of bid and offer prices

All data (both pre and post gate closure) must be prepared in line with ***Good Industry Practice (GIP)***

Ofgem has clarified that these '*parameters must be set at a level that reflects the true operating characteristics of their plant, or their reasonable expectations, based on technical parameters, of those operating characteristics*' Ofgem letter Sep 2020

Unlimited changes prior to Gate Closure permitted reflecting changes to expected commercial position

4

DRIVERS OF HIGH COSTS

OUR ANALYSIS OF WHAT HAPPENED ON THE HIGH COST DAYS FOCUSES ON THE FOLLOWING KEY QUESTIONS

WHAT DROVE HIGH COSTS ON THESE 10 DAYS?

1. HOW DID BEHAVIOUR OF MARKET PARTICIPANTS DRIVE COSTS?
2. DID ESO DISPATCH THE CHEAPEST PLANT AVAILABLE?

3. HOW DO THESE 10 DAYS COMPARE TO (RECENT) HISTORY?

OUR ANALYSIS OF WHAT HAPPENED ON THE HIGH COST DAYS FOCUSES ON THREE QUESTIONS

1

HOW DID BEHAVIOUR OF MARKET PARTICIPANTS DRIVE COSTS?

This includes discussion of:

- BM offers accepted
- Bidding behaviours
- Submitted dynamic parameters
- Interaction with the wholesale market

2

DID ESO DISPATCH THE CHEAPEST PLANT AVAILABLE?

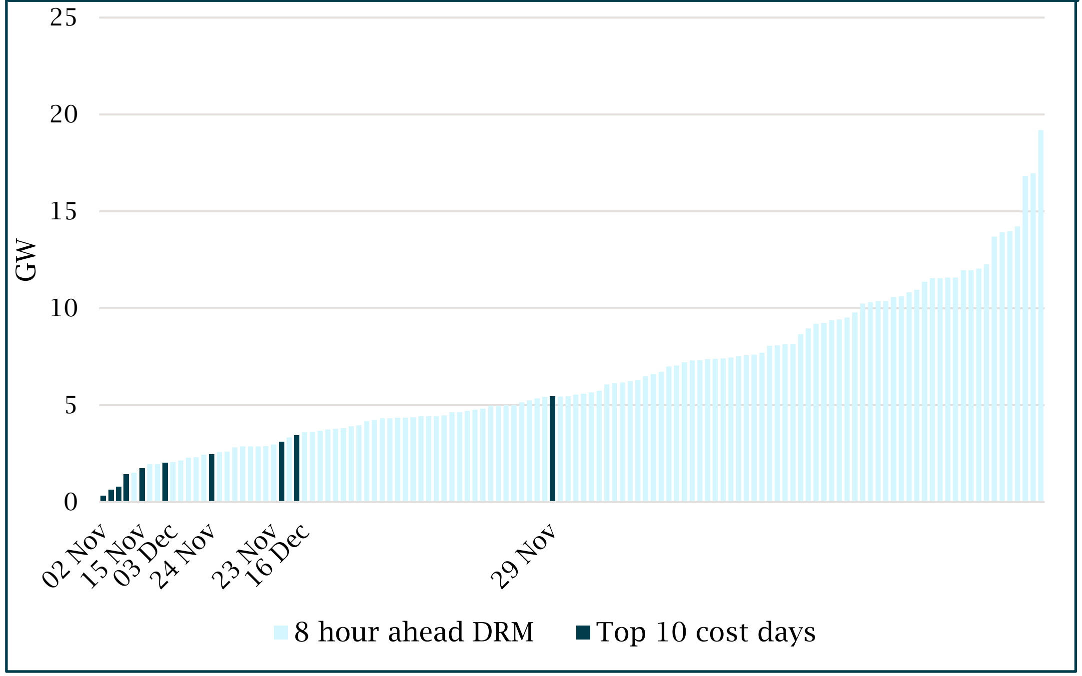
3

HOW DO THESE 10 DAYS COMPARE TO (RECENT) HISTORY?

THE SYSTEM WAS TIGHT ACROSS EACH OF THE TEN DAYS

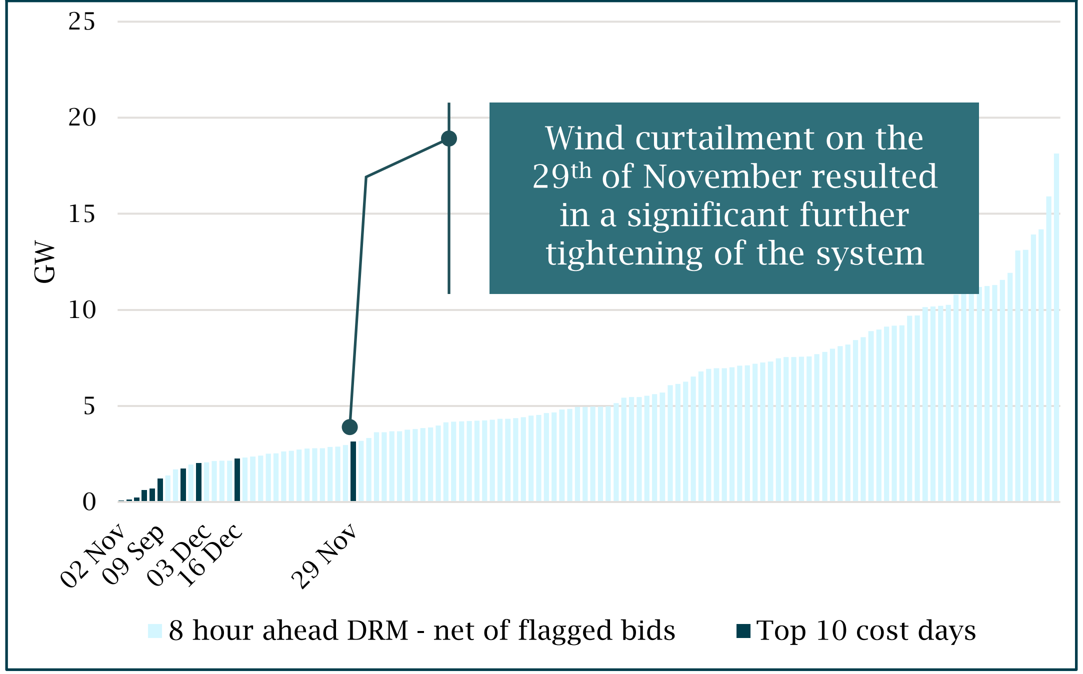
THE TEN DAYS WERE AMONG THE TIGHTEST IN THE AUTUMN 2021 PERIOD...

Minimum daily 8-hour ahead De-Rated Margin* (DRM), September-December 2021



....THE TIGHTNESS WAS EXACERBATED ON SOME DAYS DUE TO THE NEED FOR WIND CURTAILMENT

Minimum daily 8-hour ahead DRM net of flagged bids, September-December 2021



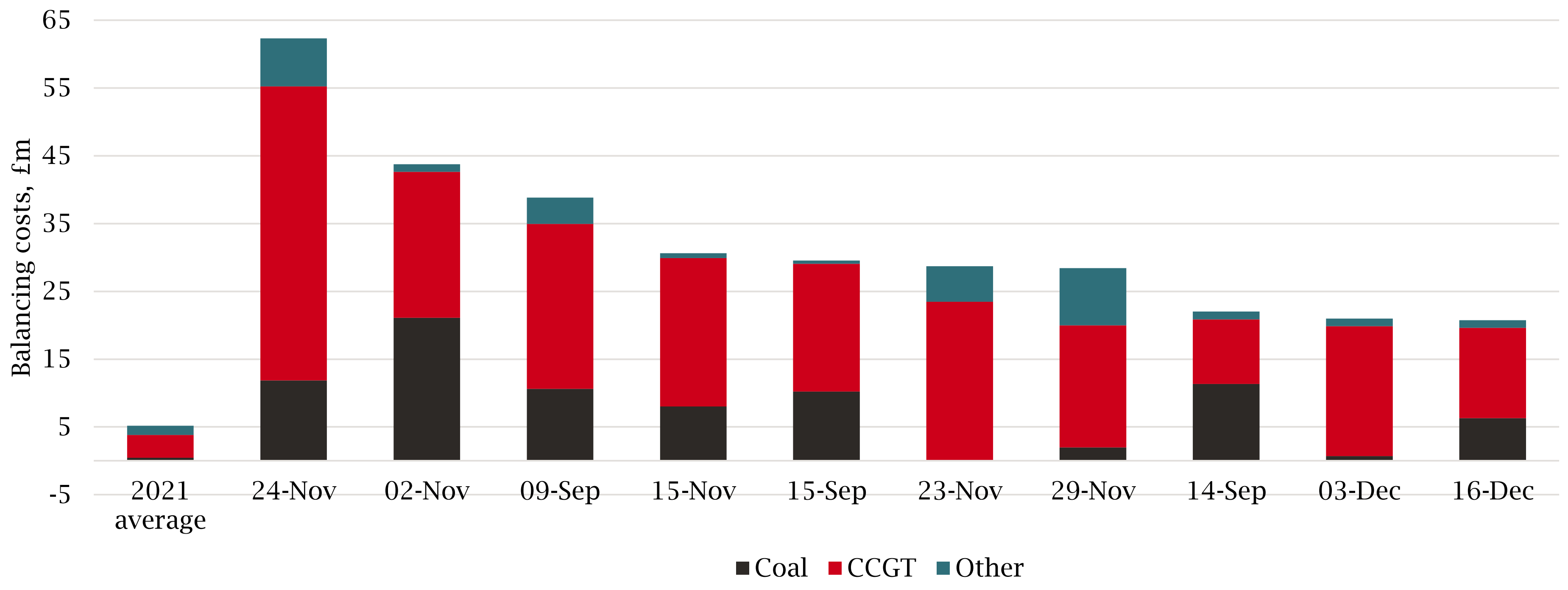
DRM is an indicator of scarcity, and in periods of scarcity there is an increased likelihood that prices will rise significantly. Given that the top 10 cost days were among the tightest days in the period, high prices were to be expected. On very tight days, prices can rise significantly above the marginal cost of the most expensive capacity on the system up towards the value of lost load – i.e. 'scarcity pricing'

*De-Rated Margin (DRM) measures the amount of the remaining capacity that is available in the system after total demand is satisfied. We use it as a proxy for system tightness

MOST OF THE BALANCING COSTS RELATED TO ACCEPTED OFFERS BY COAL AND CCGT PLANTS

THE MAIN CONTRIBUTION TO BALANCING COSTS ON THE 10 DAYS CAME FROM CCGT AND COAL UNITS. OVER THE 10 HIGH COST DAYS, PAYMENTS TO CCGT UNITS REPRESENTED 65% OF BALANCING COSTS AND PAYMENTS TO COAL UNITS 25%.

Total non-flagged BM offer costs by tech

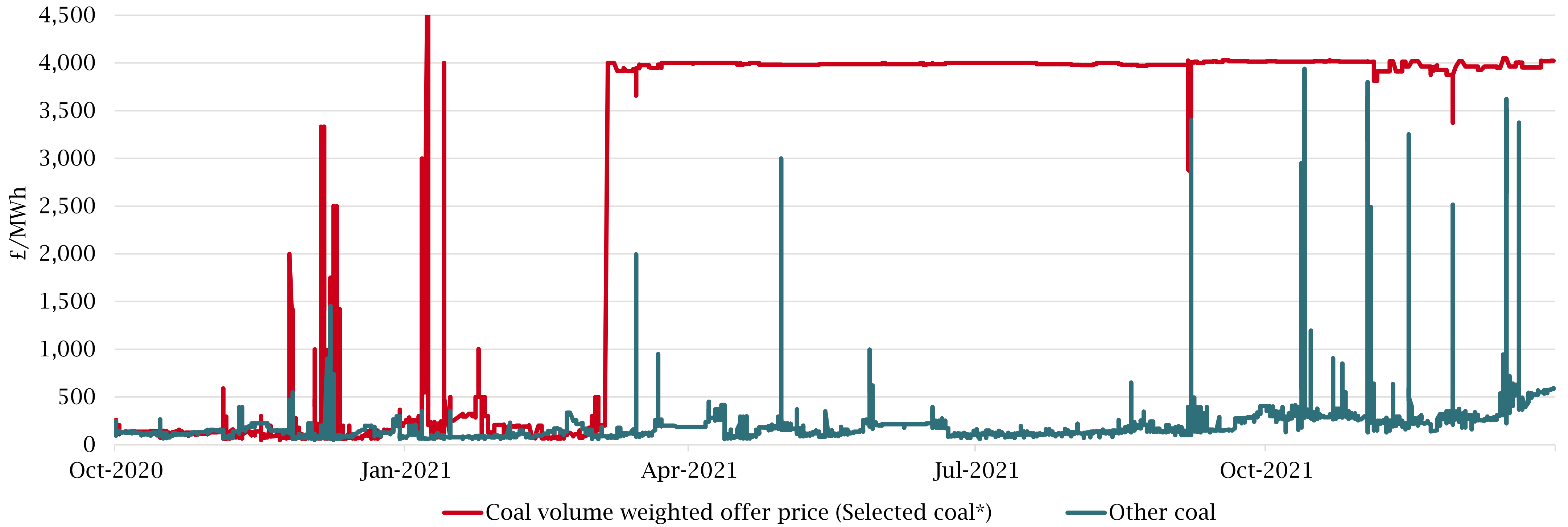


CERTAIN COAL PLANTS SYSTEMATICALLY OFFERED POWER TO THE BM AT HIGH PRICES...

❶

SINCE MARCH 2021, SOME COAL PLANTS HAVE EFFECTIVELY OPTED OUT OF THE WHOLESALE MARKET AND HAVE BEEN OFFERING ALL OF THEIR CAPACITY INTO THE BALANCING MARKET AT AROUND £4,000/MWH

Volume weighted coal BM offer price



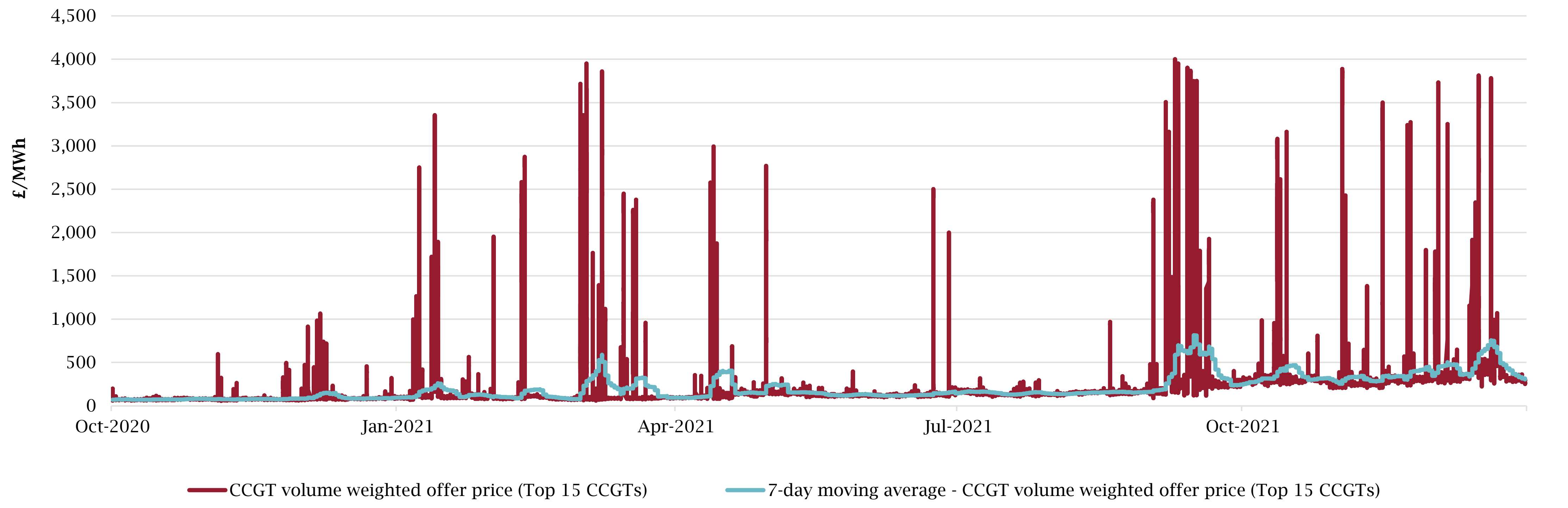
THOSE COAL PLANTS THAT CONSISTENTLY BID AT AROUND £4,000/MWH WERE NOT ACCEPTED ON ALL OF THE 10 DAYS. THEIR BIDS WERE ACCEPTED ON FIVE OF THE DAYS, AND ON TWO OTHER DAYS THOSE COAL PLANTS WERE WARMED IN ANTICIPATION THEY MAY BE NEEDED, BUT ULTIMATELY WERE NOT ACCEPTED.

*Coal plants consistently offering at around £4000/MWh from March 2021

...AND CCGTS HAVE FOLLOWED WITH OFFERS UP TO SIMILAR LEVELS

EXPECTED TIGHT MARGINS (FURTHER INDICATED BY COAL WARMING INSTRUCTIONS ON SOME DAYS WHICH ARE VISIBLE TO THE MARKET) PROVIDED INDICATION THAT CCGT OFFERS UP TO £4,000/MWH COULD BE ACCEPTED

Offer prices of top 15 CCGTs*

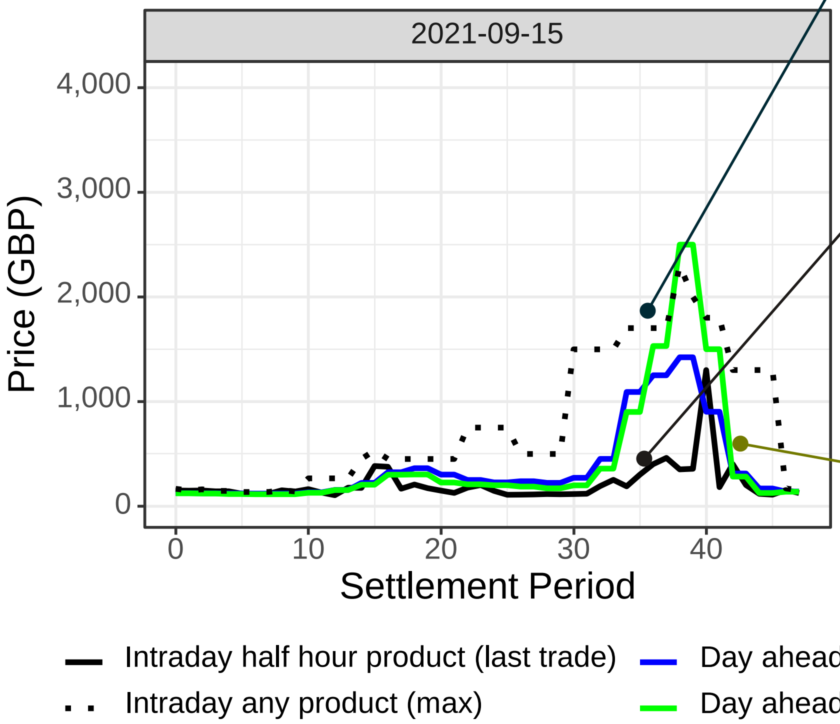


ON ONE OF THE TWO DAYS WHEN COAL PLANTS CONSISTENTLY BIDDING AT AROUND £4,000/MWH WERE NOT WARMED, CCGT OFFERS REMAINED VERY HIGH (I.E. CLOSE TO £4,000/MWH)

* 15 CCGTs with highest BM costs over study period

WE HAVE ALSO LOOKED AT DAY AHEAD (DA) AND INTRADAY (ID) MARKET DATA ACROSS THE TEN HIGHEST BM COST DAYS

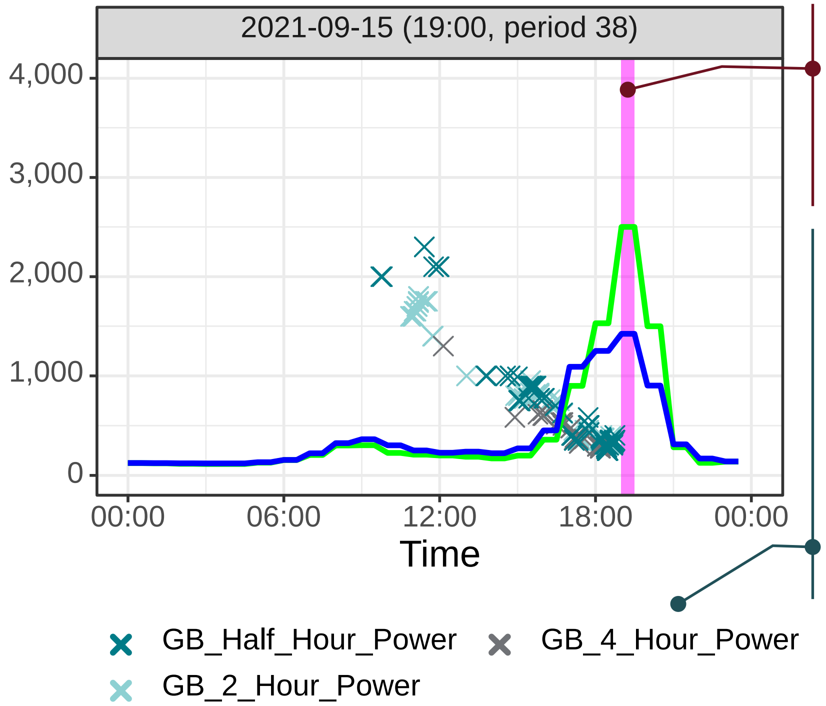
WE PRESENT TWO TYPES OF ANALYSIS: THE FINAL OR MAXIMUM PRICES FOR ALL SETTLEMENT PERIODS THROUGHOUT THE DAY (LEFT); AND THE PRICES OF ALL TRADES MADE THROUGHOUT THE DAY FOR A PARTICULAR SETTLEMENT PERIOD OF INTEREST I.E. A PEAK PERIOD (RIGHT)



We show the maximum traded (any product) price (at any point intraday) moves through the day…

… and how the last traded (half hour product) price for each half hour moves through the day.

