DE MINIMIS ACCEPTANCE THRESHOLD (DMAT) AND CONTINUOUS ACCEPTANCE DURATION LIMIT (CADL) REVIEW 2018

PAPER NAME	De Minimis acceptance Threshold (DMAT) and Continuous Acceptance Duration Limit (CADL) Review 2018
Target Audience	BSC Parties
Purpose of paper	For consultation
Deadline for responses	**17:00, Friday 9 November 2018**
Contact name and details	Market Operations team Market.operations@elexon.co.uk

1. Executive Summary

1.1 The De Minimis Acceptance Threshold (DMAT) and Continuous Acceptance Duration Limit (CADL) are two pricing parameters used to classify and remove balancing actions from the Imbalance Price Calculation.

1.2 ELEXON reviews the De Minimis Acceptance Threshold (DMAT) and Continuous Acceptance Duration Limit (CADL) on behalf of the BSC Panel, to ensure that the values remain fit for purpose.

1.3 ELEXON recommends that DMAT be reduced from 1MWh to 0.1MWh, and CADL be reduced from 15 minutes to 10 minutes. The impact on Imbalance Prices of changing these parameters is given in section 3 of this paper's appendix.

1.4 The Panel may, from time to time, determine a change to these parameters in accordance with BSC Section T1.8 and BSC Section T1.9. Before a change to these parameters can take place the BSC Panel must consider the views of industry, via an industry consultation, and seek the approval of the Authority.

Changes to DMAT Summary

1.5 The De Minimis Acceptance Threshold (DMAT) removes balancing actions smaller than a set value, currently 1MWh, from the Energy Imbalance Price calculation. DMAT has been subject to seven parameter reviews since its implementation, with each review resulting in no change from 1MWh.

1.6 The DMAT parameter was introduced in 2001 following the implementation of BSC Modification P10 'Eliminating Imbalance Price Spikes Caused By Truncating Effects'. In November 2009, the implementation of BSC Modification P217 'Revised Tagging Process and Calculation of Cash Out Prices' altered the application of DMAT, introducing the disaggregated Balancing Services Adjustment Data (BSAD), known as Balancing Services Adjustment Actions (BSAAs), into the calculation of the Energy Imbalance Price.

1.7 DMAT was introduced to deal with rounding errors in the creation of Bid and Offer volume in Settlement Administration Agent (SAA) systems that do not exist for BSAA, as SAA systems do not calculate the action volumes for BSAA.

1.8 The current value of DMAT disproportionally removed BSAAs in comparison to Bid Offer Acceptances (BOAs) between July 2017 and August 2018. The proportion of BSAA removed was 10% in this period compared to 5% of BOAs. This analysis is detailed in Section 1 of this paper's appendix. A reduction in DMAT would continue to target potentially erroneous BOA volumes and have less of an impact on BSAA.

1.9 A DMAT of 0.1MWh is recommended as 0.1MWh is greater than 0.017MWh, which is the potential error volume created by the granularity of the system: 1MW and 1 minute. The reduction in DMAT to 0.1MWh from 1MWh reduces the number of removed actions by 80%. A DMAT of 0.1MWh would increase the

percentage of actions removed with a price more than two standard deviations from the mean, from 6% to 9%.

Changes to CADL Summary

1.10 The Continuous Acceptance Duration Limit (CADL) flags Bids and Offers (BOAs) with duration of 15 minutes or less, as these actions tend to be associated with system balancing actions. The Replacement Price may then reprice these CADL flagged actions during the Imbalance Price calculation. Since it's introduced in 2001, the CADL has not changed from the initial 15-minute duration.

1.11 Modification P217 'Revised Tagging Process and Calculation of Cash Out Prices', implemented in November 2009, altered the operation of CADL in the Imbalance Price calculation. Prior to November 2009, tagged CADL actions were excluded from the Imbalance Price calculation. Since November 2009, CADL actions are flagged and may be repriced using the Replacement Price.

1.12 Analysis conducted by National Grid and ELEXON assesses the accuracy of CADL flagging against the number of Fast Reserve BOAs flagged. This analysis is given in Section 1 of this paper's appendix, and in attachments A and B.

1.13 A reduction in CADL to 10 minutes is recommended as this reduces the number of incorrectly flagged BOAs. With a CADL of 10 minutes, 55% of Fast BOAs would be correctly flagged, and 19% of Non-Fast BOAs would be incorrectly flagged as CADL. In the 11-15 minutes interval, the percentage of correctly flagged Fast Reserve BOAs rises to 73%; however, the percentage of Non-Fast BOAs incorrectly flagged would rise to 30%.

1.14 Increasing CADL above 10 minutes decreases effectiveness, because the volume of Non-Fast BOAs flagged exceeds the volume of Fast BOAs flagged.

2. Imbalance Settlement Group (ISG) views

2.1 The ISG noted the analysis presented in this Paper and agreed to the consultation questions.

2.2 The ISG did not unanimously agree with the parameter values recommended by ELEXON. The ISG commented that they are open to other Parties views on the value of these parameters, and the proposed implementation date.

Appendices

Appendix 1 – DMAT and CADL analysis.

Attachments

Attachment A – National Grid Electricity Transmission – 2016/2017 CADL Review

Attachment B – National Grid Electricity Transmission – 2017/2018 CADL Review

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APPENDIX 1 – DMAT AND CADL ANALYSIS

Section 1 – Analysis of DMAT

- Background Information
- Future changes that may impact DMAT
- Analysis of tagged acceptances and actions
- Distribution of actions less than 1MWh
- Effect of changing DMAT on November 2018 Imbalance Prices

Section 2 – Analysis of CADL

- Background information
- National Grid Analysis of CADL (2016 – 2018)
- ELEXON Analysis of CADL
- The impact of TERRE and MARI products on CADL
- Historic Data
- ELEXON analysis using National Grid data
- Cost Analysis
- Analysis of actions CADL-Flagged, but not SO-Flagged
- Impact on Imbalance Prices of changing the CADL (under Live and post 1 November 2018 scenarios)
- Market Condition reflectiveness

Section 3 – Impact of CADL and DMAT on Prices

- Combined impact on Imbalance Prices

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SECTION 1 - DMAT ANALYSIS

1. Background information

The De Minimis Acceptance Threshold (DMAT) removes balancing actions smaller than a set value, currently 1MWh, from the Energy Imbalance Price calculation. DMAT has been subject to seven parameter reviews since its implementation, with each review resulting in no change from 1MWh.

The parameter was introduced in 2001 following the implementation of BSC Modification P10 'Eliminating Imbalance Price Spikes Caused By Truncating Effects'. This was an urgent modification raised to deal with rounding errors between the Transmission Company and Settlement Administration Agent (SAA) systems, which were causing spurious Bid Offer Acceptances (BOAs) and had resulted in price spikes.

Data passed to settlement is specified to the nearest minute, and as a whole number of megawatts. Spurious BOAs can still occur when BOA instructions coincide with the ramping up or down of a BMU. **Figure 1** illustrates how this can occur for an example BOA. The figure shows the Bid Offer Pairs (BOP) above (BOP+1) and below (BOP-1) the Final Physical Notification (FPN).

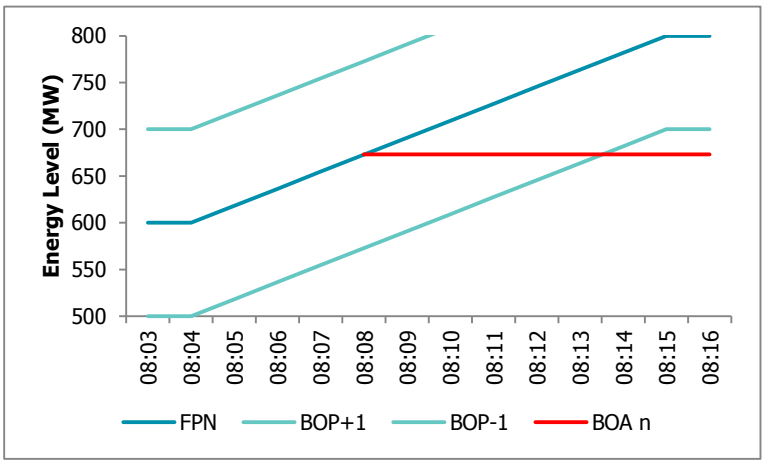

Figure 1: Example BOA instruction during a BMU ramping up

In this example, the System Operator instructs the BMU to remain at 673MW at 08:08 by a BOA. Settlement Systems calculate the FPN at 08:08 as 672.72MW. This is calculated by linear interpolation between the two instructed levels at 08:04 and 08:15. There is a positive 0.27MW difference between the BOA and FPN at 08:08 this difference results in a spurious Offer of 0.005MWh.