We also present the day ahead prices for each settlement period (for both EPEX and N2EX day ahead markets)



This chart plots traded prices throughout the day for settlement period 19:00-19:30 on the 15th of September 2021

Different ID products cover different periods of time. For the half hour period analysed here there are three products that cover it,:

- One that spans half an hour;
- One that spans 2 hours; and
- One that spans 4 hours

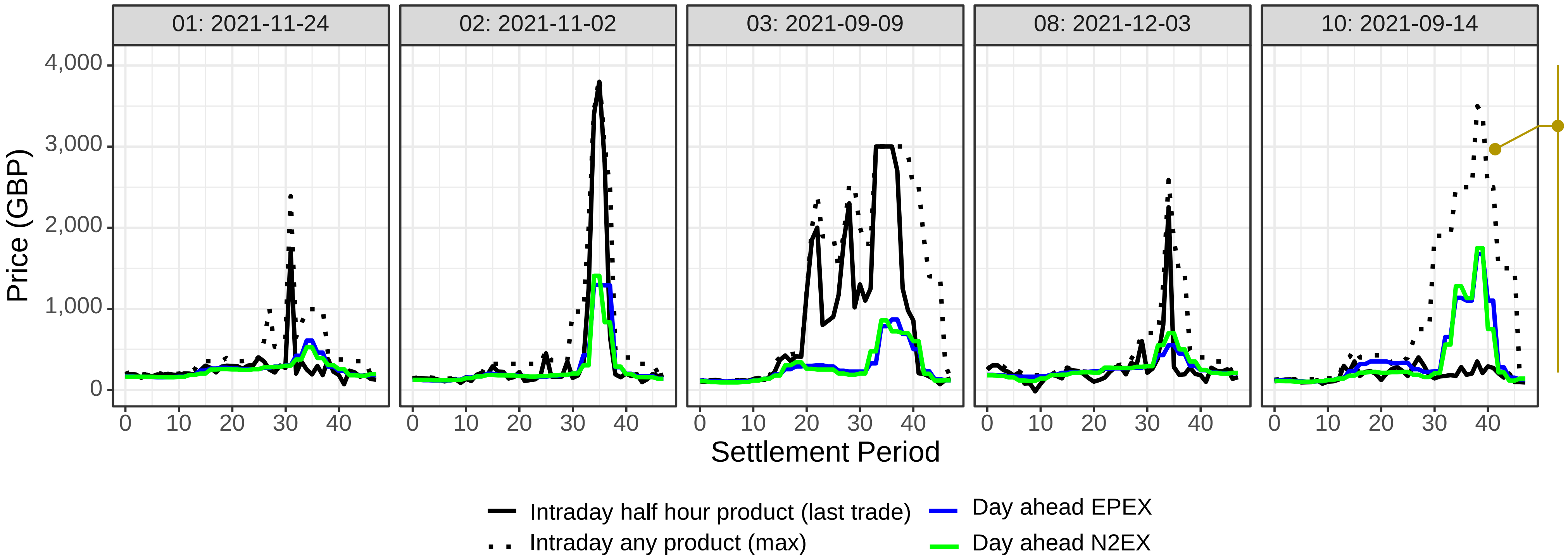
The ID market is continuously traded i.e. trades for a particular settlement period can be cleared at any time during the day. Therefore, for each settlement period it is possible to examine prices cleared in the day ahead market and see how prices for each settlement period evolve over the course of the day up to real time. This allows us to understand how market expectations of tightness evolved during day

ON FIVE OF THE DAYS WE OBSERVE INCREASING EXPECTATIONS OF SCARCITY EMERGING INTRADAY…

1

ON FIVE OF THE TEN DAYS (SHOWN BELOW), PRICES IN THE ID MARKET ROSE SIGNIFICANTLY ABOVE THE ALREADY HIGH PRICES IN THE DAY AHEAD MARKET, REACHING LEVELS BETWEEN £2,000/MWH AND £4,000/MWH - INDICATING INCREASING EXPECTATIONS OF SCARCITY AT PEAK EMERGING INTRADAY

Day ahead and Intra Day prices (increasing expectations of scarcity)



On one of the days the intraday price **spiked above earlier** in the day before updated expectations meant prices dropped back closer to the settlement period

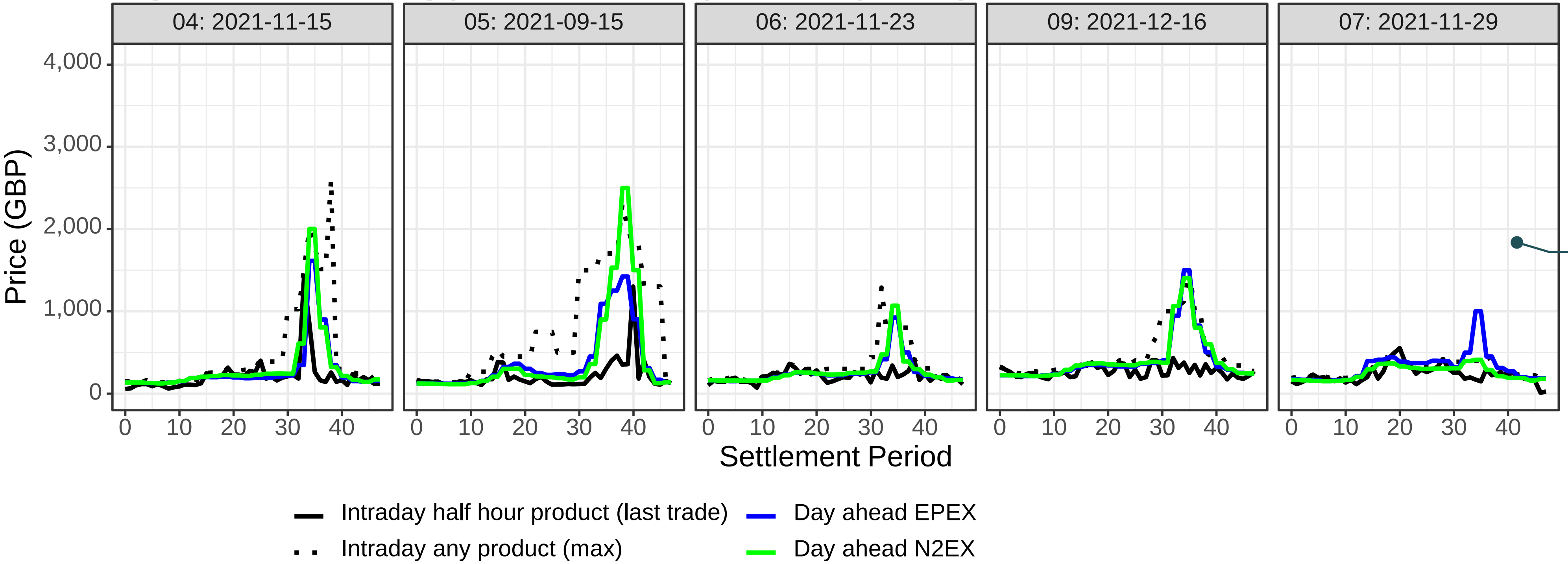
While market participants will have taken a view on the degree and likelihood of market tightness at the day ahead stage, in general, events that turn an expected tight day into an extremely tight day with a high degree of certainty become clearer intraday. The intraday price spikes demonstrate greater consistency between wholesale and balancing markets in terms of expectations of scarcity at peak.

...ON MOST OTHER DAYS, EXPECTATIONS OF SIGNIFICANT SCARCITY WERE SET DAY AHEAD AND REMAINED CONSISTENT INTRADAY

1

ON FOUR OF THE TEN DAYS (SHOWN BELOW), PRICES IN THE ID MARKET REMAINED IN LINE WITH PRICE SPIKES SET AT THE DAY AHEAD STAGE, AT LEVELS BETWEEN £1,000/MWH AND £2,000/MWH - INDICATING CONSISTENT EXPECTATIONS OF SCARCITY AT PEAK BETWEEN DAY AHEAD AND INTRADAY MARKETS

Day ahead and Intra Day prices (consistent expectations of scarcity)



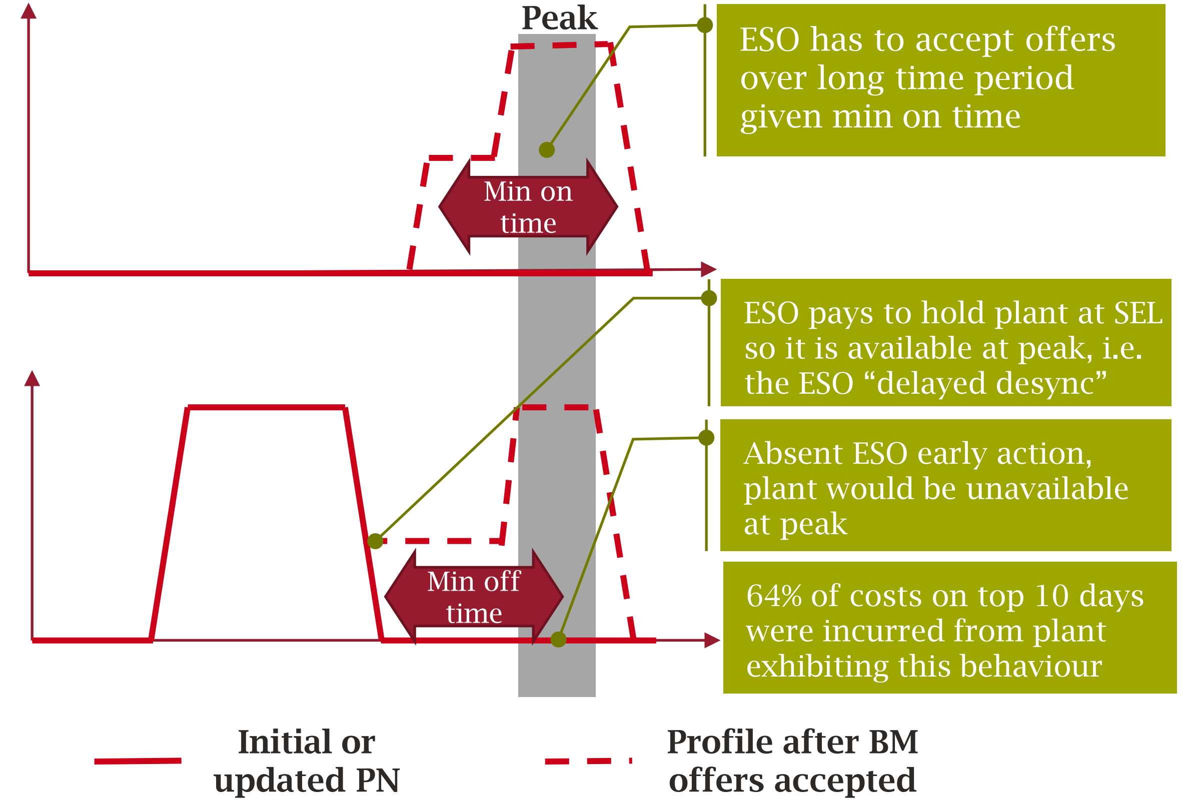
On one of the days, we observe intraday prices **below day ahead prices**, particularly over the peak period

Although on these days it appears that expectations of scarcity did not materially change intraday, on all but one day prices for the peak remained generally high, again indicating significant expectations of scarcity and consistent with high prices in the balancing market.

PLANT INFLEXIBILITIES MEANT OFFERS HAD TO BE ACCEPTED OVER LONG TIME PERIODS ❶

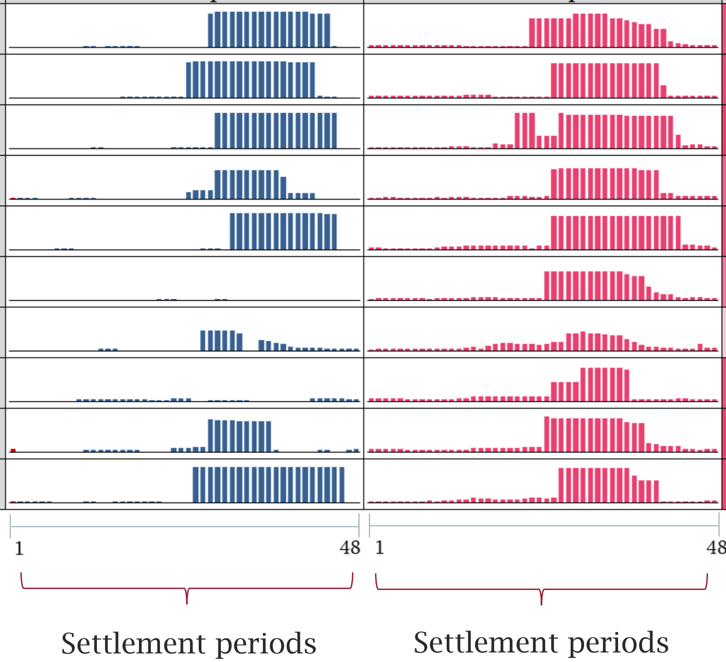
COAL AND GAS PLANTS FACE REAL TECHNICAL CONSTRAINTS ON THEIR OPERATION. THESE INFLEXIBILITIES COMBINED WITH PLANNED PRODUCTION PROFILES (INCLUDING UPDATED PNs) MEANT THAT EXPENSIVE BM OFFERS HAD TO BE ACCEPTED OVER MULTIPLE HOURS TO ENSURE PRODUCTION OVER THE TIGHT PEAK PERIOD

Illustration of the technical parameters for a CCGT/Coal and implications for period of offer acceptance



On the review days (2021) when they were accepted, CCGTs and coal had offers accepted for extended periods, and in general at very high prices

£/MWh	Max accepted Coal offer by settlement period	Max accepted CCGT offer by settlement period	Max CCGT offer of day
24-Nov			3,750
02-Nov			3,875
09-Sep			4,000
15-Nov			3,500
15-Sep			3,750
23-Nov			3,250
29-Nov			2,150
03-Dec			3,745
16-Dec			3,950
14-Sep			3,900

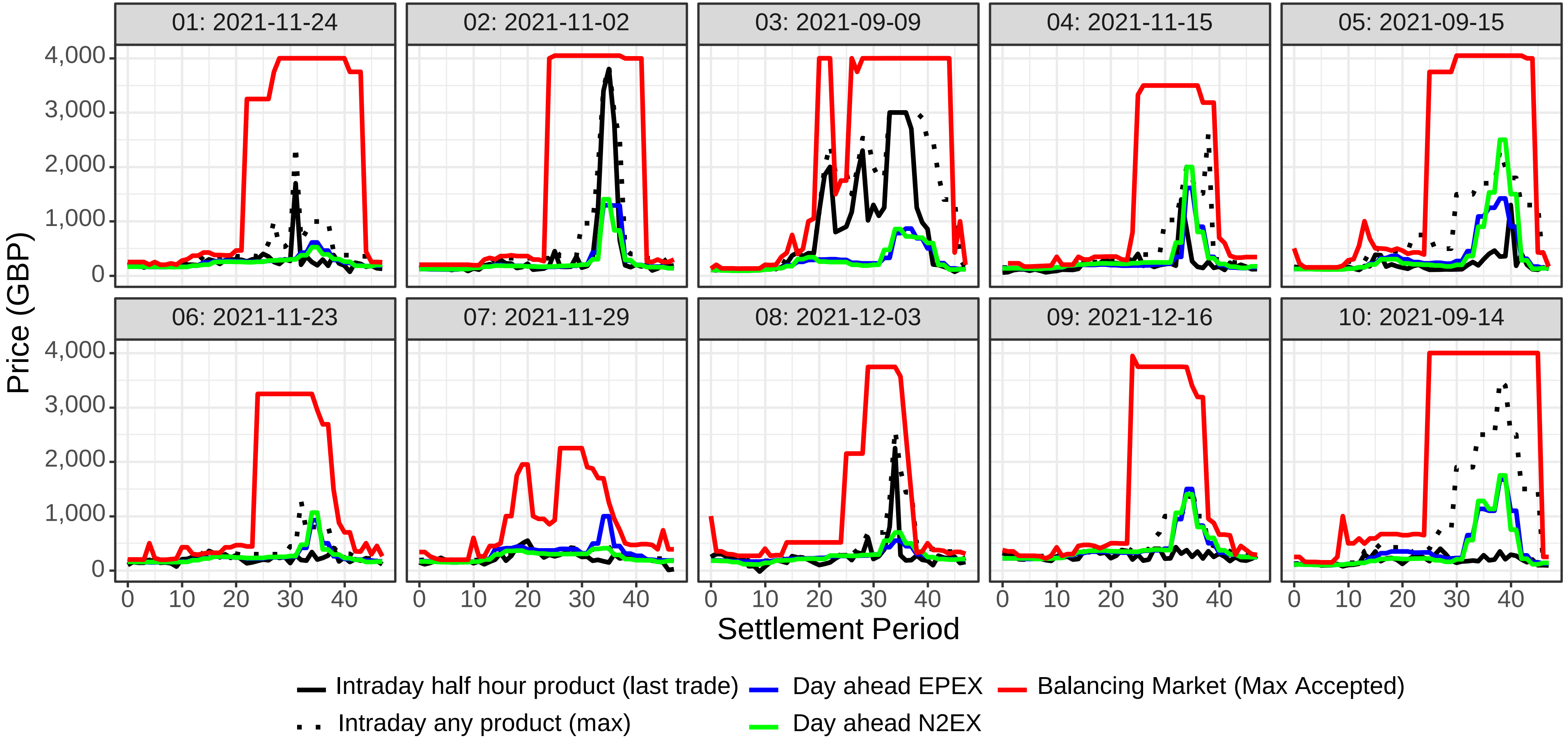


PRICE SPIKES IN THE BM WERE SIGNIFICANTLY MORE EXTENDED THAN THOSE OBSERVED IN THE ID MARKET...

1

EVEN WHEN INTRADAY PRICES SPIKED TOWARDS HIGHEST PRICED OFFERS ACCEPTED IN THE BM (AS ALREADY NOTED, THIS DID NOT HAPPEN ON EVERY DAY), THEY ONLY ALIGN FOR A SHORT PERIOD. MOST OF THE HIGH BM ACCEPTED PRICES EXTENDED OUTSIDE PEAK AND WERE NOT MATCHED BY THE INTRADAY MARKET.