Spurious BOAs produced because of the level of granularity of Settlement Systems will naturally have a small volume. A difference of 1MW between an FPN and a BOA for a minute would result in an erroneous volume of 0.017MWh.

As no rounding of acceptance volumes takes place during the price calculation, this suggests that a non-zero DMAT is a sensible precaution.

In November 2009, BSC Modification P217 'Revised Tagging Process and Calculation of Cash Out Prices' was implemented, which altered the application of DMAT. Prior to the Modification, DMAT was only applied to BOAs. P217A introduced disaggregated Balancing Services Adjustment Data (BSAD), known as Balancing Services Adjustment Actions (BSAAs), into the calculation of the Energy Imbalance Price. The modification detailed that BSAAs should be subjected to the same flagging and tagging rules as BOAs.

Modification P217 also changed the impact of small acceptance volumes. At classification, the price of First-Stage Flagged actions are compared to the most expensive unflagged action, and are unflagged if less expensive. As this calculation step occurs after DMAT Tagging, small potentially erroneous volumes cannot be the most expensive unflagged action. Without DMAT Tagging, a very small spurious acceptance volume could change the merit order of the pricing stack, and therefore the Replacement Price used to reprice flagged actions.

2. Future changes that may impact DMAT

BSC Modification P344 'Project TERRE' was approved in August 2018, and will mean that TERRE providers will be able to participate in the Balancing Mechanism (BM) with Secondary BMUs. This change will allow smaller BSC Parties to participate in the BM. This may lead to BOAs with smaller volumes being chosen for energy balancing.

In November 2018, the Price Average Reference (PAR) will reduce to 1MWh with the implementation of the second phase of BSC Modification P305 'Electricity Balancing Significant Code Review Developments'. The impact of changing DMAT on the PAR 1MWh System Price is analysed in part five of this section.

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3. Analysis of tagged acceptances and actions

This analysis covers the period 1 August 2014 to 31 July 2018. For each year, the assessed period runs from August to July.

Graph 1, 2 and **3** compare the historic volumes and numbers of BOAs and BSAAs.

Graph 1 shows that the percentage of BSAA volume removed by DMAT Tagging has increased, from 0.0003% of volume in 2014/15 to 0.24% in 2017/18.

The highest percentage of BSAA removed occurred in 2017/18, when 9.92% of BSAA were removed. 13.06% of all BSAA were DMAT Tagged during February 2018.

The percentage of BOA volume removed has remained between 0.07% and 0.10% between 2014/15 and 2017/18, while the percentage of BOA actions removed has decreased from 7.27% in 2014/15 to 4.60% in 2017/18.

Graph 2 shows the number and average absolute volume of DMAT tagged actions in each year.

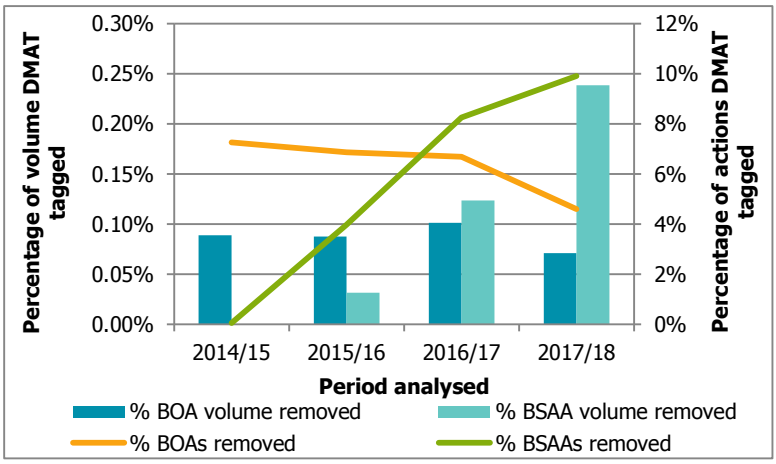
The number of DMAT tagged BOAs has reduced year on year over the review period, and are 39.81% less in 2017/18 than in 2014/15.