Day ahead, Intra Day and BM prices



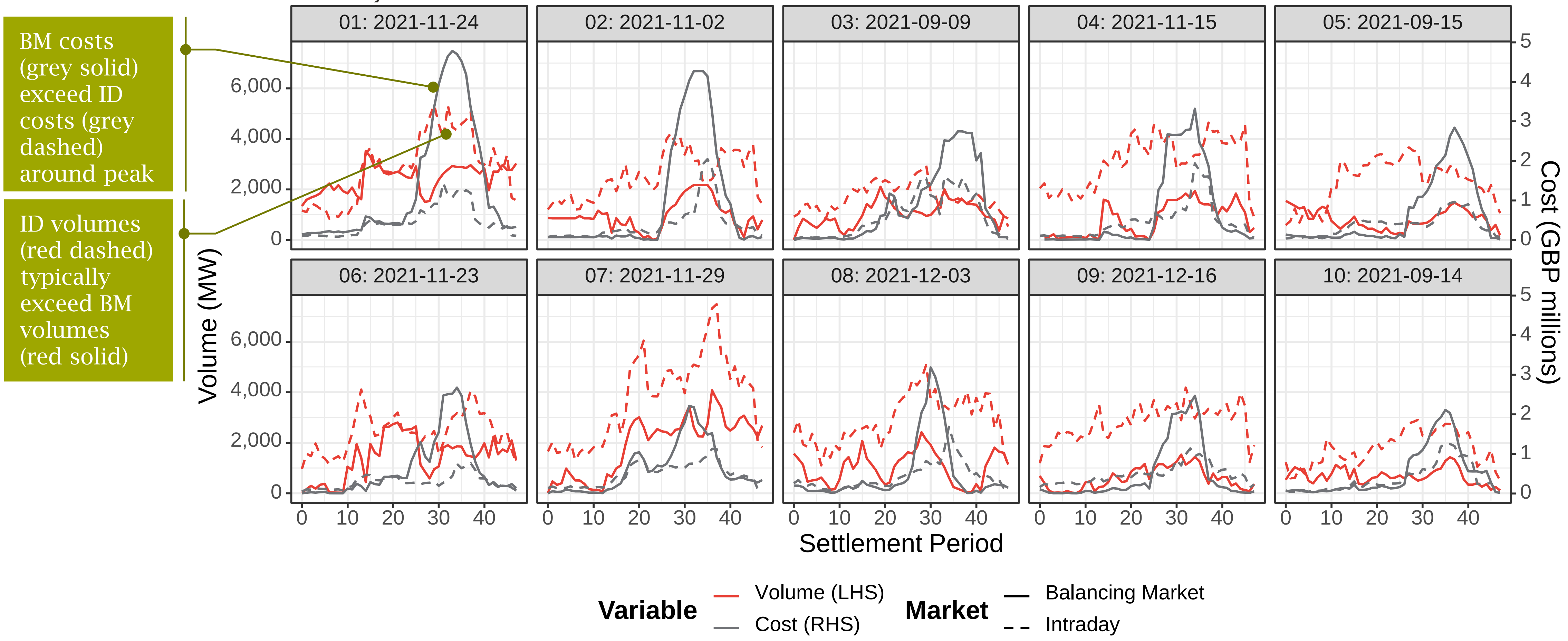
- Correlation between intraday and BM prices in the peak period is not surprising as market participants are incentivised to contract to meet peak demand
- Unlike intraday, in the BM market participants will contract ahead of the peak in recognition of plant inflexibilities
- This results in large differences between intraday and BM prices in the afternoon, when ESO was accepting high offers to ensure production over the peak

...RESULTING IN HIGHER OVERALL COSTS IN THE BM, DESPITE LOWER VOLUMES THAN ID MARKETS

❶

ACROSS ALL TEN HIGH COST DAYS TOTAL BM VOLUMES WERE BELOW THOSE IN THE ID MARKET, BUT THE TOTAL COST OF THE BM EXCEEDED THAT OF THE ID MARKET

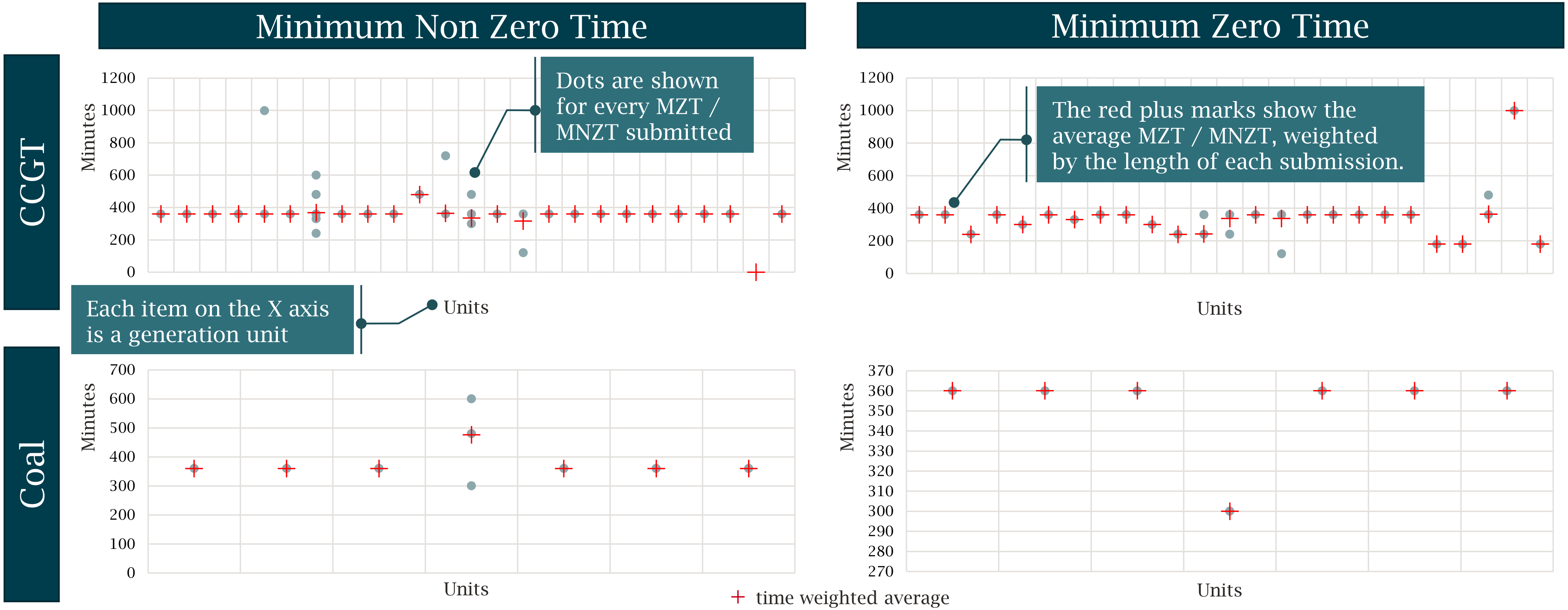
Intraday and BM volumes and costs



THERE IS NO CLEAR EVIDENCE THAT MOVEMENT IN DYNAMIC PARAMETERS HAS EXACERBATED COSTS IN THIS AUTUMN 2021...

1

MINIMUM ZERO TIMES (MZT) AND MINIMUM NON ZERO TIMES (MNZT) WERE GENERALLY CONSISTENT ACROSS THE PERIOD ANALYSED AND WITHIN UNIT TYPES, ALTHOUGH THERE WAS SLIGHTLY MORE VARIATION IN MINIMUM ZERO TIME (MZT) BETWEEN UNITS.



Note: The analysis presents MNZT and MZT values submitted across Sep-Dec 2021

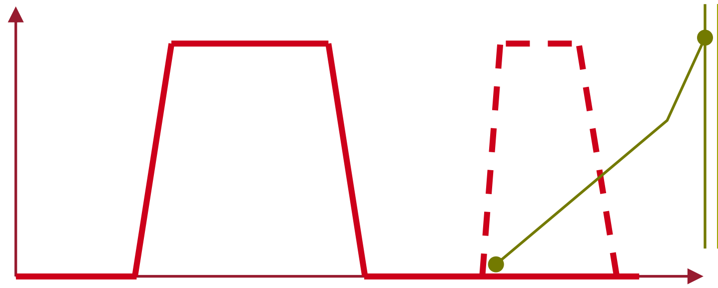
…AS AN ILLUSTRATION, WE CONSIDER THE POTENTIAL SAVINGS THAT COULD ARISE IF SHORTER MZT WAS TECHNICALLY FEASIBLE

❶

IN AUTUMN 2021 WE OBSERVED MZT OF LESS THAN 6 HOURS (E.G. AROUND 4 HOURS FOR SOME PLANTS). THEREFORE, AS AN ILLUSTRATION WE HAVE CONSIDERED THE POTENTIAL IMPACT ON BM COSTS OF AN MZT OF 4 HOURS (INSTEAD OF 6 HOURS) FOR ALL CCGT PLANTS, WITH POTENTIAL SAVINGS LINKED TO PN BEHAVIOUR.

Scenarios for potential savings if MZT was 4 hours instead of 6 hours

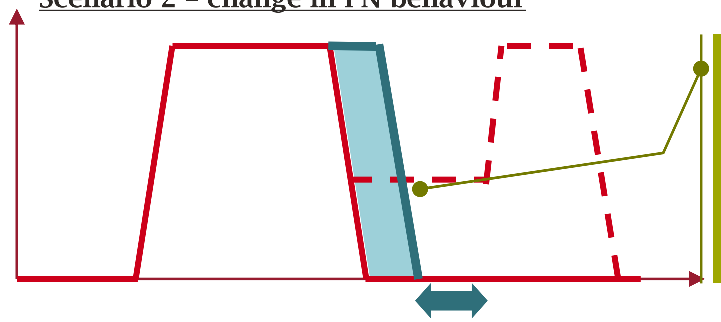
Scenario 1 – no change in PN behaviour



High savings

If there is no change in the profile of PNs, then a shorter MZT could have meant ESO allows CCGTs to desync confident that they could be available again for the evening peak.

Scenario 2 – change in PN behaviour

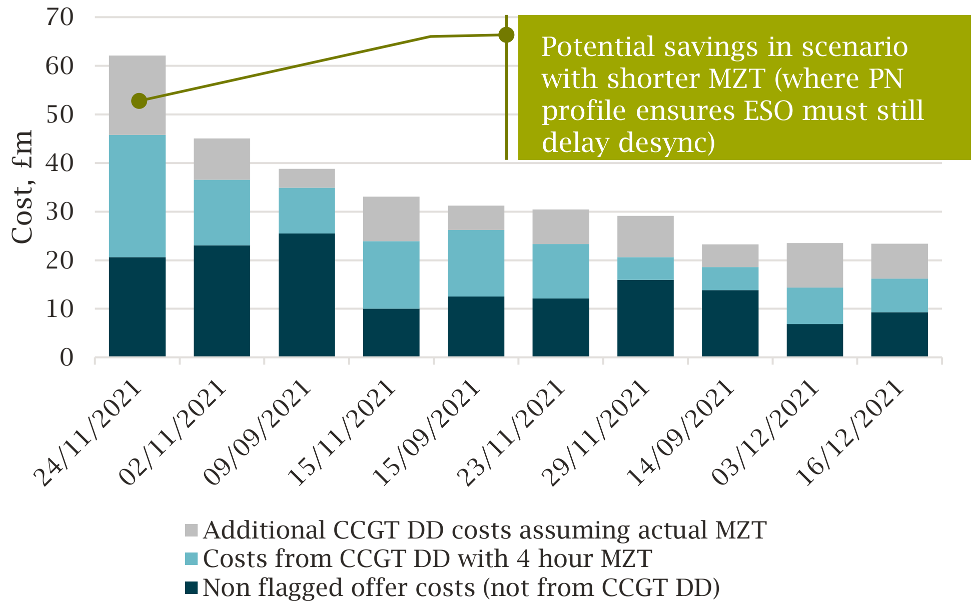


Lower savings

If CCGT also changes profile of PNs, then ESO must still delay desync so the CCGT is available for the evening peak. However, savings still arise due to BM payments over a shorter period

Initial or updated PN — **Profile after BM offers accepted** — **Alternative PN with reduced MZT**

In scenario 2 with lower savings, the potential savings for the ESO across the 10 days could have been £80m, or 23% of non-flagged offer costs



Note: We do not have a view on whether MZT of 4 hours is feasible generally (we examine historic levels as part of Question 3). Shorter zero time / short production runs have real technical consequences and costs for CCGT and coal plants. **This illustration also takes no account of potential changes in offer prices.**

SUMMARY OF KEY MESSAGES FROM ANALYSIS

❶

HOW DID BEHAVIOUR OF MARKET PARTICIPANTS DRIVE COSTS?

- The system was tight, or expected to be tight, which led to market participants (in particular coal and CCGTs) offering power at prices up to £4,000/MWh in the BM.
- Analysis of the day ahead and intraday prices shows price spikes at peak consistent with an expectation of scarcity (though at lower levels than BM offers). On around half of the days, expectations of scarcity appear to have increased intraday prices relative to day ahead prices.
- The high price BM offers were accepted across a large volume of coal and CCGT capacity on most of the days.
- The size and inflexibility of the relevant units (embodied by declared dynamic parameters) meant ESO had to accept offers up to £4,000/MWh across multiple hours just to cover the peak.
  - With regard to coal plants, offers had to be accepted for the full minimum non-zero time, typically around 6 hours.
  - With regard to CCGTs, their minimum zero time of around 6 hours combined with a plan to desynchronise in the afternoon, often meant the ESO had to delay their planned desync to ensure they were available for the peak, resulting in accepted offers much earlier in the day.
- As expected, the duration of high prices observed in the BM contrasts with the intraday market where peaks in prices were confined to peak periods.
- While our analysis of BM bidding behaviour is not exhaustive, our analysis has found no evidence that movements in dynamic parameters in this period were a driver of high costs.

OUR ANALYSIS OF WHAT HAPPENED ON THE HIGH COST DAYS FOCUSES ON THREE QUESTIONS

1

HOW DID BEHAVIOUR OF MARKET PARTICIPANTS DRIVE COSTS?

2

DID ESO DISPATCH THE CHEAPEST PLANT AVAILABLE?

- This includes discussion of:
    - Analysis of ESO forecasting.
    - Assessment of whether capacity ultimately not accepted could have provided a cheaper option for ESO
    - Impact of STOR under-procurement on balancing costs.

3

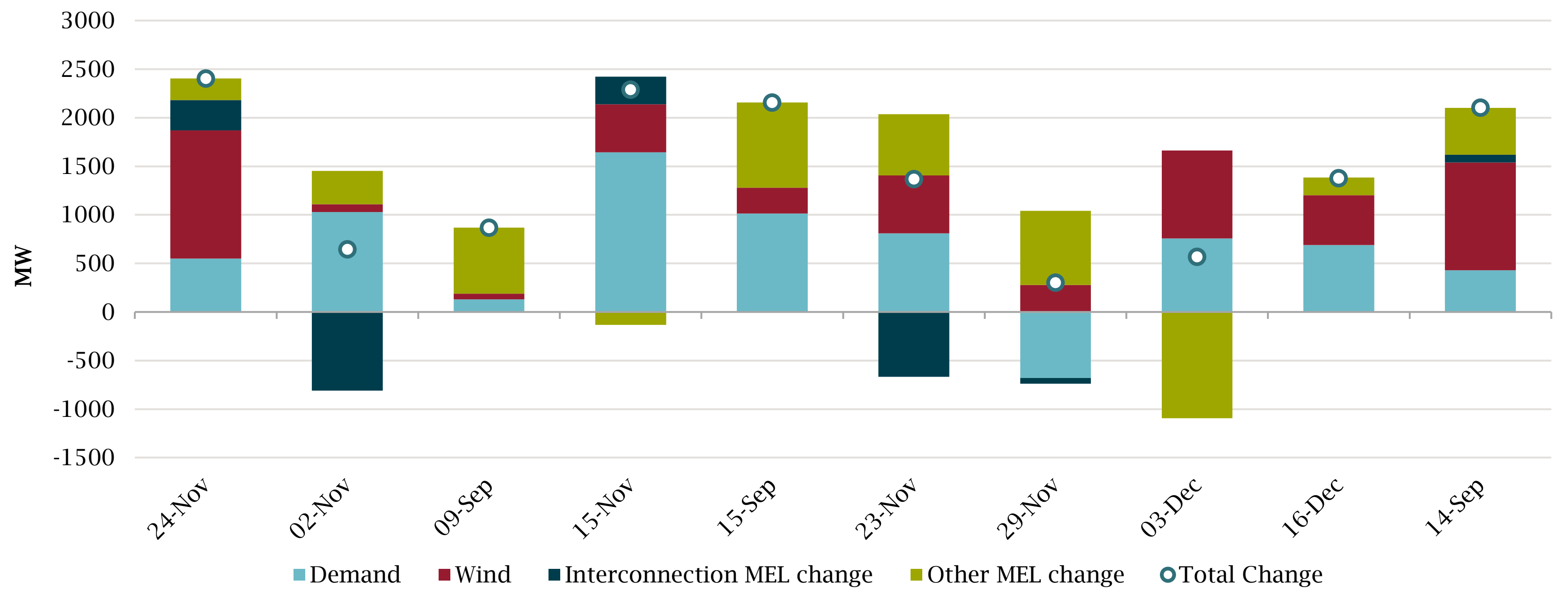
HOW DO THESE 10 DAYS COMPARE TO (RECENT) HISTORY?

ON ALL 10 DAYS, THE SYSTEM DID NOT END UP BEING AS TIGHT AS FORECAST

2

ACROSS THE 10 DAYS, ESO'S EXPECTED DE-RATED MARGIN WAS BETWEEN 300MW AND 2400MW LOWER THAN IT TURNED OUT TO BE. WITH MORE ACCURATE FORECASTS, ESO MAY HAVE BEEN ABLE TO AVOID ACCEPTING SOME OFFERS FROM LESS FLEXIBLE PLANT (WITH LONG MNZT AND MZT)

Change between forecast (from up to 8 hours ahead) and actuals over peak period



Changes were the result of:

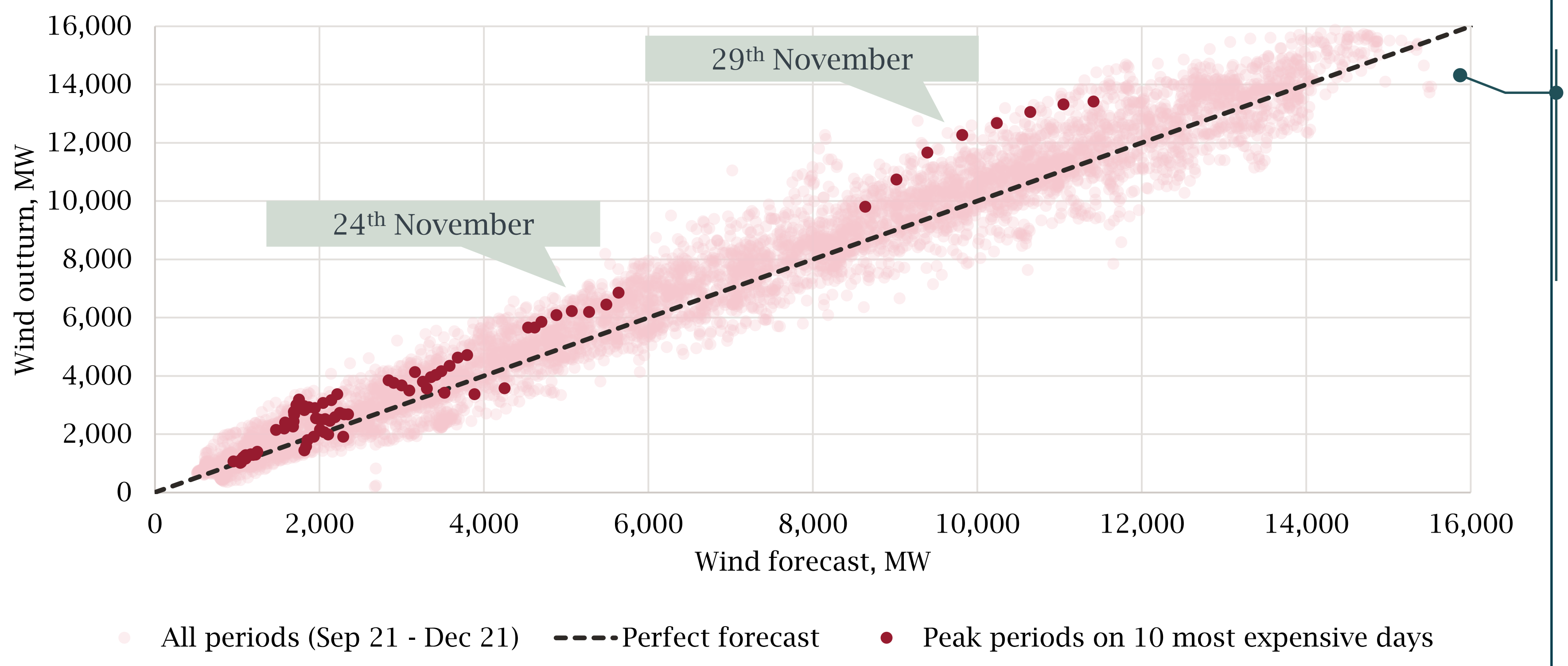
- **wind being higher** than was initially forecast (10 out of 10 days);
- **demand being lower** than initially forecast (9 out of 10 days); and
- **available capacity** (MELs) including interconnection **being higher** than expected (7 out of 10 days).