DMAT tagging removed 17,960 BSAA actions in 2017/18, compared to 23 BSAA in 2014/15.

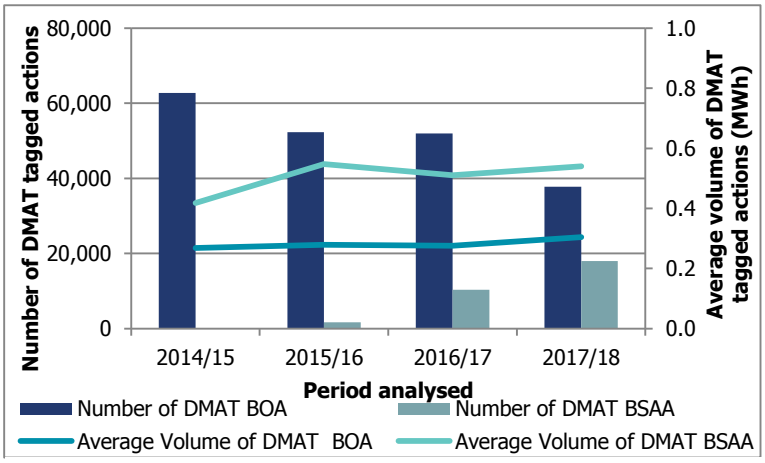
Graph 2 can be compared with **graph 3,** which shows that over the same period the number of BSAA utilised has increased from 40,702 in 2014/15 to 181,066 in 2017/18.

The average absolute volume of a BSAA has decreased from 90MWh to 22MWh. This shows a change in how BSAA has been utilised and aggregated since the last review in 2016.

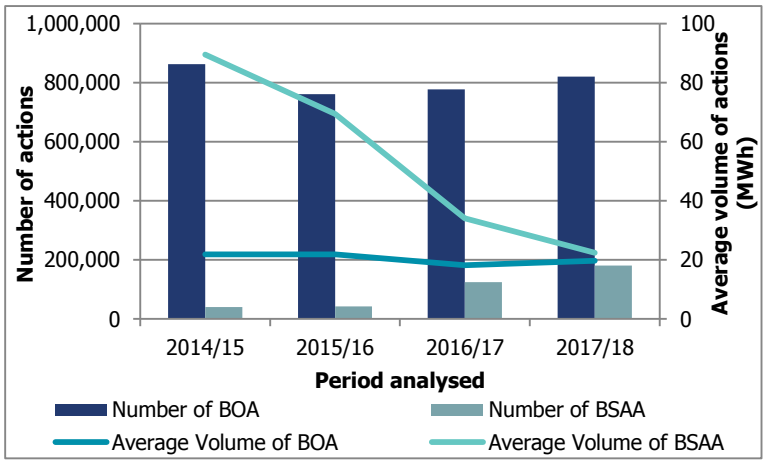
The number of BOAs utilised has decreased by 0.05%, and the average volume of a utilised BOA has reduced by 9.98% (from 22MWh in 2014/15 to 20MWh in 2017/18).



Graph 1: Percentage of BOA and BSAA volumes and actions removed



Graph 2: Number and average volume of DMAT tagged BOA and BSAA



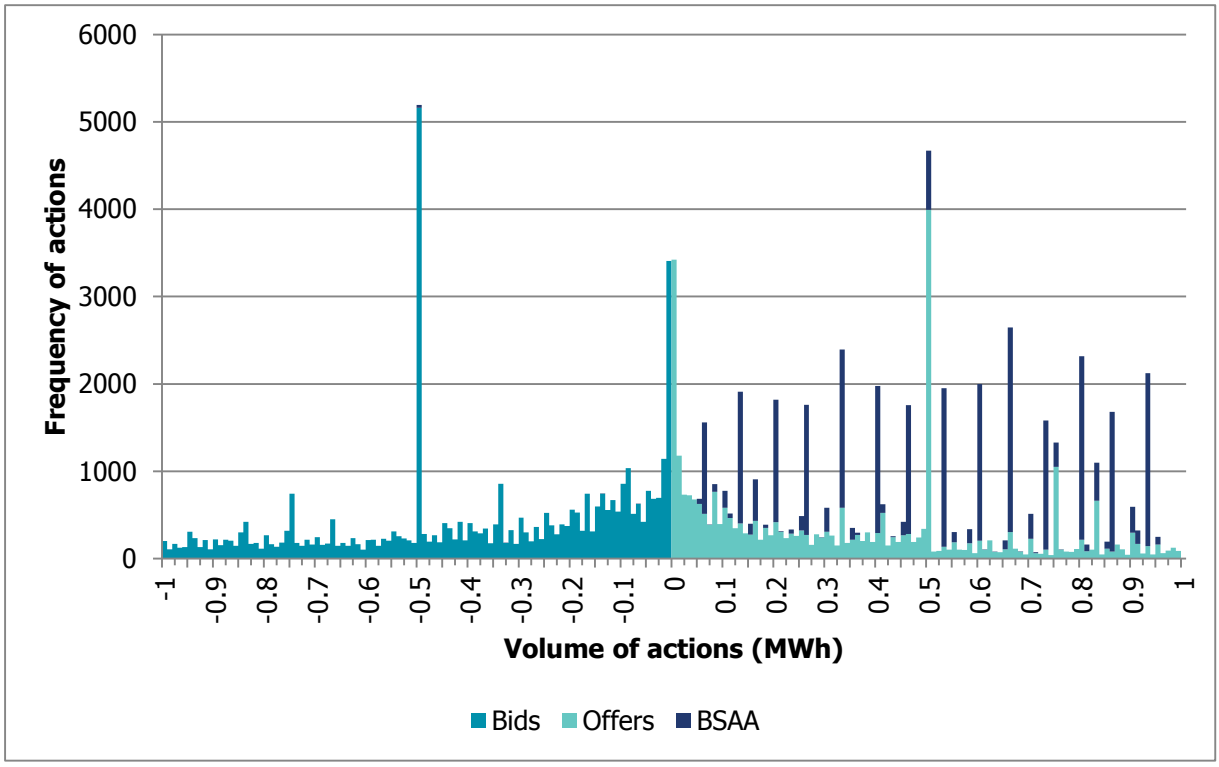
Graph 3: Number and average volume of BOA and BSAA

The average absolute volume of a DMAT tagged BOA over the entire period is 0.28MWh, whilst the average volume of a DMAT tagged BSAA for the same period was 0.53MWh.

The analysis presented in these graphs shows that over the period analysed, there are distinct differences in how BSAAs and BOAs have been utilised, and the volumes and number of these actions that have been DMAT tagged. The analysis also shows the way BSAA has been utilised has changed since the last review, with more BSAAs of smaller volumes being utilised. This has had the effect of changing the number and percentage of BSAA that are DMAT tagged, which supports our recommendation to change the DMAT value.

4. Distribution of actions less than 1MWh

Graph 4 shows how the volumes of actions less than 1MWh were distributed between August 2016 and July 2018. The volumes have been split into 0.01MWh bins. August 2014 to July 2016 has not been included in this graph, due to the change in volumes of DMAT tagged BSAA shown in **graphs 2** and **3** above.



Graph 4: Number of Bids, Offers and BSAA less than 1MWh between August 2016 and July 2018

Over the period, 72% of tagged actions were Bids and Offers. The distribution of DMAT tagged BOAs has a degree of symmetry with 56% Bids and 44% Offers. In contrast 99.9% of tagged BSAA are greater than 0MWh.

The graph shows two peaks at -0.5MWh and +0.5MWh. For volumes less than 1MWh, 12% of Bids have a volume of -0.5MWh and 12% of Offers have a volume of 0.5MWh, while 3% of BSAA have a volume of -0.5MWh or +0.5MWh.

These 0.5MWh Bids and Offers are not created as a result of an error, but due to how the Bid Offer Pair (BOP) levels are set.