Some degree of forecast error is to be expected, and errors are likely to be greater on days with extreme conditions such as these. It is difficult to assess the extent to which these errors could have been reduced, and as a result what degree of costs could have been avoided.

IN GENERAL, WE HAVE OBSERVED A BIAS TOWARDS UNDER-FORECASTING OF WIND OUTPUT, PARTICULARLY ON LOW WIND DAYS…

DURING SEP-DEC 2021, OUTTURN WIND WAS HIGHER THAN FORECAST DURING LOW WIND PERIODS ACROSS PEAK OF THE DAY (AVERAGE OF 250MW WHEN WIND OUTPUT BELOW 3000MW). WHILE THE ERROR WAS TYPICALLY SMALL, IT WAS LARGER ACROSS THE 10 DAYS (660MW ON AVERAGE DURING PEAK PERIODS).

Wind outturn, before curtailment vs Wind forecast



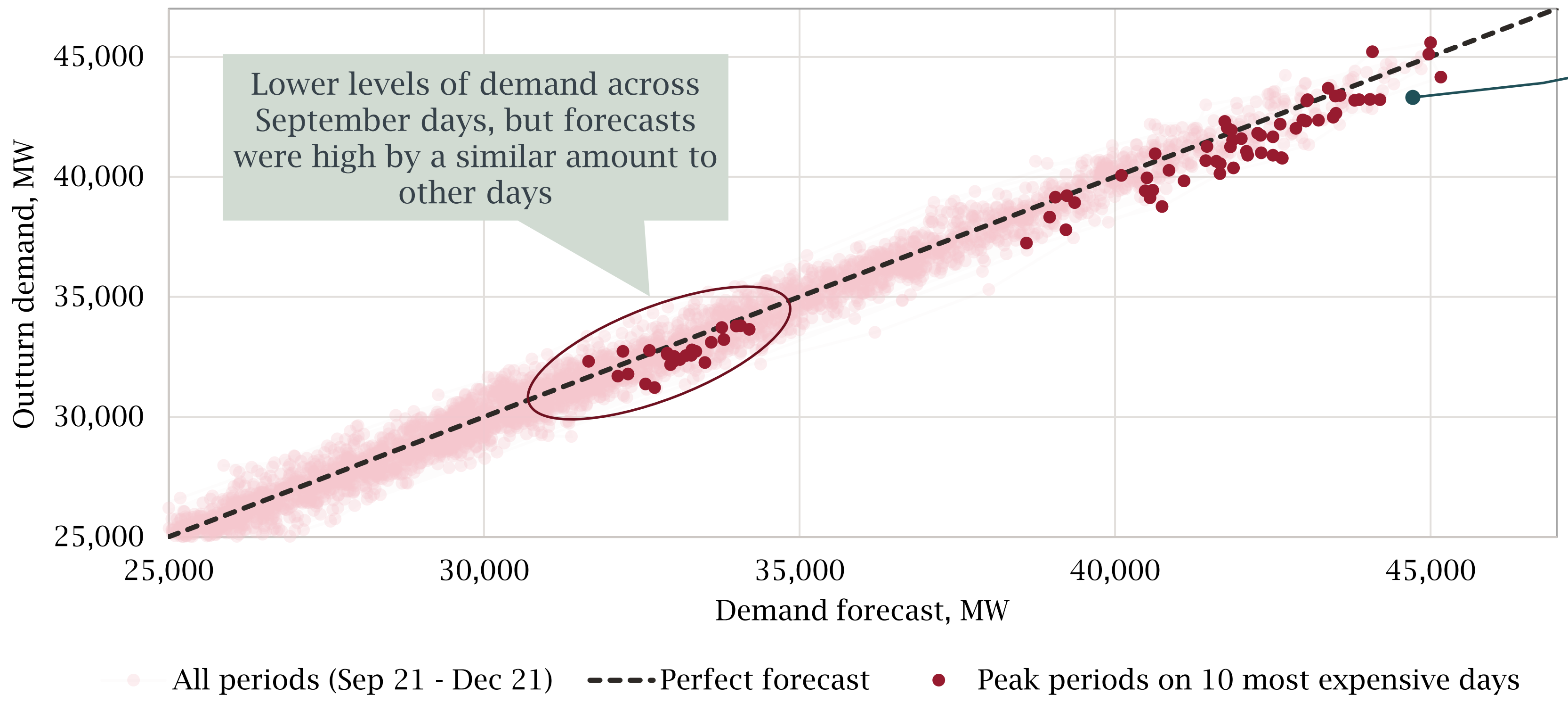
For observations above (below) the straight line wind forecasts were underestimated (overestimated).

...DEMAND FORECASTS APPEAR TO BE MORE ACCURATE BUT WERE TYPICALLY HIGH ACROSS EACH OF THE 10 DAYS

2

DURING SEP-DEC, OUTTURN DEMAND WAS ON AVERAGE LOWER THAN FORECAST DURING PEAK PERIODS (AVERAGE OF 150MW DURING PEAK PERIODS). WHILE THE ERROR WAS TYPICALLY SMALL, IT WAS LARGER ON THE 10 DAYS (AVERAGE OF 590MW DURING PEAK PERIODS)

Demand outturn vs Demand forecast



For observations above (below) the straight line demand forecasts were underestimated (overestimated).

We note that the Grid Code (Operating Code No 1) prevents ESO from explicitly taking into account price response in its National Demand forecasts.

This forecast is one of a number of important inputs into ESO control room decisions. Given price response is likely to be most significant on high cost days, it is possible this contributed to the over-estimation of demand, with implication for costs.

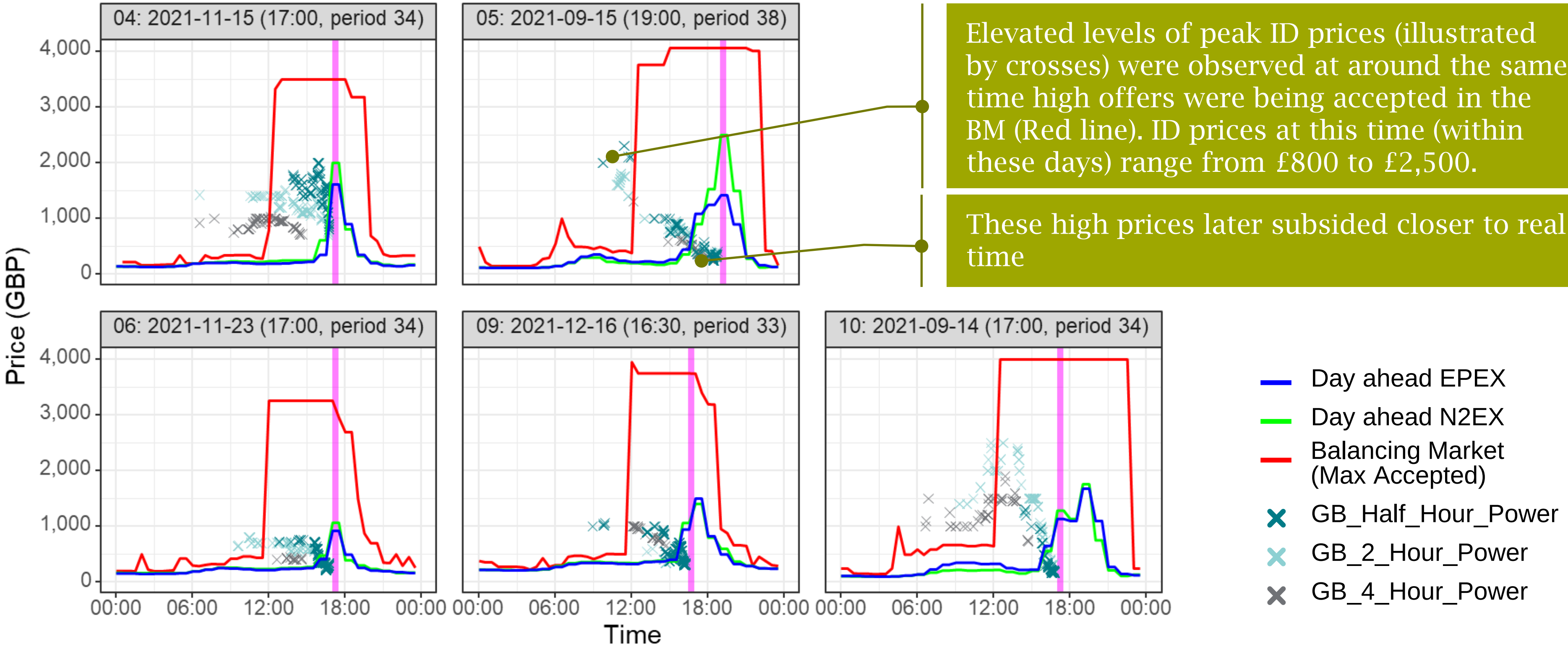
THERE IS EVIDENCE ON SOME OF THE DAYS THAT THE MARKET ALSO ANTICIPATED GREATER TIGHTNESS THAN TURNED OUT TO BE THE CASE

2

AS NO FORECAST CAN BE PERFECT, IT IS DIFFICULT TO DETERMINE AN APPROPRIATE 'BEST PRACTICE' BENCHMARK AGAINST WHICH TO COMPARE ESO'S FORECASTS. ONE POSSIBLE COMPARISON COULD BE MARKET PRICES, WHICH REFLECT MARKET PARTICIPANTS' EXPECTATIONS OF SYSTEM TIGHTNESS.

On five of the days (shown here), there is evidence that the market had been expecting greater tightness earlier in the day, at the same time ESO was also making commitment decisions for coal and CCGT plant. Market prices then subsided as expectations of extreme tightness reduced.

On the other five days (not shown), there is no evident reversal of market participants' expectations of tightness.



Elevated levels of peak ID prices (illustrated by crosses) were observed at around the same time high offers were being accepted in the BM (Red line). ID prices at this time (within these days) range from £800 to £2,500.

These high prices later subsided closer to real time

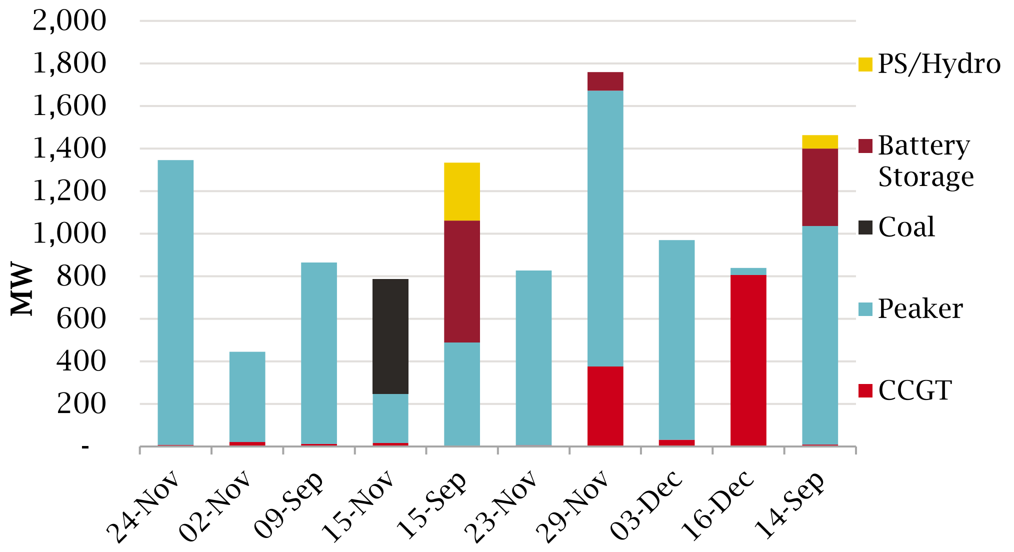
While some market participants may rely on ESO forecasts, intraday data provides some evidence that on at least half of the days, the ESO's early expectations of tightness were to a degree consistent with those of the market more generally

WITH MORE ACCURATE FORECASTS THERE MIGHT HAVE BEEN SOME (LIMITED) OPPORTUNITIES TO REDUCE BALANCING COSTS

2

ON ALL TEN DAYS, LOWER PRICED OFFERS WERE AVAILABLE WHICH ESO DID NOT END UP ACCEPTING DUE TO ITS FORECASTED MARGIN. WHILE SOME OF THIS CAPACITY WOULD HAVE BEEN REQUIRED TO MAINTAIN RESERVE, MORE ACCURATE FORECASTING ON DAYS OF EXTREME TIGHTNESS MAY HAVE LED TO REDUCED BALANCING COSTS

Lower priced* offers not accepted over tightest period, accounting for NDZ, excluding capacity needed for fast reserve



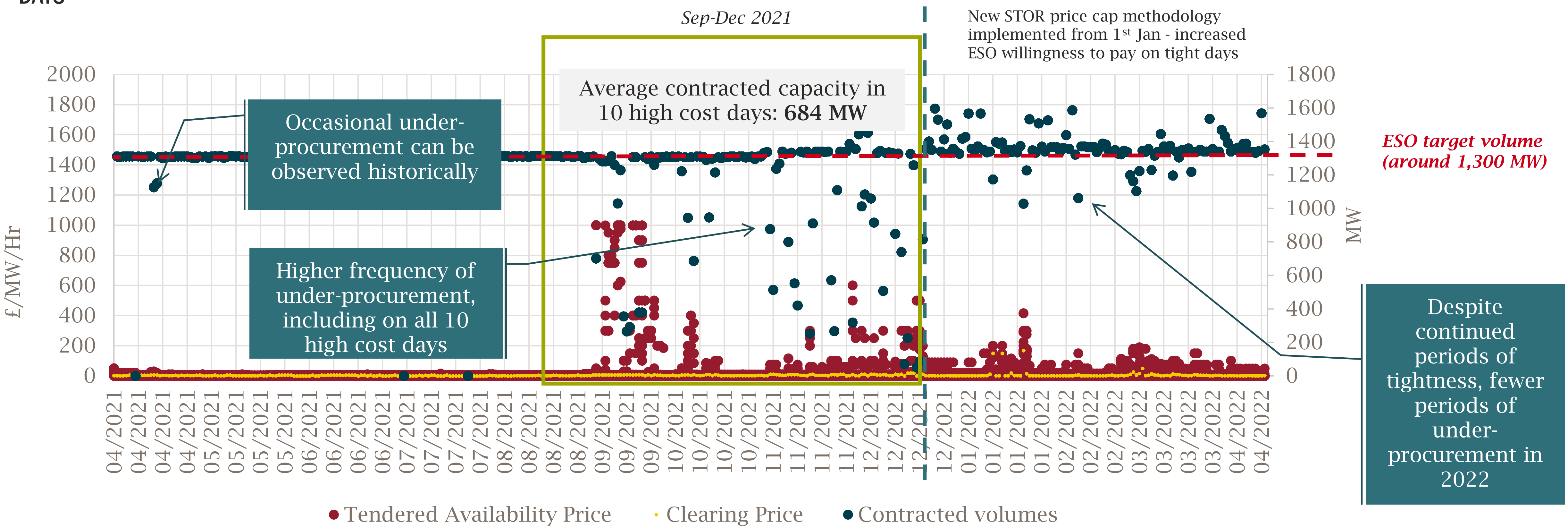
* This also includes higher priced offers from flexible capacity which may have still have been cheaper overall given they can be dispatched for short periods in contrast to inflexible plants.

- On each of the ten days there were between 400 – 1700 MW of potentially lower priced options that in theory could have been accepted in place of inflexible plants.
- Assuming all of these could be accessed essentially assumes perfect foresight, which is not a reasonable benchmark
  - Based on its forecasts at the time, ESO would have perceived much less of an opportunity e.g. on most of these days, early in the day it expected to need all of the flexible and inflexible capacity.
  - We have also seen that on around half of the days, ESO's early forecasts were not out of line with those of the market.
- There are other reasons why assuming all of these lower priced options could be accessed is not realistic
  - It would not account for the total volume of reserve, which was below target on a number of these days – swapping an inflexible plant for a lower priced offer would reduce the overall reserve available as the CCGT would no longer be running
  - It would not account for price response. While we can observe that these offers had a lower price given the CCGTs were synchronised, if ESO had let some CCGTs desynchronise, owners may have adjusted their offers upwards, reducing any potential savings.

We conclude that it is unrealistic to believe all of these lower priced offers could have been accessed. However, this does not mean that there is not scope to access some cost reduction through improved forecasting

STAKEHOLDERS SUGGESTED THAT HIGH COSTS COULD HAVE BEEN DRIVEN BY ESO NOT BUYING ENOUGH CAPACITY THROUGH STOR

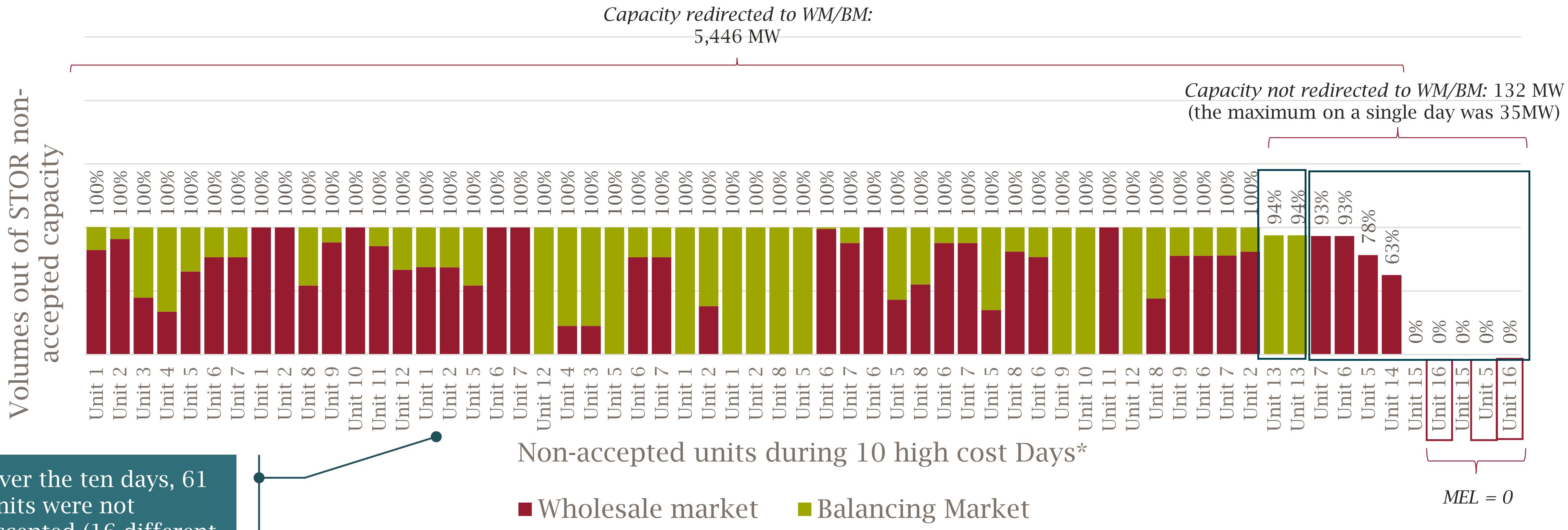
TENDERED STOR PRICES STARTED TO RISE SIGNIFICANTLY IN SEPTEMBER 2021 AND CONTRACTED VOLUMES WENT BELOW THE ESO TARGET ON SOME DAYS DURING THE SEPTEMBER-DECEMBER 2021 PERIOD. SINCE JANUARY 2022, CONTRACTED VOLUMES HAVE STABILISED CLOSER TO THE ESO TARGET, BUT STILL FALL SHORT ON SOME DAYS



HOWEVER, THE TENDERED STOR CAPACITY THAT WAS NOT PROCURED WAS STILL AVAILABLE TO THE MARKET…

2

ON AVERAGE, 53% OF CAPACITY THAT WAS REJECTED AS STOR WAS CONTRACTED IN THE WHOLESALE MARKET INSTEAD, AND 37% WAS OFFERED INTO THE BM. ONLY ON 5 OUT OF 61 OCCASIONS DID REJECTED STOR UNITS NOT PARTICIPATE IN EITHER MARKET, MOST OF WHICH ARE EXPLAINED BY OUTAGES (I.E. ZERO MEL)



Over the ten days, 61 units were not accepted (16 different units)

*Each bar relates to a specific unit that wasn't accepted in a specific STOR auction i.e. the same unit may appear multiple times

2

...HOWEVER, REDUCED LEVELS OF STOR CAPACITY MAY STILL HAVE HAD SOME INFLUENCE ON THE HIGH COST DAYS

IT IS DIFFICULT TO KNOW TO WHAT EXTENT THERE WOULD HAVE BEEN A CHANGE IN BM COSTS DUE TO REDUCED LEVELS OF STOR. HOWEVER, THROUGH DISCUSSIONS WITH ESO WE HAVE IDENTIFIED TWO POTENTIAL ROUTES THROUGH WHICH IT COULD HAVE LED TO HIGHER BM COSTS

IMPACT ON SYSTEM TIGHTNESS

- It has been suggested that on tight days, purchasing the full amount of STOR capacity can trigger additional capacity to be provided by the market (given around 1.4GW has been effectively removed from the wholesale market).
- If this were the case, under-procurement of STOR effectively makes more capacity available to the market (we showed on the previous slide that a significant proportion of non-accepted STOR capacity sold in the wholesale market instead) and may reduce the market's incentive to bring forward more capacity, increasing overall system tightness.
- However, we do not expect this to be a key driver, given we would expect all capacity that could be made available to have come forward given the possibility of high prices in the BM, combined with the clear signal that ESO will need additional reserve.