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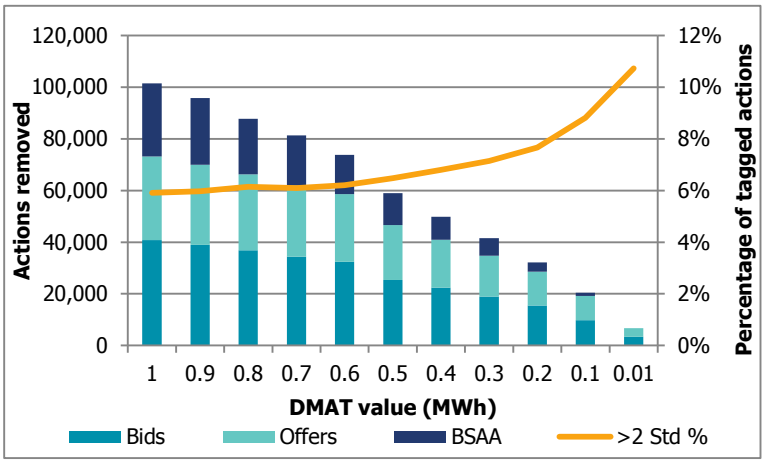
For 90% of Offers with a volume of 0.5MWh, the BOP was 1MW above the Final Physical Notification (FPN). A BOP+1 of 1MW means that any acceptances that are more than 1MW above the FPN for the duration of the Settlement Period will result in a Bid volume of 0.5MWh for BOP+1, as well as any additional Bid volume in BOPs of higher numbers. For 85% of Bids with a volume of 0.5MWh, the Bid Offer Pair (BOP) was 1MW below the final physical notification.

Graph 4 also shows that, the highest frequency of BSAA is within 0.66MWh to 0.67MWh with 2,343 BSAA in this bin. The smallest BSAA was 0.05MWh.

Graph 5 shows the numbers of Bids, Offers and BSAA removed with each DMAT value. The percentage of tagged actions where the price of the action is greater than two standard deviations from the mean price of balancing actions in the same direction in that Settlement Period is also shown.



Graph 5: Bids, Offers and BOAs removed and percentage of removed actions greater than two standard deviations from the mean for each DMAT

The purpose of DMAT tagging is to remove small potentially erroneous balancing actions from distorting the Imbalance Price. We have identified 5,994 Bids, Offers and BSAAs (6% of actions) with a volume less than 1MWh, where the price of that action is greater than two standard deviaitons from the mean, and thefore not representative of the mean price of actions in that Settlement Period.

Reducing DMAT to 0.6MWh, would continue to remove the 0.5MWh and -0.5MWh actions seen in **graph 4**, for which the majority are a genuine Bid or Offer. 6% of the prices of the actions removed had prices greater than two standard deviations from the mean. This is the same percentage as 1MWh DMAT, so would not represent an efficiency increase. This suggests a value for DMAT that is less than 0.5MWh and greater than 0MWh.

Reducing the value of DMAT to 0.01MWh would reduce the number of actions removed by 93%. None of the actions removed would be BSAAs. 11% of the actions removed have prices that are greater than two standard deviations from the mean. However, of the actions that are greater than two standard deviations from the mean, 12% of these would be removed.

Based on our analysis we recommend a DMAT of 0.1MWh. This value will reduce the number of number of removed actions by 80% and removes 30% of actions where the price is greater than two standard deviations from the mean. It would increase the percentage of actions removed with a price more than two standard deviations from the mean to 9%.

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5. Effect of changing DMAT on November 2018 Imbalance Prices

The Price Average Reference (PAR) is currently 50MWh, and the Value of Lost Load (VoLL) is £3,000/MWh. The PAR will reduce to 1MWh, and the VoLL increase to £6,000/MWh, on 1 November 2018 when the second phase of BSC Modification P305 'Electricity Balancing Significant Code Review Developments' is implemented.

As we will not be taking a paper to the BSC Panel until December 2018, analysis on the impact of changes to DMAT has been undertaken using post 1 November 2018 values (PAR 1MWh and VoLL £6,000/MWh).

Imbalance Prices between 1 August 2017 and 31 July 2018 have been recalculated using post 1 November 2018 parameters, across a number of different DMAT values: 1MWh, 0.6MWh, 0.1MWh, 0.01MWh and 0MWh.

For 95% of Settlement Periods, the Imbalance Price is the same regardless of which DMAT value is used.

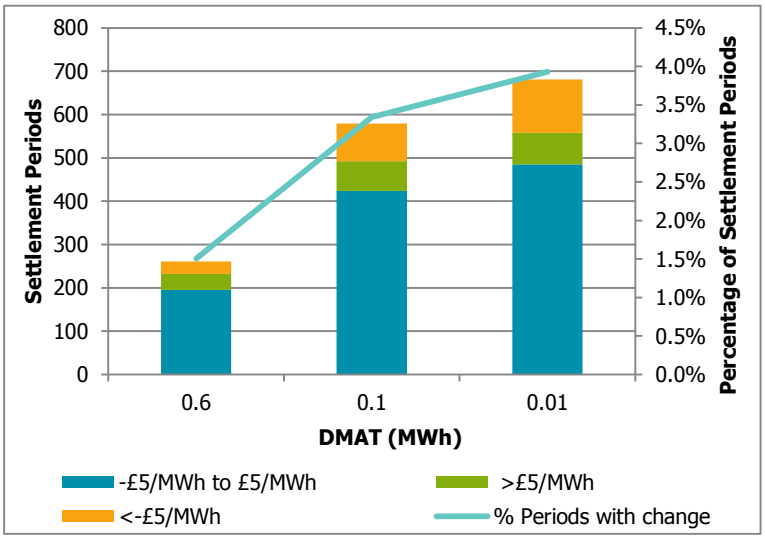
DMAT values of 0.6MWh, 0.1MWh and 0.01MWh have been compared against DMAT values of 1MWh and 0MWh, as we recommend a non-zero DMAT lower than the current 1MWh level.

We then compared these various DMAT level scenarios against a DMAT of 1MWh (**Graph 6a**) and DMAT of 0MWh (**Graph 6b**) to see the number of price differences.

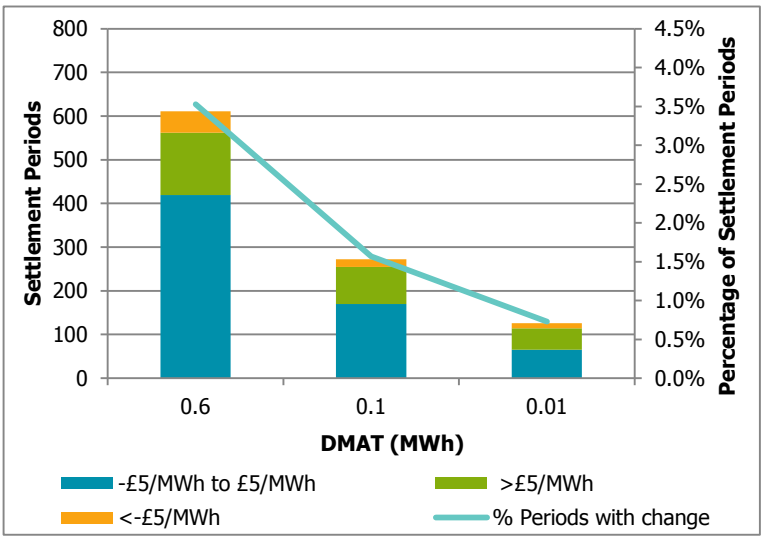
A DMAT of 0.01MWh would change the price in 3.9% of Settlement Period compared to a DMAT of 1MWh, and 0.7% of Settlement Periods with a DMAT of 0MWh.

A DMAT of 0.1MWh would change the price in 3.3% of Settlement Period compared to a DMAT of 1MWh, and 1.6% of Settlement Periods with a DMAT of 0MWh.

A DMAT of 0.6MWh would change the price in 1.5% of Settlement Period compared to a DMAT of 1MWh, and 3.5% of Settlement Periods with a DMAT of 0MWh.



Graph 6a: DMAT values compared to DMAT 1 MWh, price differences greater than and less than £5/MWh



Graph 6b: DMAT values compared to DMAT 0 MWh, price differences greater than and less than £5/MWh

A DMAT of 0.01 has the highest proportion of changes greater than £5/MWh or less than -£5/MWh. Prices change in 29% of Settlement Period compared to a DMAT of 1MWh, and in 48% of Settlement periods when compared to a DMAT of 0MWh.

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SECTION 2 - ANALYSIS OF CADL

1. Background information

The Continuous Acceptance Duration Limit (CADL) flags Bid Offer Acceptances (BOAs) with duration of 15 minutes or less, as these actions tend to be associated with system balancing actions. The Replacement Price may then reprice these CADL flagged actions during the Imbalance Price calculation. Since its introduction in 2001, the CADL has not changed from the initial 15-minute duration.