IMPACT ON CONTROL ROOM DECISIONS

- STOR purchases provide certainty that sufficient reserve will be available. If too little STOR has been purchased the control room must rely on capacity coming forward in the BM.
- This may have led to a situation in which the control room preferred to lock in some additional reserve capacity ahead of the peak by delaying the desync of some CCGTs. This may have been more expensive than additional purchases through STOR.
- The market may have also taken the under-procurement as a signal that offers from inflexible capacity are more likely to be accepted.

We note recent improvements (applied in January 2022) in the STOR pricing methodology has reduced the incidences of under-procurement

SUMMARY OF KEY MESSAGES FROM ANALYSIS

2

DID ESO DISPATCH THE CHEAPEST PLANT AVAILABLE?

- On all 10 days, the system did not end up being as tight as ESO forecast it to be. During the 10 days, we observe repeated under-forecasting of wind and over-forecasting of demand by ESO.
- Some degree of forecast error is inevitable, and errors are likely to be greater on days with extreme conditions such as these. In addition, we note that:
  - there is evidence from the intraday market that on some of the days the market expected greater tightness early during the day than it did closer to real time (although some of this may be driven by participants relying on ESO's forecasts)
  - there are restrictions in the Grid Code which limit ESO's ability to take price response into account in its demand forecasts, which may have been especially important on such high price days.
- While lower priced offers were available in the BM which ESO did not end up accepting, it is not reasonable to assume these could all have been accessed because to do so:
  - assumes perfect foresight – on the basis of ESO's forecast, it expected to need all inflexible and flexible capacity at the time it had to accept offers from inflexible capacity
  - ignores the fact that some of this lower priced capacity would have been required to maintain reserve
  - assumes that the owners of this capacity would not have changed their prices if the CCGTs were not running.
- It is difficult to identify an appropriate 'best practice' benchmark for forecast accuracy. That said, it remains the case that more accurate forecasting could have led to reduced balancing costs.
- Under-procurement of STOR relative to target capacity is unlikely to have fundamentally affected the overall supply demand balance on the system. However, it may have been a further driver for the ESO to lock-in inflexible capacity early to ensure sufficient reserve would be available at peak.

OUR ANALYSIS OF WHAT HAPPENED ON THE HIGH COST DAYS FOCUSES ON THREE QUESTIONS

1 HOW DID BEHAVIOUR OF MARKET PARTICIPANTS DRIVE COSTS?

2 DID ESO DISPATCH THE CHEAPEST PLANT AVAILABLE?

3 HOW DO THESE 10 DAYS COMPARE TO (RECENT) HISTORY?

This includes discussion of:

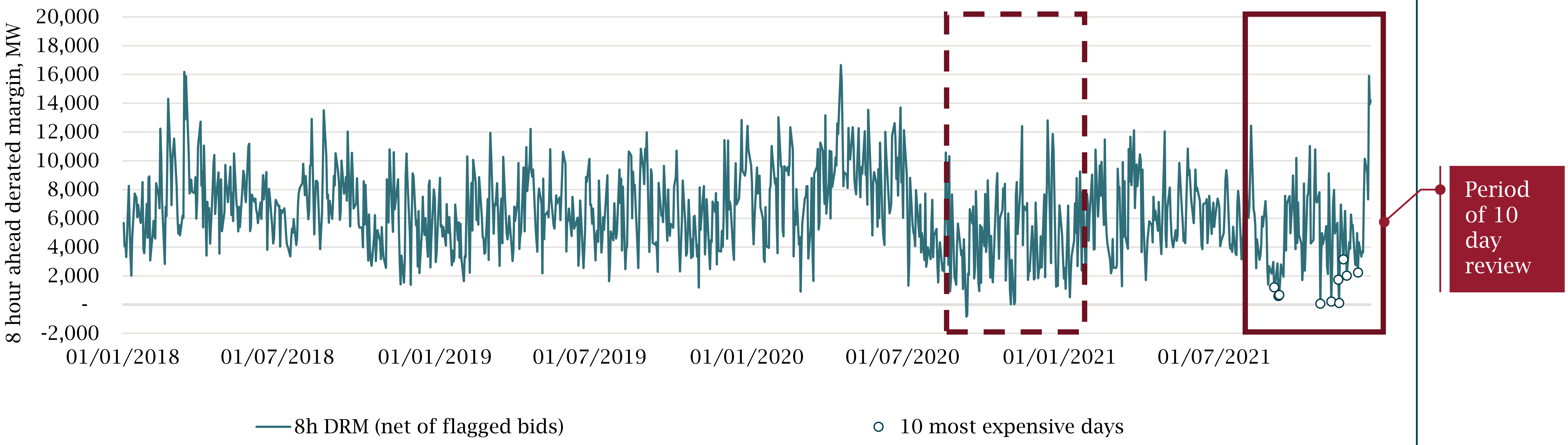
- Historical levels of system tightness
- Historical offers of CCGT and coal plants
- Historical behaviour with PNs and MNZT and MZT parameters

THE REVIEW PERIOD HAS SEEN A CLUSTER OF TIGHT DAYS, THOUGH SOME SIMILAR TIGHTNESS WAS SEEN IN LATE 2020/EARLY 2021...

3

A CLUSTER OF TIGHT DE-RATED MARGINS FROM SEPTEMBER TO DECEMBER 2021 CONTRIBUTED TO ABNORMALLY HIGH COSTS. SIMILAR LEVELS OF TIGHTNESS HAVE BEEN OBSERVED PREVIOUSLY (E.G. LATE 2020 / EARLY 2021), THOUGH THE FREQUENCY OF TIGHT MARKET CONDITIONS APPEARS TO HAVE INCREASED SINCE THEN

8 hour ahead derated margin

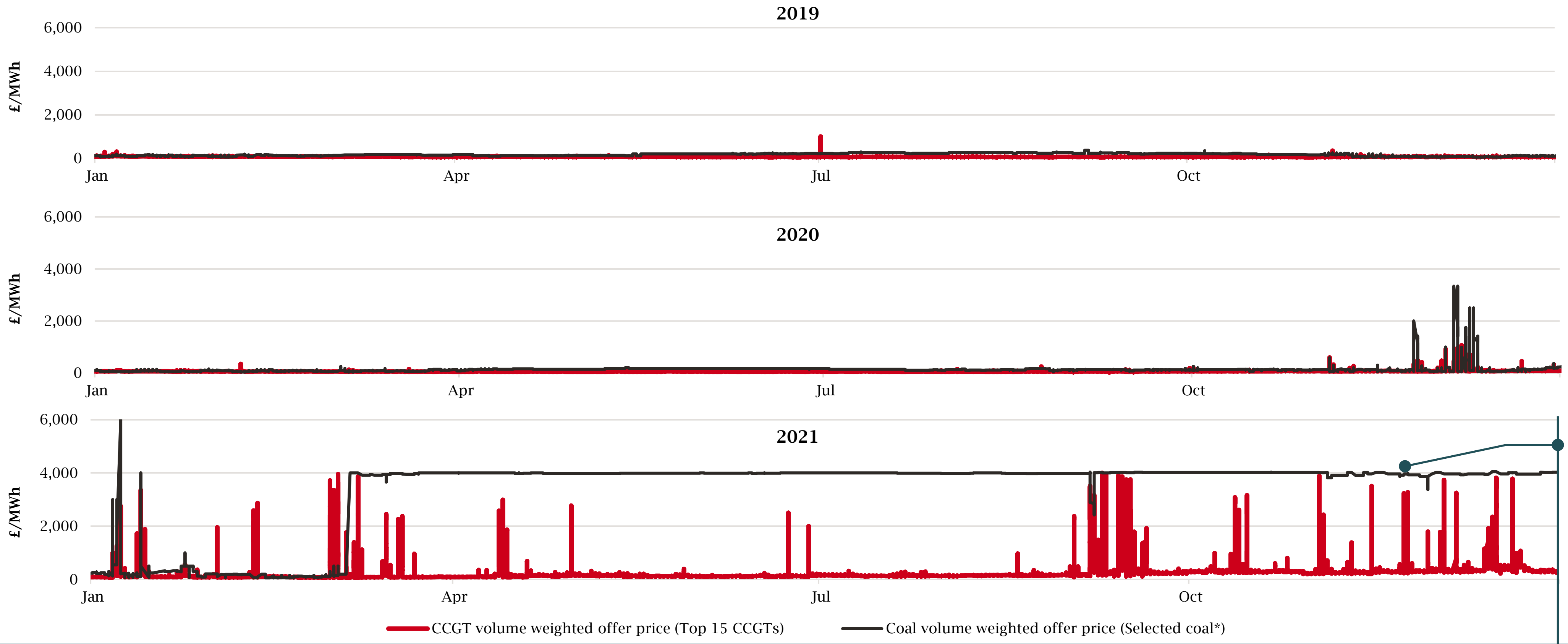


... OFFERS AROUND £4,000/MWH WERE MORE COMMON IN LATE 2021 THAN IN PREVIOUS TIGHT PERIODS

3

WHILE INCREASES IN CCGT AND COAL OFFERS WERE SEEN FROM LATE 2020, MORE CONSISTENT HIGH PRICE OFFERS IN THE BM ACROSS CCGT AND COAL PLANTS HAVE CONTRIBUTED TO HIGHER COSTS IN LATE 2021

Offer prices of Coal* and top 15 CCGTs



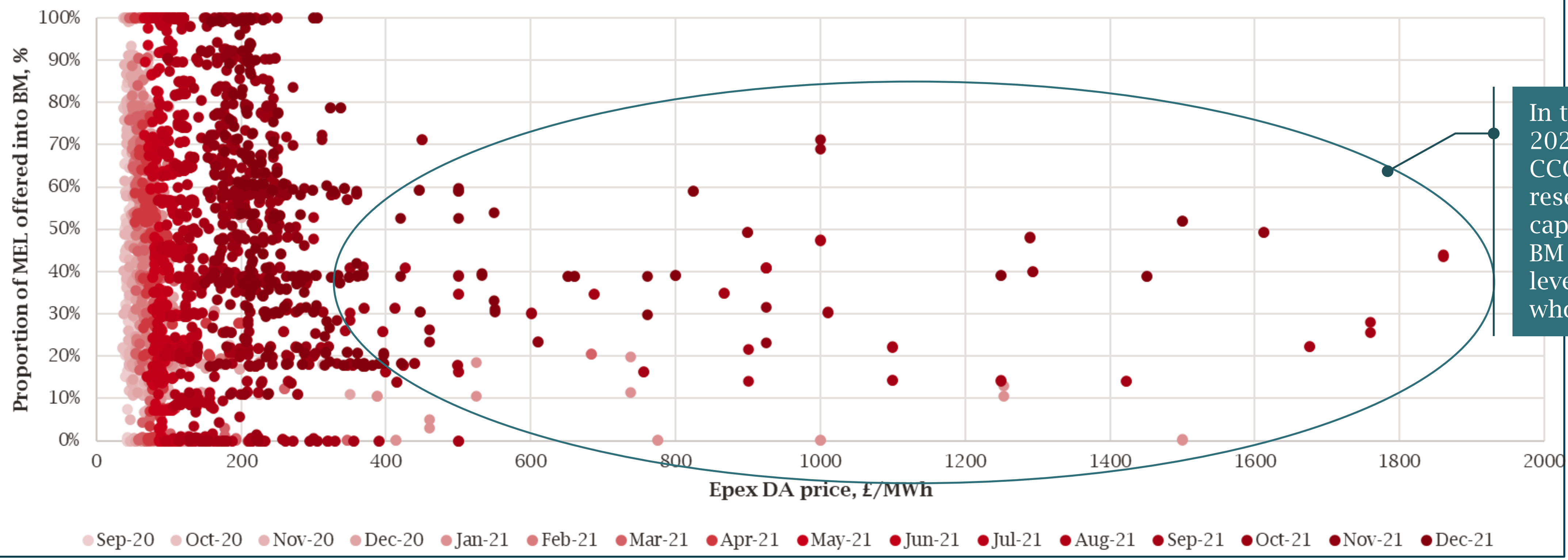
From March 2021 some coal reserves capacity for the BM market irrespective of wholesale prices

*Coal plants consistently offering at £4000/MWh from March 2021

CCGTS HAVE ALSO MORE CONSISTENTLY FOCUSED CAPACITY ON THE BM RATHER THAN THE WHOLESALE MARKET

3

Proportion of MEL offered into BM for top 5 highest cost CCGT units over the evening peak (5pm-9pm)



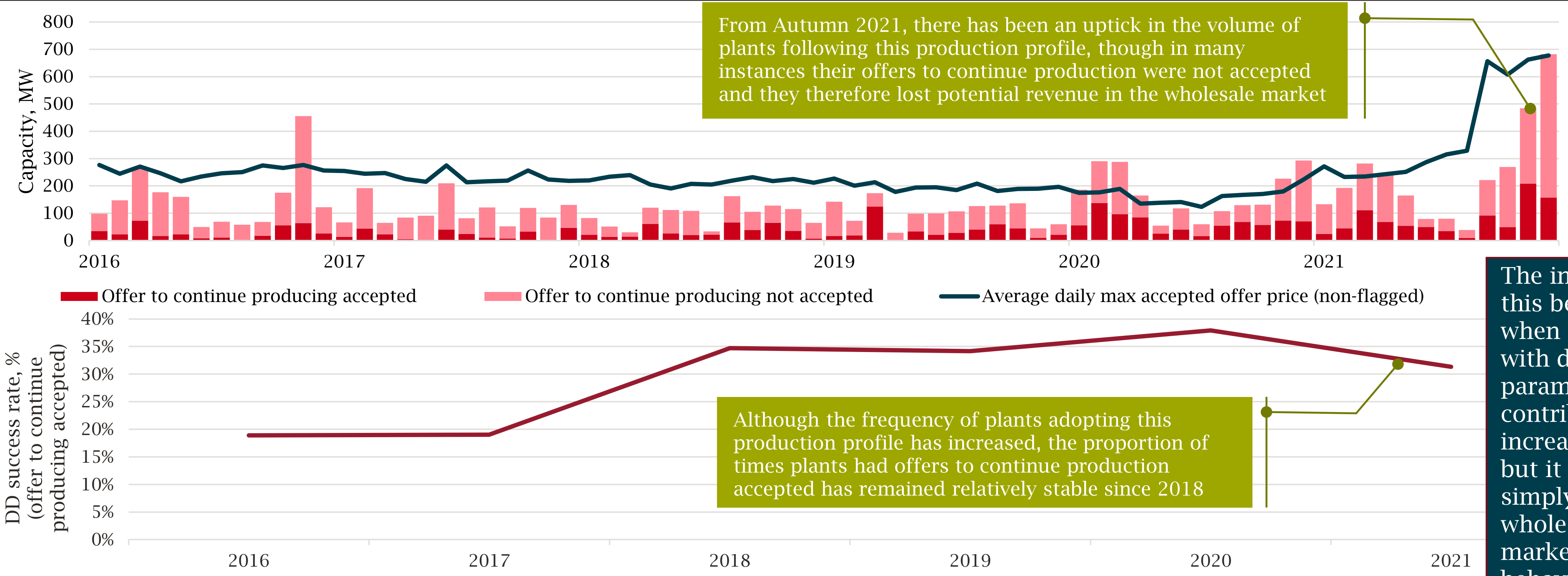
In the Autumn 2021 some CCGTs are reserving more capacity for the BM for a given level of wholesale prices

PNs THAT RESULT IN A "DELAYED DESYNC" (DD) ARE NOT NEW, THOUGH THEIR OCCURRENCE HAS INCREASED OVER TIME

3

THE VOLUME OF INFLEXIBLE CAPACITY SUBMITTING A POSITIVE PN OVER THE MIDDLE OF THE DAY BUT NOT OVER THE EVENING PEAK INCREASED SIGNIFICANTLY IN 2021 (IN LINE WITH HIGHER OFFER PRICES), THOUGH THE PROPORTION OF THESE OFFERS THAT WERE ACCEPTED HAS REMAINED RELATIVELY STABLE IN RECENT YEARS.

Average daily volume of plant submitting a positive PN in the morning and not over the evening peak



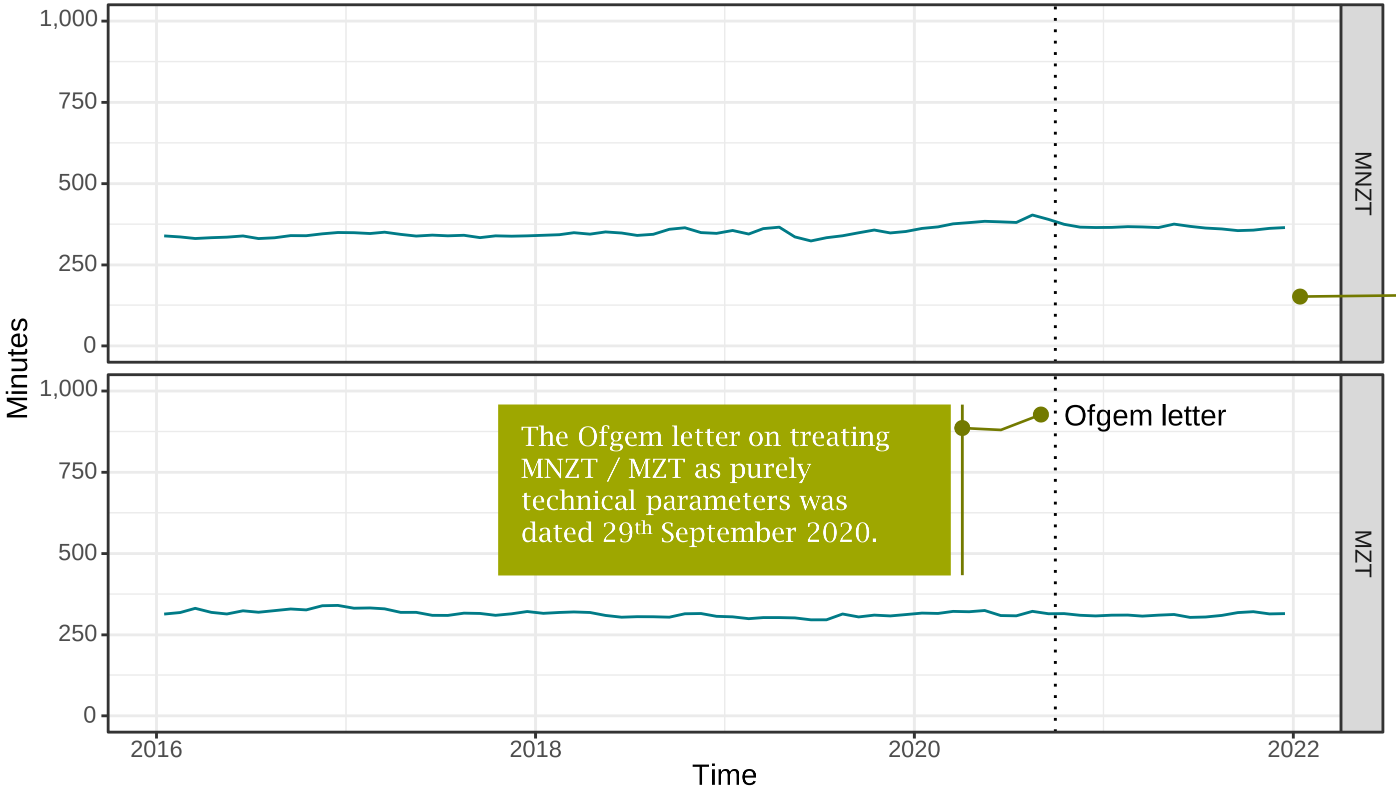
The increase in this behaviour when combined with dynamic parameters has contributed to increased costs, but it may simply reflect wholesale market behaviour.

Methodology: Settlement periods 21-27 (inc) defined as mid day, settlement periods 33-40 (inc) defined as evening peak. An attempted DD classed as average load factor (LF) of PN over morning > 30%, average LF of PN over evening peak <5%, residual demand (Demand – Nuclear availability – Wind forecast) over peak > residual demand over mid day + 500MW. Successful DD when attempted DD has accepted offers over evening peak.

THE AVERAGE LEVELS OF CCGT MZT AND MNZT SEEN DURING THE REVIEW PERIOD ARE BROADLY IN LINE WITH HISTORIC VALUES

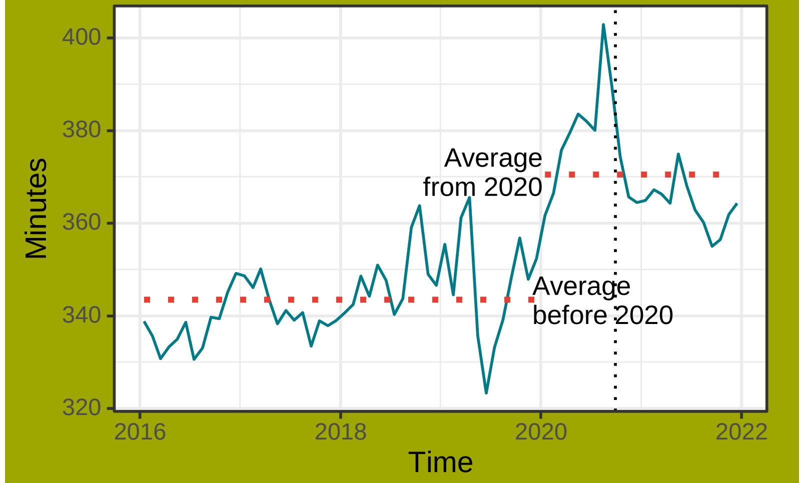
THERE HAS BEEN RELATIVE STABILITY IN THE LEVEL OF MNZT AND MZT HISTORICALLY AT AROUND 5-6 HOURS. THE AVERAGE LEVEL OF MNZT DID SEEM TO HAVE BEEN INCREASING PRIOR TO OFGEM'S LETTER OF 29TH SEPTEMBER 2020. IT SUBSEQUENTLY CAME BACK DOWN AGAIN, TO SETTLE AT A SLIGHTLY HIGHER LEVEL

Mean (weighted by MEL) MNZT and MZT values for CCGTs



Recent increase in MNZT

Mean (Weighted MEL) MNZT for CCGTs



By limiting the range of the MNZT plot, its increase over time is more apparent. To illustrate the step change that occurred across 2020, we show the average monthly mean weighted MEL before 2020 and from 2020.

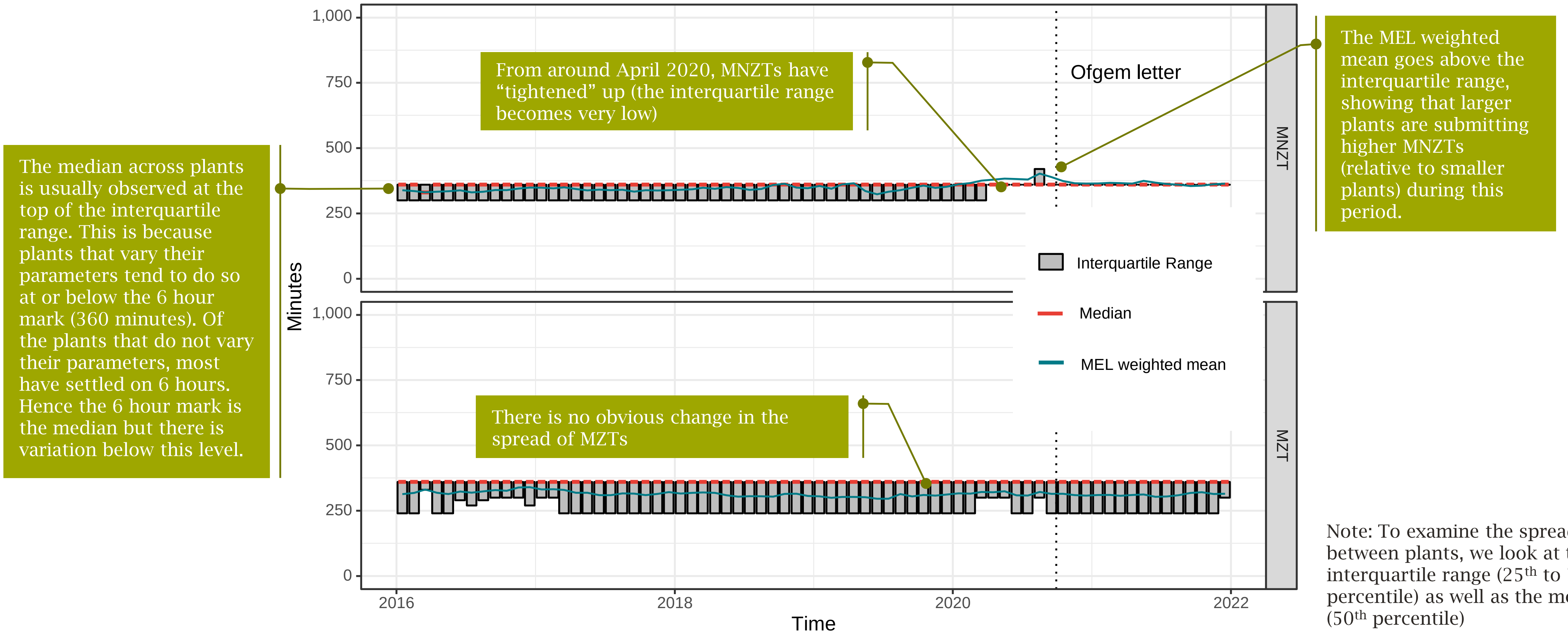
Note: Mean weighted MEL - this is the weighted average across each half hour in a given month where MEL is greater than zero. Weighting by the MEL allows a representation of the average MNZT / MZT per MW.

Note: We have removed offers of 999 minutes for MZT and MNZT. A parameter value of 999 minutes is likely not an actual minimum on or off time, rather it represents a unit indicating that it cannot be turned on or off (and so puts in the maximum time allowed for by the interface).

LOOKING AT THE SPREAD AROUND THE AVERAGE, WE DO SEE A CHANGE: THE SPREAD IN MNZTS HAS LARGELY DISAPPEARED SINCE APRIL 2020

3

LOOKING AT INDIVIDUAL MNZT SUBMISSIONS, IT IS APPARENT THAT THERE WAS A STRUCTURAL SHIFT FROM ABOUT APRIL 2020, WITH THE INTERQUARTILE RANGE OF SUBMISSIONS COLLAPSING. THIS BROADLY COINCIDED WITH LARGER PLANT DECLARING SLIGHTLY HIGHER MNZT VALUES THAN THEY HAD HISTORICALLY.



Note: To examine the spread between plants, we look at the interquartile range (25th to 75th percentile) as well as the median (50th percentile)

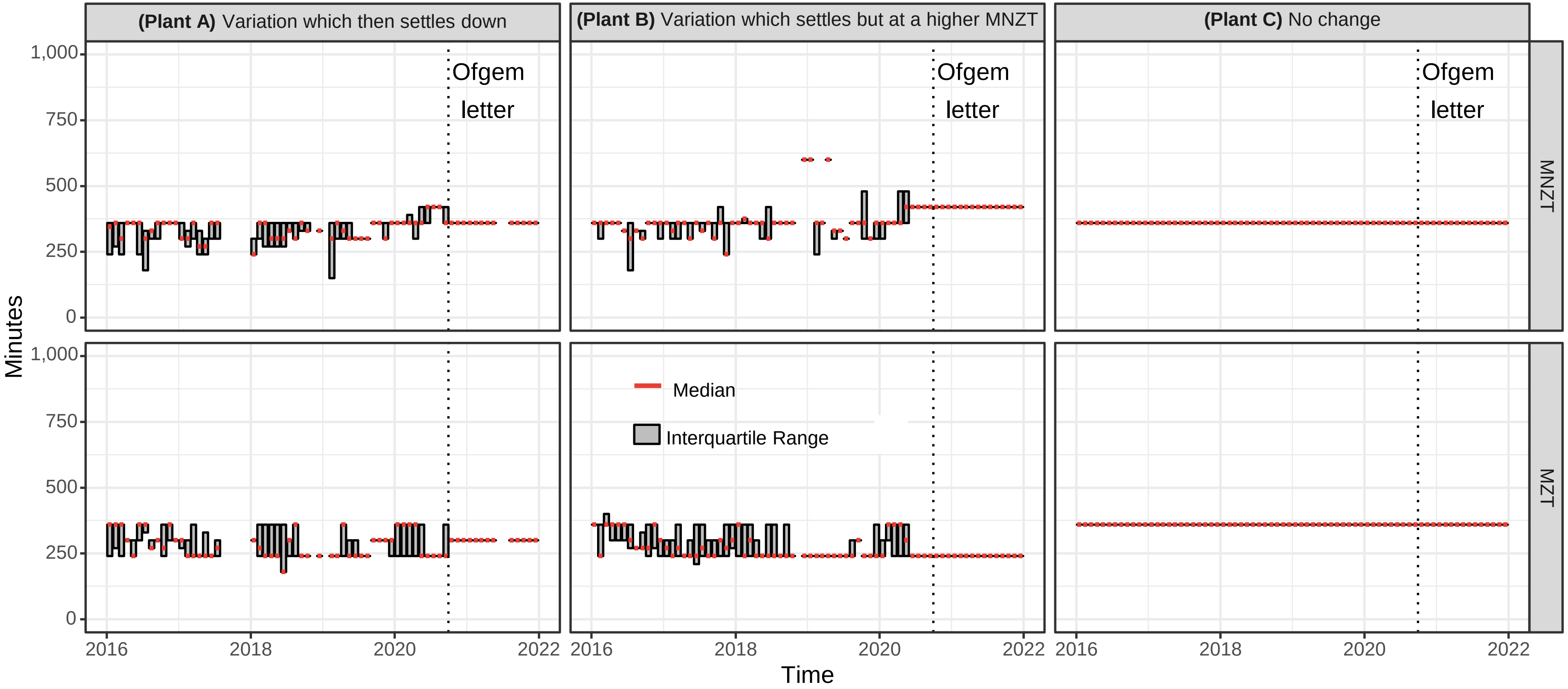
Note: We have removed offers of 999 minutes for MZT and MNZT. A parameter value of 999 minutes is likely not an actual minimum on or off time, rather it represents a unit indicating that it cannot be turned on or off (and so puts in the maximum time allowed for by the interface).

AND AT THE INDIVIDUAL PLANT LEVEL WE OBSERVE DIFFERENT APPROACHES TO THE SUBMISSION OF MNZT AND MZT OVER TIME

3

LOOKING AT INDIVIDUAL PLANTS, WE OBSERVE SOME HISTORICAL VARIATION OF MNZT / MZTs WHICH THEN TIGHTEN UP TO SINGLE VALUES DURING 2020. THE TIMING OF THE CHANGE IN BEHAVIOUR VARIED BY PLANTS, BUT FOR SOME MAY BE LINKED TO THE OFGEM LETTER ON TECHNICAL PARAMETERS

Plant archetypes of historic MNZT and MZT submissions



At the plant level, we observe a number of different behaviours that we have illustrated using real but anonymised data:

- **Plant A** saw historic variation in both parameters, but following Ofgem's letter has settled at a single value broadly within its historic range
- **Plant B** – saw historic variation in both parameters, but shortly before Ofgem's letter settled at a higher single value of MNZT
- **Plant C** – saw no variation in the parameters pre- and post Ofgem's letter.

Note: We have removed offers of 999 minutes for MZT and MNZT. A parameter value of 999 minutes is likely not an actual minimum on or off time, rather it represents a unit indicating that it cannot be turned on or off (and so puts in the maximum time allowed for by the interface).

THERE REMAINS A QUESTION AS TO WHETHER THESE PARAMETERS ARE BEING INTERPRETED TECHNICALLY

3

HISTORIC VARIATION OF THESE PARAMETERS SUGGESTS THEY WERE MORE LIKELY BEING USED TO MANAGE RISKS AROUND THE RECOVERY OF COSTS ASSOCIATED WITH A FULL GENERATION CYCLE, RATHER THAN REPRESENTING A PURE TECHNICAL MINIMUM

OBSERVED TRENDS IN DYNAMIC PARAMETERS

- Historically, there has been relative consistency in the average values of MNZT and MZT. However, there have been differences in submissions between plants and differences in submissions over time for individual plants.
- Since 2020, MNZT values appear to have largely settled around a constant value (6 hours) across plants but MZT values continue to vary between plants (though some individual plants have settled around a constant value)

IMPLICATIONS FOR COSTS

- The small increase in average MNZT relative to history is likely only to have had a minor impact on costs during the 10 days

IMPLICATIONS FOR INTERPRETATION OF PARAMETERS BY GENERATORS

- Given the level and historic variation in these parameters for individual plants, the parameters may not have been set to reflect true technical minimum on and off times.
- This may not be surprising. Costs of starting and ramping over a generation cycle may be a more direct driver of non-variable cost than the length of time the plant is on or off. Changes in these parameters may therefore reflect changes in planned recovery of start and ramping costs over a generation cycle, rather than the fundamental MZT/MNZT of the plant.
- In light of Ofgem's letter, participants may now be avoiding change to these parameters.
- The consistency of this approach with the parameters being set in line with the operating / technical characteristics of the plant (for example over a typical generation cycle) remains an open question.

SUMMARY OF KEY MESSAGES FROM ANALYSIS

3

HOW DO THESE 10 DAYS COMPARE TO (RECENT) HISTORY?

- Late 2021 saw a cluster of days with tight system conditions. Similar conditions, in terms of tightness, were observed in late 2020 and 2021
- There was some similarity in bidding behaviour in late 2020/early 2021 with that on the high cost days. But the key driver of high balancing costs in late 2021 has been the greater consistency with which some coal and CCGT plants offered into the BM up to levels around £4,000/MWh on very tight days.
- We identified the profile of PNs as an important driver of costs on the high cost days.
  - The relevant PN profile driving cost in the high cost days (positive in the middle of day and zero over the evening) is not new behaviour and does not always result in offers being accepted. But it was more frequent in Autumn 2021
  - The increase in this behaviour when combined with dynamic parameters has contributed to increased costs, but it may simply reflect wholesale market behaviour.
- We also identified the importance of the values of MNZT and MZT as cost drivers
  - The average values of MNZT and MZT observed are broadly consistent with those seen historically – a material change in the average level does not appear to be a driver of costs on the high cost days
  - the level and variability of historical values of dynamic parameters for individual plants suggests that they may not have been set to reflect absolute technical minimum on and off times
  - this could be consistent with them being set on a technical basis (i.e. to recover associated with the operating characteristics of a plant over a generation cycle)
  - since Ofgem's letter, for numerous plants, values for MNZT appear to have stabilised at a level above the lowest levels seen historically (at least for some plants)
  - the consistency of this behaviour with Ofgem's guidance remains an open question

5

EVIDENCE OF BEHAVIOUR INCONSISTENT WITH RULES

BASED ON THE INFORMATION AVAILABLE TO US, WE HAVE NO CLEAR EVIDENCE OF BEHAVIOUR INCONSISTENT WITH THE MARKET RULES

DYNAMIC PARAMETERS

- Ofgem's guidance states plant should **judge dynamic parameters technically rather than commercially.** We do not have the evidence to judge the basis on which generators have historically applied these parameters.
- The analysis suggests that key parameters (MNZT, MZT) may not be being set to pure technical minimums.
- But given the need to recover some non-variable costs over a generation cycle, there remains an open question as to the extent to which this behaviour can be considered inconsistent with Ofgem's guidance

PHYSICAL AVAILABILITY

- **Movements in PNs** during high cost days do contribute to high balancing costs.
- This is consistent with the rules provided PNs reflect updated expectations of output and contracted position.
- We do not have evidence to judge if movements were inconsistent with this.

PRICING (BID-OFFERS)

- The rules do not place any restrictions on the level of bid and offer prices.
- We note that rational behaviour in a pay as bid market would entail:
  - participants increasing offers up to their expectations of the marginal accepted offer
  - in periods of scarcity, participants increasing offers potentially to VoLL

6

FEEDBACK FROM STAKEHOLDERS

STAKEHOLDER ENGAGEMENT HAS BEEN A KEY PART OF THE BM REVIEW

THE STAKEHOLDER PROCESS WAS FACILITATED AND LED BY CORNWALL INSIGHT THROUGH THE FOLLOWING STAGES

01 LAUNCH WEBINAR

A launch webinar open to all interested stakeholders was hosted on 9 February 2022, with 135 individually identified attendees.

During the event 52 queries were raised.

02 PRELIMINARY FINDINGS WEBINAR

A webinar was hosted on 29 March 2022 with 155 identified attendees.

Frontier Economics and LCP presented preliminary findings, with feedback from stakeholders during the session. It was recorded and circulated via email to registered parties following the meeting.

03 QUESTIONNAIRE

A questionnaire was sent to test stakeholders' views on the preliminary findings.

The questionnaire was open between 5-22 April 2022 and received 7 responses.

04 ROUND TABLES AND BILATERAL ENGAGEMENT

Seven sessions took place between 5-19 April 2022, lasting between 30-90 minutes. There were 27 participants from 19 organisations, with parties grouped by theme.

Some parties undertook bilateral engagement, rather than joining a group in a round table discussion.

SUMMARY OF STAKEHOLDER FEEDBACK

THESE COMMENTS RECEIVED BROAD SUPPORT AMONG STAKEHOLDERS, ALTHOUGH SOME STAKEHOLDERS MAY STILL HOLD DIFFERENT VIEWS

VERY FREQUENTLY EXPRESSED VIEWS

- The very high cost days are likely to continue and are not expected to stop when coal generation is forecast to end.
- The initial findings captured at least some of the drivers believed to be behind the very high costs days.
- The market is complex. There are many factors to balance. ESO's task is difficult. There is no easy fix.
- A knee jerk reaction could be harmful, leading to negative unintended consequences. Although there was some support for speedier change if it would better protect consumers ahead of the upcoming Winter period.

RECURRING THEMES WITH BROAD SUPPORT

- Parties are acting rationally according to their incentives, likely within the rules of the marketplace.
- ESO decision making isn't as transparent as it could be, which might affect confidence and engagement with the market.
- More flexible assets believe they have been skipped and don't always know why.
- Scarcity pricing has a role in a well-functioning market.
- It is reasonable to see relatively higher pricing for warming coal, due to the costs associated with these and other thermal assets.
- There is discomfort around some parties' behaviours with PNs. There is an appetite for Ofgem to be seen to take more definite steps in these cases and more generally, in order to shore up confidence that potential wrongdoing is investigated and innocent parties exonerated.
- ESO's system limitations have been explored as part of BSC Issue 098, and therefore proposing solutions around more complex bid-offer options would be unlikely to resolve anything in the short to medium term.

SUMMARY OF STAKEHOLDER FEEDBACK

OTHER VIEWS WERE EXPRESSED ON SEVERAL OCCASIONS, BUT NOT OFTEN ENOUGH TO GAUGE THE STRENGTH OF FEELING AMONG OTHER STAKEHOLDERS

RECURRING THEMES NOT TESTED WIDELY WITH STAKEHOLDERS

- Batteries and other more flexible assets are being skipped in the merit order, possibly due to resource or system constraints at the ESO, rather than for economic or security reasons.
- Smaller and more flexible assets firmly believe they could have provided more proportionate and cost-effective services on the very high cost days than the thermal generation that was called upon.
- The Capacity Market could be doing more lifting in terms of reducing the level of scarcity seen.
- Reserve needs could be analysed. ESO could seek powers to take action sooner, potentially in advance of gate closure or at the Day Ahead stage.
- If the BM is too difficult to engage with, then smaller/more flexible assets won't bother with it and will instead seek other revenue streams – such as NIV Chasing, which could impact consumer pricing in other ways.
- Stress placed on assets characterised as less flexible - especially thermal generation – should be acknowledged, and that response limitations may be due to the technical characteristics of a plant, rather than be purely a result of strategy.
- One party noted their experience in the north eastern United States (the PJM market), where the technical characteristics of plants were explored and regulated.
- Limitations of ESO forecasting during the very high cost days should be acknowledged more prominently in the report (compared to the provisional findings).

SUMMARY OF STAKEHOLDER FEEDBACK

OTHER VIEWS WERE EXPRESSED ON SEVERAL OCCASIONS, BUT NOT OFTEN ENOUGH TO GAUGE THE STRENGTH OF FEELING AMONG OTHER STAKEHOLDERS

RECURRING THEMES, NOT TESTED WIDELY WITH STAKEHOLDERS

- The Grid Code should contain all the applicable rules in order to aid transparency. Some parties perceived there were ‘unwritten rules’ in the control room. A single place repository for all BM rules and policy would help ensure that there is no requirement for BM parties to respond to the ‘spirit’ of the rules, only the letter of them.
- Aggregated assets could deliver the response needed, but will not be called on due to ESO system limitations.
- Supply side changes could help (demand, PNs, greater liquidity in the wholesale market), but is not seen as a route to substantial relief.
- The average bill payer/ customer likely cares most about pricing and the impact on the bill. However, very high cost days, and other drivers of charges, should be justifiable and ultimately feel fair.
- Retail and supply side parties note the inability to hedge against volatility. This adds additional strain to suppliers (and the risk of SoLR events).

FOLLOWING OUR INITIAL FINDINGS, WE HAVE UPDATED OUR ANALYSIS TO REFLECT STAKEHOLDER COMMENTS (1)

Stakeholder comments

ASSESSMENT OF EVIDENCE BEYOND THE BALANCING MARKET

- There was some concern that other factors beyond the BM were also important to consider, such as the interaction between the BM and the wholesale market and STOR market.
- It was noted that ESO was not purchasing its full reserve requirement in the STOR auctions and that this may have contributed to the high costs in the BM.

ANALYSIS OF ESO FORECASTING

- There were several comments on the limitations of ESO forecasting during the very high cost days.

Further analysis undertaken

INTRADAY MARKET

As noted in the initial findings report, we have now included further analysis of ID market data to better understand the interactions between ID and BM prices. (Slides 25-27, 29, 30, 38)

SHORT-TERM OPERATING RESERVE (STOR)

We have analysed STOR auction data on the ten high cost days. (Slides 40-42)

ESO FORECASTING

We have assessed if there is potential improvement by ESO on wind and demand forecasting. (Slides 35-39)

FOLLOWING OUR INITIAL FINDINGS, WE HAVE UPDATED OUR ANALYSIS TO REFLECT STAKEHOLDER COMMENTS (2)

Stakeholder comments

FURTHER ANALYSIS OF DYNAMIC PARAMETERS AND PNs

- There was a request to understand the historical behaviour related to submissions of PNs and dynamic parameters (in particular, MNZT and MZT), in order to understand if the particular patterns and levels identified as important contributors to high costs were new behaviours in Autumn 2021.

ASSESSMENT OF POLICY OPTIONS

- Overall there is a view that high costs in the BM will continue, though mixed views on whether there is a problem to solve.
- Some stakeholders have proposed policy options that could address high costs in the BM - some were directly related to the BM rules and functioning, and others had a broader scope.

Further analysis undertaken

HISTORICAL PATTERNS OF DYNAMIC PARAMETERS (MNZT AND MZT)

We have extended our analysis of submissions of MNZT and MZT parameters back to 2016. (Slides 48-52)

We have also included an illustration of the potential impact on costs of different levels of MZT parameters. (Slide 32)

HISTORICAL ANALYSIS OF PN PROFILES DURING THE DAY

We have analysed if the particular profile of positive PNs in the morning and zero PNs during the afternoon and peak was adopted before 2021. (Slide 31)

POLICY OPTIONS

We have set out a set of options which were identified due to the analysis and also included additional ones identified by stakeholders. For each, we have considered the high-level pros and cons and their potential impact on high costs in future. (Slides 65-75)

7

THE CASE FOR INTERVENTION

THE ANALYSIS AND EVIDENCE PRESENTED SUGGESTS THERE IS A CASE FOR CONSIDERING POTENTIAL REFORMS…

THIS DOES NOT APPEAR TO BE A TEMPORARY PHENOMENON

- No evidence to suggest system will become less tight in future - future de-rated margins will continue to be set by reliability standard of 3 hours of LOLE.
- Significant volumes of large inflexible capacity (CCGTs) will remain on the system.
- No evidence to suggest plant are likely to change their bidding behaviour in the future.
- There was a clear view from stakeholders that this is not temporary.

WE HAVE IDENTIFIED FOUR DRIVERS OF HIGH COSTS

- Period of increased **scarcity**
- **Bidding behaviour** – high offers from coal and CCGT plants
- **ESO behaviour** – scope for improved forecasting and under-procurement of reserve
- **Bidding rules** – the way technical characteristics of plants are expressed in commercial bids

IT IS REASONABLE TO CONSIDER POTENTIAL CHANGES TARGETED AT THESE DRIVERS

- While there is not a clear view from stakeholders that there is a case for reform, given the costs involved we think the evidence suggests further investigation of options is merited.
- We consider potential market reforms that could address each of these four key factors.
- Some of the potential reforms could be implemented quickly (short-term) and others are longer-term.

Alongside any potential reform, while we have not identified evidence of behaviour inconsistent with the rules, we do not have the information to definitively confirm this is the case. In addition, we have not considered issues related to REMIT or competition law. It is therefore for Ofgem or any other relevant regulatory authorities to consider whether there is also a need for further investigation.

SOME STAKEHOLDERS HAVE SUGGESTED THAT THE BM IS FUNCTIONING PROPERLY AND THAT NO INTERVENTION IS NEEDED

BEFORE CONSIDERING THE POTENTIAL OPTIONS, WE SUMMARISE THE IMPACTS OF REMAINING WITH THE STATUS QUO, IN PARTICULAR CONSIDERING THE IMPLICATIONS FOR INVESTMENT SIGNALS

MEASURE	DESCRIPTION	RATIONALE / PROBLEM IDENTIFIED	HIGH-LEVEL ASSESSMENT	POTENTIAL IMPACT ON HIGH COST DAYS

CONTINUE WITH STATUS QUO	▪ Do not implement any measures either in the balancing market or other markets in direct response to the high cost days.	▪ Some stakeholders expressed the view that the market is operating as intended and that no problem has been proved.
		▪ High prices are evidence of scarcity pricing, which has an important economic function as an investment signal.
		▪ Intervention could result in unintended consequences that weaken this signal
			▪ Scarcity prices provide incremental revenue in periods of system tightness. In theory, this should provide a signal to invest in new capacity, in particular flexible capacity. Over time, if sufficient investments in flexible capacity take place, this may reduce dependence on large inflexible capacity on the high cost days, reducing overall costs.
			▪ It also avoids potentially distortionary options with unintended consequences.
			▪ However, continuation with the status quo raises the following concerns / issues:
			  ▪ Without intervention, periods of high costs driven by scarcity are likely to happen again. High costs days will continue to be driven by large inflexible assets for some time – given large volumes of CCGTs will remain on the system.
			  ▪ Current approach to bidding limits may be limiting options available to the ESO to secure the system at least cost.
			  ▪ Flexible assets unable to fully benefit from scarcity prices on these high cost days due to large inflexible assets being accepted ahead of lower priced flexible options.
				No impact short-term, though capacity mix may evolve slowly leading to reduced reliance on large inflexible capacity on very tight days in medium to long-term.

THERE IS A RANGE OF SHORT AND LONGER TERM OPTIONS WHICH ADDRESS THE KEY COST DRIVERS IDENTIFIED IN THE REVIEW

OPTIONS HAVE BEEN RAISED BY THE ANALYSIS AND SUGGESTED THROUGH CONVERSATIONS WITH STAKEHOLDERS AND ESO

SHORT-TERM REFORMS

ESO behaviour

- **Forecasting improvements** – address systematic under-forecasting of wind and over-forecasting of demand on tight days
- **STOR price cap** – adjust price cap methodology to increase likelihood of meeting target
- **Clarify operating principles**

Bidding behaviour

- **Bidding code of practice / Licence condition** – codify bidding behaviour
- **Enhanced market monitoring** - actively seek justifications of offers/parameters under a greater set of situations – e.g. could require original certification proof of MZT/MNZT
- **BM offer caps** – capping of extreme offer prices
- **Reduced information disclosures**

LONGER-TERM REFORMS

Scarcity

- **Procure more capacity in CM** - target a LOLE < 3 hours in the CM, review Least Worst Regrets methodology for setting CM capacity to procure. (This can be changed quickly but its impacts will take time to come through)

Bidding behaviour

- **Adjust ancillary service contracts (i.e. STOR)** – design contracts to constrain utilisation costs, or more forward trading
- **Reliability option CM** – implement changes which could require agreement holders to pay back at BM prices above a strike price (set administratively).

Bidding rules

- **BM bid structure options** – change way in which bidders communicate inflexibilities
  - **Complex pricing** – offers include multiple elements (e.g. start costs (cold, warm, hot start £/kW), prices (£/MWh) etc.)
  - **Menu of prices** – offers reflect different combinations of dynamic parameters and prices.
  - **Simple BM pricing** – remove dynamic parameters i.e. offers for each hour reflect their marginal cost of power, start costs, costs resulting from fast return to production, etc.

ANY POTENTIAL OPTIONS WOULD NEED TO BE DEVELOPED FURTHER AND THEN ASSESSED IN MORE DETAIL BEFORE CONSIDERING MORE SERIOUSLY, IN PARTICULAR TO CONSIDER THEIR INCENTIVE EFFECTS AND THE RISK OF UNINTENDED CONSEQUENCES. OPTION DEVELOPMENT WOULD LIKELY BE CARRIED OUT ALONGSIDE BEIS, OFGEM AND THE BROADER INDUSTRY

SHORTER-TERM OPTIONS FOR REFORM – ESO BEHAVIOUR

WHILE THE IMPACT ON HIGH COST DAYS IS QUITE UNCERTAIN AND MAY BE LIMITED, THERE IS MERIT IN ESO CONTINUING TO REVIEW ITS FORECASTING AND STOR PROCUREMENT METHODOLOGIES

MEASURE	DESCRIPTION	RATIONALE / PROBLEM IDENTIFIED	HIGH-LEVEL ASSESSMENT	POTENTIAL IMPACT ON HIGH COST DAYS
FORECASTING IMPROVEMENTS	▪ Review forecasting methodology to ensure that ESO forecasts are maintained at the frontier of forecasting best practice. ▪ In doing so, identify options to address systematic under-forecasting of wind and over-forecasting of demand on tight days	▪ In the 10 high cost days wind outturn was higher than forecast, and demand lower than expected. As a result, ESO may have perceived a greater need to accept expensive inflexible offers than would have been the case with better forecasting. ▪ ESO dispatch decisions partly depend on national demand forecasts that cannot incorporate price response (Operating Code NO.1)	▪ The analysis shows lower priced options were available for ESO on tight days. However, ESO ability to capture the full value of these would depend on a range of factors, including perfect foresight. ▪ While perfect foresight is unrealistic, forecasting improvements on tight days has potential to allow ESO to capture some of the potential cost reductions by avoiding locking in more inflexible capacity than is necessary. ▪ The omission of price responsive demand in ESO forecasting may have contributed to over-contracting of inflexible capacity.	The size of the forecast errors identified could have a material effect on costs. However, the extent to which there is scope for improvement is unclear, though any review should include any restrictions placed on forecasting methodology by the Grid Code.
STOR PRICE CAP	▪ Assess whether the new methodology (implemented since Jan 2022) that sets the ESO willingness to pay (i.e. price cap) is more accurately taking into account the opportunity cost of participation in STOR by market participants in the peak hours of the day	▪ Late in 2021, ESO regularly failed to purchase STOR target capacity, in part due to presence of a price cap, leading to a shortfall in STOR capacity. ▪ A new methodology was put in place at the beginning of 2022 which appears to have reduced frequency of under-procurement.	▪ We believe it is unlikely that under-procurement of STOR fundamentally affected available capacity to the overall system on the tight days i.e. tightness was not exacerbated by shortage of STOR capacity. However, it may have been a further driver for the ESO to lock-in inflexible capacity early to ensure sufficient reserve would be available at peak ▪ Therefore ensuring the STOR target is met may help to reduce balancing costs marginally. ▪ Recent changes to the STOR pricing methodology appear to have reduced the frequency of under-procurement, though it does still occur and so should be kept under review.	Low – room for improvement likely to be more limited given recent changes

SHORTER-TERM OPTIONS FOR REFORM – ESO BEHAVIOUR (2)

ADDITIONAL CLARITY FROM THE ESO ON ITS OPERATING PRINCIPLES/PROCEDURES MAY SUPPORT THE FUNCTIONING OF THE BM, HOWEVER IT IS UNLIKELY TO DIRECTLY AFFECT THE HIGH COST DAYS

MEASURE	DESCRIPTION	RATIONALE / PROBLEM IDENTIFIED	HIGH-LEVEL ASSESSMENT	POTENTIAL IMPACT ON HIGH COST DAYS
FURTHER CLARIFICATION OF GUIDING PRINCIPLES OF ESO DECISION-MAKING	▪ Increase the simplicity of the Balancing Principles Statement and the Dispatch Transparency Methodology and assess whether all principles and rules that the control room follows for BM dispatch decisions are included.	▪ Stakeholders have identified a lack of understanding on why the ESO picks some units and reject others and claim that ESO documentation is complex and that ESO follows “unwritten” rules on its dispatch decisions.	▪ The publication by ESO of a simplified version of the Balancing Principles Statement and assessing whether all the principles behind ESO’s control room decision making on BM dispatch are written would increase transparency for market participants, and hence support investment in new flexible capacity that would be able to participate more effectively in the BM. ▪ However, while it may improve the functioning of the BM, it is unlikely to directly impact the key drivers of high costs identified in this review.	Low – but may help provide more clarity to market of cost drivers on high cost days

SHORTER-TERM OPTIONS FOR REFORM – BIDDING BEHAVIOUR (1)

INTERVENTIONS TO CHANGE BIDDING BEHAVIOUR HAVE THE POTENTIAL TO HAVE A HIGH IMPACT – HOWEVER, THE GREATER THE IMPACT, THE GREATER THE RISK OF UNINTENDED CONSEQUENCES

MEASURE	DESCRIPTION	RATIONALE / PROBLEM IDENTIFIED	HIGH-LEVEL ASSESSMENT	POTENTIAL IMPACT ON HIGH COST DAYS
BM OFFER CAPS	▪ Administrative limits on very high offers. Impact will depend on the level of any cap, but it could be set to only cap the most extreme offer prices.	▪ There is currently no limit on offers in the BM. Imbalance prices are capped at £6,000/MWh (Value of lost load "VoLL"), and demand reduction may be favoured ahead of offers above this level.	▪ On the one hand, it reduces offer costs on expensive days (depending on level of cap), and the impact on investment may be limited if expectations of such high prices do not feed into investment decisions in capacity market. ▪ On the other hand, it could weaken effects of scarcity pricing if set below VoLL, with potential knock-on implications for investment/cost of capacity market if expectation of scarcity prices is currently reflected in lower CM bids. It also potentially tilts investment away from flexible capacity who are more reliant on price spikes. ▪ It may weaken investor confidence more generally in market.	High potential impact in short-term, though risk of knock-on implications elsewhere

BIDDING COP/LICENCE CONDITION	▪ Codify "acceptable" bidding behaviour further e.g. through a code of practice or licence condition enforced by Ofgem (similar to Transmission Constraint Licence Condition).	▪ Uncertainty persists among market participants regarding exact interpretation of some aspects of rules, e.g. GIP and Ofgem letter leave some room for ambiguity.
		▪ There is currently no limit on offers in the BM.
			▪ Depends on the approach:
			  ▪ If measure provides clarity on rules beyond GIP and REMIT, then this may bring more confidence to the market that rules are being followed and limit "abusive behaviour" (although we have not identified evidence of behaviour inconsistent with the rules).
			  ▪ If measure more deterministic e.g. constraining bids to a plant's marginal cost, then implications could be more significant, akin to a lower price cap (above).
				Medium to high depending on how prescriptive code is, though higher prescription has increased potential for knock-on impacts elsewhere

SHORTER-TERM OPTIONS FOR REFORM – BIDDING BEHAVIOUR (2)

A "SOFTER" MEASURE SUCH AS ENHANCED MARKET MONITORING COULD BE IMPLEMENTED IN THE SHORT TERM, THOUGH ITS IMPACT IS UNCERTAIN. FOR EXAMPLE, IF USED TO ENFORCE TECHNICAL MINIMUMS OF MNZT AND MZT ITS IMPACT COULD BE LARGE, THOUGH IT WOULD DEPEND ON THE SCALE OF ANY RESULTING CHANGES TO OFFER PRICES.

MEASURE	DESCRIPTION	RATIONALE / PROBLEM IDENTIFIED	HIGH-LEVEL ASSESSMENT	POTENTIAL IMPACT ON HIGH COST DAYS
ENHANCED MARKET MONITORING	▪ Actively seek justifications of offers/parameters under a greater set of situations – e.g. could require proof of MZT/MNZT	▪ There is no information available to ESO on an ongoing basis to judge pure technical basis of dynamic parameters	▪ Measure may reduce behaviour inconsistent with the rules. However, we have not identified clear evidence that such behaviour existed. ▪ If the measure resulted in submission of MNZT and MZT at lower levels than currently submitted this could in theory result in reduced costs. However, if parameters are linked to cost recovery over generation cycle, a reduction in this parameter may see increases (e.g. offer prices) elsewhere. ▪ Clarity over interpretation of rules and enhanced monitoring could provide greater confidence to the market that markets are operating fairly and that BM costs are being minimised in line with the rules. ▪ Potential for additional admin burden for market participants.	Potential cost reductions if MNZT and MZT are enforced at lower values, however, impacts likely to be dependent on scale of any resultant changes to offer prices.
REDUCED INFORMATION DISCLOSURES	▪ Limit the publication of market information closer to real-time.	▪ The publication of de-rated margins and coal warming instructions close to real-time could in theory facilitate bidding behaviour that leads to an increase in BM costs.	▪ ESO data may provide clear signal of scarcity to market leading to scarcity pricing. However, in reality market participants will be using range of other information to inform decisions so explicit impact of ESO publications may be limited. ▪ Reducing ESO information disclosures may risk capacity not coming forward when really needed creating a security of supply risk. ▪ It may also be perceived as a decrease in transparency.	ESO disclosures unlikely to be key driver of scarcity prices therefore impact likely to be low. May also create security of supply risk.

LONGER-TERM OPTIONS FOR REFORM: BIDDING RULES

THE CURRENT SYSTEM LIMITS FLEXIBILITY TO MINIMISE SYSTEM COSTS BY LIMITING THE WAYS IN WHICH THE TRUE CAPABILITY OF PLANTS CAN BE EXPRESSED I.E. BY USING MZT AND MNZT AND A SINGLE PRICE /MWH – BELOW WE HAVE IDENTIFIED THREE ALTERNATIVE APPROACHES FOR SUBMITTING BM BIDS AND OFFERS

DISAGGREGATED (COMPLEX) PRICING

- Offers reflect the underlying cost drivers of the plant output, including for example:
  - start costs (cold, warm, hot start £/kW) reflecting time since last on
  - cost to run at SEL (£/MWh), and
  - cost to run up to MEL (£/MWh)
- ESO then selects offers that minimise overall system costs

MENU OF PRICES

- Plants offer prices for different combinations of dynamic parameters and prices e.g.
  - Price at SEL for 1 hour (£/MWh) with costs to run up to MEL (also reflecting time since last on)
  - Price for SEL for 2 hours (£/MWh)…
  - …
  - Price at SEL for 6 hours (£/MWh)…
- Market participants build up menu offers from underlying costs, and ESO then optimises from menu of options

SIMPLE PRICING

- Remove dynamic parameters such that ESO can choose offers in cost order for each half-hour
- Market participants internalise the implications of their own technical characteristics into their bids (i.e. in a similar way to day ahead and intraday markets) so that all incremental costs (including start costs) are recovered over the course of a running cycle.
  - For example, generator with positive PN in the morning (and MZT of 6 hours) keen to capture peak prices in the evening, would need to offer power in ID market or BM at prices to ensure they are operating at SEL ahead of the evening peak, and therefore could be selected by ESO.

Increasing responsibility (and risk) on generators to internalise the recovery of their underlying costs into bids and offers

Each option allows full flexibility to optimise the dispatch of plants based on the underlying costs of the plants – the key difference is which party takes on the responsibility (and risk) of reflecting these in prices and dispatch.

LONGER-TERM OPTIONS: THERE APPEARS TO BE MERIT IN CONSIDERING REFORMS TO THE BID RULES

ANALYSIS OF HIGH COST DAYS MOTIVATES BROADER CONSIDERATION OF ALTERNATIVE OPTIONS THAT ENABLE A MORE FLEXIBLE APPROACH TO THE TREATMENT OF PLANT TECHNICAL CHARACTERISTICS

<table>
<tr><th>MEASURE</th><th>RATIONALE / PROBLEM IDENTIFIED</th><th>ASSESSMENT</th><th>POTENTIAL IMPACT ON HIGH COST DAYS</th></tr>
<tr><td>DISAGGREGATED (COMPLEX) PRICING</td><td rowspan="3">▪ The current system limits flexibility for the ESO to minimise system costs by limiting the ways in which the true capability of plants can be expressed i.e. by using MZT and MNZT and a single price /MWh
▪ Dynamic parameters may be used as tool for cost recovery over generation cycle, creating ambiguity over whether they are being used technically or commercially.</td><td rowspan="2">▪ Greater optionality/flexibility for ESO to minimise system costs i.e. it can trade-off shorter and longer run times taking into account clearly expressed costs.
▪ It will be easier for ESO to see the value of waiting i.e. choosing not to dispatch inflexible plants early may not remove the option for later (though prices and costs will vary).
▪ Complex IT system/algorithm required – significant development relative to today.
▪ Potential for reduced transparency of ESO decision making relative to today.
▪ Easier to monitor plant bids, as bid structure more closely reflects actual cost drivers. Removes debate about ‘technicality’ of dynamic parameters.
▪ Imbalance prices calculated through algorithm (may lack transparency and/or efficiency)</td><td rowspan="3">Unknown, although given role of inflexibility in multiplying cost, potential for high impacts. Further work is required</td></tr>
<tr><td>MENU OF PRICES</td></tr>
<tr><td>SIMPLE BM PRICING</td><td>▪ Simpler dispatch decisions by ESO, as optimisation of plants (taking into account full range of optionality given technical characteristics) internalised by plant owners i.e. system costs minimised and prices set by market participants.
▪ Greater transparency of ESO dispatch decisions, though impact of plant technical characteristics on overall costs is less clear.
▪ Bidding behaviour for market participants more complex, potentially creating new barriers to entry - though skills in line with ID markets.
▪ Current ESO IT system may already be able to accommodate this bidding approach.</td></tr>
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LONGER-TERM OPTIONS FOR REFORM: BIDDING BEHAVIOUR

THE IMPACT OF THESE OPTIONS ARE DIFFICULT TO DETERMINE, BUT RELIABILITY OPTIONS COULD BE CONSIDERED MORE BROADLY BY GOVERNMENT AS PART OF ITS ON-GOING REVIEW OF THE ELECTRICITY MARKET ARRANGEMENTS (REMA)

MEASURE	DESCRIPTION	RATIONALE / PROBLEM IDENTIFIED	ASSESSMENT	POTENTIAL IMPACT ON HIGH COST DAYS
ADJUST ANCILLARY SERVICES CONTRACTS	▪ Capacity contracted for reserve (e.g. STOR) would constrain the price providers offer in the BM.	▪ There is currently no limit on offers in the BM. Imbalance prices are capped at £6,000/MWh (Value of lost load "VoLL")	▪ Measure acts to lock-in the cost of some energy prior to real-time at prices below those that might arise on tight days. ▪ However, while this might reduce offer costs of flexible capacity contracted under STOR, this does not cover all capacity, and unlikely to affect the offers of less flexible coal plant and CCGTs which were the key drivers of high costs. ▪ The constraints may also affect pricing in the STOR market, and may potentially dampen imbalance prices.	Low as no impact on offers of inflexible plant
RELIABILITY OPTION CM	▪ Alternative CM contract which could require agreement holders to pay back at BM prices above a strike price (set administratively).	▪ There could be an argument that it is cheaper overall to pay more up front (i.e. in a higher capacity price) but then constrain BM revenues on tight days.	▪ This should reduce BM costs ▪ Net effect will depend on whether revenue from extreme price spikes is bankable and hence currently reduces CM offers. ▪ If it does, then net effect would have to take into account increased total CM costs. Since CM price paid to all contracted capacity, overall customer impact may be small or even negative	High – but with potential risks for other markets, and hence net customer cost increase

LONGER-TERM OPTIONS FOR REFORM: SCARCITY

A SIGNIFICANT AMOUNT OF STAKEHOLDER COMMENTS RELATED TO THE ROLE OF THE CAPACITY MARKET – THERE IS A QUESTION FOR GOVERNMENT TO CONSIDER REGARDING THE TIGHTNESS AT WHICH IT WISHES THE SYSTEM TO OPERATE, AND THE ESO TO CONSIDER REGARDING ITS METHODOLOGY FOR SETTING TARGET CM CAPACITY

MEASURE	DESCRIPTION	RATIONALE / PROBLEM IDENTIFIED	ASSESSMENT	POTENTIAL IMPACT ON HIGH COST DAYS
PROCURE MORE CAPACITY IN THE CM	▪ Procure more capacity in CM by: ▪ targeting a LOLE < 3 hours in the CM; ▪ factoring the risk of high BM costs more into the Least Worst Regrets methodology for setting CM capacity to procure.	▪ The analysis suggests that scarcity has played an important role in driving up BM costs, which could therefore be alleviated by more capacity	▪ There is a trade-off: ▪ On the one hand, procuring more capacity would reduce the system tightness and, as a result, reduce BM costs. ▪ On the other hand, capacity mechanism costs could rise due to more demand in the T-4 auction.	High – but risk of net customer cost increase

SUMMARY OF REFORM PRIORITIES

ESO BEHAVIOUR	▪ While the impact on high cost days is quite uncertain and may be limited, there is merit in ESO continuing to review its forecasting and STOR procurement methodologies.
BIDDING BEHAVIOUR	▪ In the shorter term: ▪ There may be merit in interventions to change bidding behaviour. They have the potential to have a high impact (and could be implemented quickly). However, if pursued, design needs to balance the scale of impact against the risk of unintended consequences (may imply preference for "code of practice" over caps) ▪ A "softer" measure such as enhanced market monitoring could be implemented in the short term, though its impact is uncertain. For example, if used to enforce technical minimums of MNZT and MZT its impact could be large, though it would depend on the scale of any resulting changes to offer prices. ▪ In the longer-term, there is merit in considering reliability options as part of government's on-going Review of the electricity market arrangements (REMA).
BIDDING RULES	▪ ESO should consider alternative bidding rules - analysis indicates inflexibility plays a key role, motivating broader consideration of alternative bidding rules that enable systems' physical flexibility to be more fully communicated to ESO.
SCARCITY	▪ Finally, there is a question for: ▪ Government to consider regarding the tightness at which it wishes the system to operate; and ▪ The ESO to consider regarding its methodology for setting target CM capacity.

8

ANNEX: MARKET RULES

WE HAVE FOCUSED ON OBLIGATIONS (“RULES”) WITHIN THE GRID CODE AND BALANCING AND SETTLEMENT CODE

FOCUS OF REVIEW

LICENCE TO GENERATE

Allows the licensee to generate electricity for the purpose of giving or enabling a supply to any premises

- The key requirement of relevance is for licensees to comply with the requirements of the Grid Code
- Limited specific rules of relevance

THE GRID CODE (GC)

Technical requirements for connecting to and using the National Electricity Transmission System (NETS)

- Balancing Code 1 – pre-gate closure process
- Balancing Code 2 – post gate closure process – including the accuracy of Physical Notifications (PNs)

All in accordance with the BSC

BALANCING AND SETTLEMENT CODE (BSC)

Rules for balancing mechanism submission and imbalance settlement

- Section Q – Rules for submitting Balancing Mechanism (BM) data.

THE KEY RULES ON BMU DATA AS WRITTEN

> **Good industry practice (GIP):** *The exercise of that degree of skill, diligence, prudence and foresight which would reasonably and ordinarily be expected from a skilled and experienced operator engaged in the same type of undertaking under the same or similar circumstances.*

DYNAMIC PARAMETERS

Dynamic Parameters shall reasonably reflect the expected **true operating characteristics** of the unit and shall be prepared in accordance with **GIP.**

GC BC1.4.2(e)

MAXIMUM EXPORT AND IMPORT LIMITS (MEL/MIL)

The maximum export (import) to (from) the Transmission System that a unit **wishes** to make available. These must be prepared in accordance with **GIP.**

GC BC1.4.2(c)

PHYSICAL NOTIFICATIONS (PN)

The **intended** input or output of active power.

GC BC1.A.1.1

They represent the users' **best estimate** of expected import/export, prepared in accordance with **GIP.**

GC BC1.4.2(a)

BID-OFFERS

A series of levels with bids (removing energy) and offers (adding energy)

GIP is <u>not</u> mentioned in connection with the preparation of bid-offers.

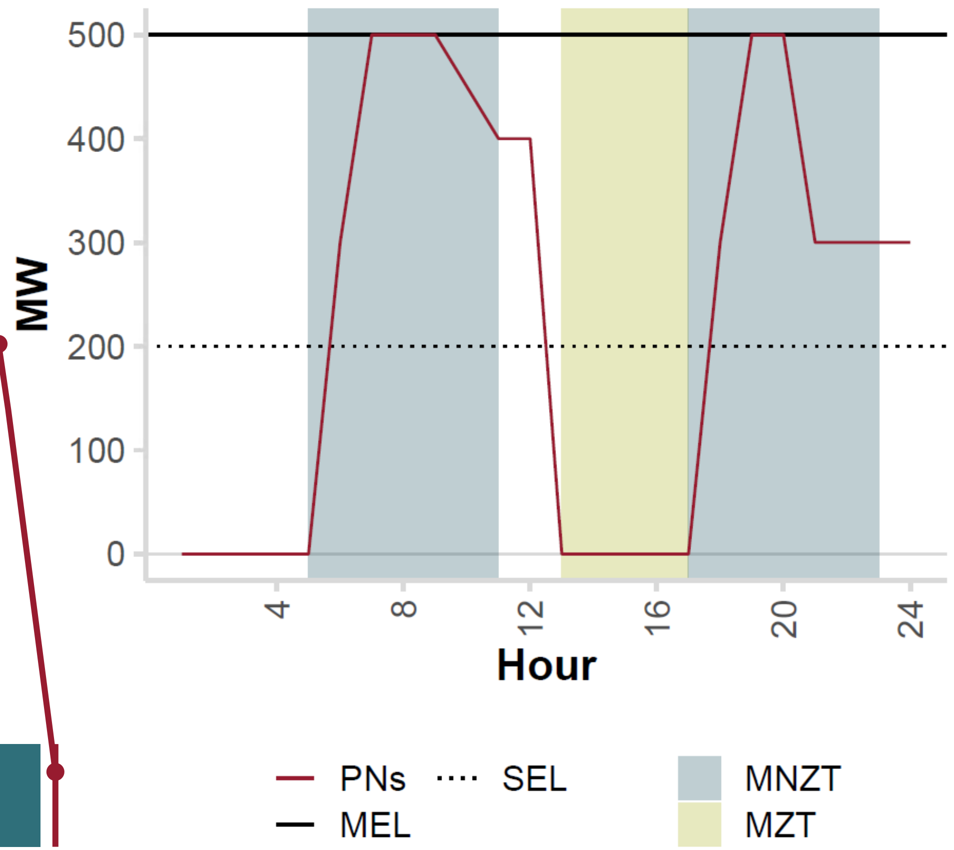
REASONABLE ENDEAVOURS SHOULD BE MADE TO ENSURE ALL DATA HELD BY ESO IS ACCURATE AT ALL TIMES (GC BC1.4.3)

SUMMARY OF DYNAMIC PARAMETERS

ITEM	NOTES
Run up and Run down Rates	Up to 3 each (broken line curve)
Notice to Deviate from Zero (NDZ)	Notification time **required** to start importing/exporting from a zero PN level (as a result of bid offer acceptance)
Notice to Deliver Offers (NTO) and Notice to Deliver Bids (NBO)	Notification time **required** to start delivering offers and bids from the time that bid-offer acceptance is issued.
Minimum Zero Time (MZT) and Minimum Non-Zero Time (MNZT)	**Minimum** on and off times.
Stable Export Limit (SEL) and Stable Import Limit (SIL)	**Minimum** generation level the unit **can** operate at, **under stable conditions** (and its import equivalent)
Maximum Delivery Volume (MDV) Maximum Delivery Period (MDP)	The **maximum** energy that the unit **may** import (export) from bids (offers) over the period specified.
Last Time to Cancel Synchronisation	Notification time **required** to cancel the units transition from operation at zero

MZT and MNZT are key parameters that drive costs

Illustrative data submissions over time



OFGEM HAS OFFERED SUPPLEMENTARY GUIDANCE ON HOW TO INTERPRET DYNAMIC PARAMETERS

OFGEM EXPECTS THAT DYNAMIC PARAMETERS REFLECT TECHNICAL CHARACTERISTICS OF THE PLANT

Ofgem’s Open letter to all Balancing Mechanism Participants (29/9/2020)

“ Dynamic parameter expectations

[T]hese parameters must be set at a level that reflects the true operating characteristics of their plant, or their reasonable expectations, **based on technical parameters**, of those operating characteristics.

Generators must **not** use dynamic parameters as a **commercial tool** in order to influence the payments that are received from the ESO.

Parameter specific clarifications

STABLE EXPORT LIMIT (‘SEL’) PARAMETER

- *Where there is a change to a unit’s SEL, we would expect this to be the result of a change in operating conditions at the plant which affects that minimum stable output level.*
- *Where it is more costly to operate at a lower level of output (but this can nevertheless be achieved under stable conditions), this should not affect the SEL that a generator submits, but rather be reflected in the schedule of bids and offers that is submitted to the ESO.*

MINIMUM NON-ZERO TIME (‘MNZT’) PARAMETER

- *The level of the MNZT should not reflect the generator’s commercial preference for how long it would like that unit to be turned on for if it is instructed to do so by the ESO.*

9

GLOSSARY

GLOSSARY

- **10 high cost days:** 10 days with highest balancing costs between September and December 2021. 24th November, 2nd November, 9th September, 15th November, 15th September, 23th November, 29th November, 3rd December, 16th December and 14th September 2021 *[In order of highest to lowest cost]*
- **BSC:** Balancing and Settlement Code. The Legal document setting out the rules for the operation and governance of the Balancing Mechanism and Imbalance Settlement.
- **BM**: Balancing Market. Operated by the ESO National Grid (the GB System Operator) to ensure the electricity system balances (i.e. supply equals demand) at any one time. Participants in the balancing market can submit 'offers' (proposed trades to increase generation or decrease demand) and/or 'bids' (proposed trades to decrease generation or increase demand). ESO then accepts offers and bids to balance the system.
- **CCGT**: Combined cycle gas turbine power plant
- **CM:** Capacity Market**.** The Capacity Market ensures security of electricity supply by providing a payment for reliable sources of capacity, alongside their electricity market revenues, to ensure they deliver energy when needed by the system.
- **DA**: Day-ahead market. Market for buying and selling electricity for delivery on the day after trading takes place.
- **ESO**: National Grid Electricity System Operator
- **GC**: The Grid Code. It details the technical requirements for connecting to and using the National Electricity Transmission System
- **Gate Closure**: means, in relation to a Settlement Period, 1 hour before the spot time at the start of that Settlement Period
- **GIP:** Good Industry Practice. In relation to any undertaking and any circumstances, the exercise of that degree of skill, diligence, prudence and foresight which would reasonably and ordinarily be expected from a skilled and experienced operator engaged in the same type of undertaking under the same or similar circumstances.
- **Flagged actions**: Balancing actions that have been impacted by transmission constraints, as opposed to non-flagged actions which are taken for energy balancing reasons.
- **ID:** Intraday market. On the Intraday market, market participants trade continuously, 24 hours a day, with delivery on the same day. As soon as a buy- and sell-order match, the trade is executed.
- **LOLE**: Loss of Load Expectation. It represents the number of hours per annum in which, over the long-term, it is statistically expected that supply will not meet demand.

GLOSSARY

- **MEL:** Maximum Export Limit. A series of MW figures and associated times, making up a profile of the maximum level at which the BM Unit may be exporting (in MW) to the GB Transmission System at the Grid Supply Point.
- **MIL**: Maximum Import Limit. MW figures and time that make up a profile of the maximum level that a BM Unit can import at the Grid Supply Point.
- **MNZT:** Minimum Non-Zero Time. Is the minimum time that a BM Unit can operate at a non-zero level as a result of a Bid-Offer Acceptance
- **MZT:** Minimum Zero Time. The minimum time that a BM Unit which has been exporting must operate at zero or be importing before returning to exporting, or the minimum time that a BM Unit which has been importing must operate at zero, or be exporting before returning to importing.
- **PN(s): Physical Notification(s):** In respect of a Settlement Period and a BM Unit, a notification made by (or on behalf of) the Lead Party to the ESO under the Grid Code as to the expected level of Export or Import, as at the Transmission System Boundary, in the absence of any Acceptances, at all times during that Settlement Period.
- **SEL:** Stable Export Limit. A MW value that expresses the minimum stable export operating level for a BM Unit.
- **Settlement Period:** A period of 30 minutes beginning on the hour or the half-hour.
- **STOR**: Short Term Operating Reserve. It provides ESO with additional power when actual demand on the National Electricity Transmission Network is greater than forecast and / or there is unforeseen generation unavailability. STOR can be provided by BM and non-BM participants.
- **VoLL:** Value of Lost Load. Assessment of the value that electricity consumers attribute to the security of supply.

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