The Balancing and Settlement Code (BSC), Section T, 1.9 states that:

> *1.9.1 For the purposes of the Code, the "Continuous Acceptance Duration Limit" (CADL) shall be 15 minutes or such other amount (in minutes) determined by the Panel and approved by the Authority.*
>
> *1.9.2 The Panel may revise such amount from time to time subject to the approval of the Authority.*
>
> *1.9.3 In revising the amount of the Continuous Acceptance Duration Limit from time to time, the Panel shall consult with Parties and consider the views expressed in the course of such consultation prior to making its determination (and shall provide a detailed summary of such views to the Authority)*

Note that any change to the CADL requires the Panel to consult with BSC Parties before giving its determination, and that any change will need to be approved by the Authority (Ofgem).

Modification P217 'Revised Tagging Process and Calculation of Cash Out Prices', implemented in November 2009, altered the operation of CADL in the Imbalance Price calculation. Prior to November 2009, tagged CADL actions were excluded from the Imbalance Price calculation. Since November 2009, CADL actions are flagged and may be repriced using the Replacement Price.

The analysis provided by National Grid (NG) splits all BOAs into two groups: Actions from specific Fast Reserve plants, and actions from all other plants (Non-Fast Reserve). Their analysis details the number and volume of Fast Reserve and Non-Fast Reserve flagged BOAs, and covers the period 1 August 2016 to 31 July 2018 (referred to as the analysis period), which had been split into two annual periods (see attachments A and B for NG reports).

2. National Grid Analysis of CADL (2016 – 2018)

When reviewing the CADL, ELEXON request NG provide detailed analysis of energy and system balancing actions for the previous two years.

Their methodology defines plants that offer Fast Reserve actions as those which match, individually or as a group, the following minimum criteria:

- Initial ramp rate is greater than or equal to 25 MW/min; and
- BOA size is greater than or equal to 50 MW; and
- Start point is greater than or equal to the unit's Stable Export Limit (SEL), unless it is a hydro or open cycle gas turbine (OCGT) station.

The Transmission Company provided analysis on the volume flagged by CADL in the Energy Imbalance Price calculation, defining if it was considered as either Fast BOAs volume or Non-Fast BOAs volumes.

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During the review period, five Hydro power stations accounted for 94.8% of Fast Reserve BOAs, with 14 Gas power stations accounting for the remaining 5.2%.[1]

The analysis includes modelling the flagging of actions at various durations of CADL. The aim is to find the most appropriate level of CADL (i.e. where the largest numbers of Fast Reserve BOAs are flagged), whilst leaving other actions unflagged. NG's analysis is included as Attachment A (2016-17) and Attachment B (2017-2018).

Table 1, based on the analysis provided by NG, shows how the Fast and Non-Fast BOAs Reserve Volumes flagged differ across varying CADL time values for the period 1 August 2017 to 31 July 2018 (note period 1 August 2016 to 31 July 2017 is shown in Attachment A). Previous analysis highlighted that the current CADL of 15 minutes had a similar percentage of Fast and Non-Fast Reserve CADL Flagged actions (around 50% each).

CADL FLAGGED BOAs vs TOTAL BOAs (01 Aug 2017 to 31 July 2018)						
Duration (min) (cumulative) (a)	Cumulative CADL Flagged Fast BOAs (MWh) (b)	Cumulative All CADL flagged BOAs (MWh) (c)	CADL Flagged Fast BOAs as % of All CADL flagged BOAs (b)/(c)	All CADL Flagged BOAs as % of all BOAs (d) = (e)+(f)	CADL Flagged Fast BOAs as % of all BOAs (e)	CADL flagged Non Fast BOAs as % of All BM BOAs (f)
10	94,853	186,548	50.8%	1.2%	0.6%	0.6%
11	109,683	226,778	48.4%	1.4%	0.7%	0.7%
12	121,729	258,058	47.2%	1.6%	0.8%	0.9%
13	131,737	290,220	45.4%	1.8%	0.8%	1.0%
14	142,961	325,363	43.9%	2.0%	0.9%	1.1%
15	153,133	355,795	43.0%	2.2%	1.0%	1.3%
16	162,113	393,384	41.2%	2.5%	1.0%	1.4%
17	171,119	423,436	40.4%	2.6%	1.1%	1.6%
18	178,797	460,769	38.8%	2.9%	1.1%	1.8%
19	187,642	493,597	38.0%	3.1%	1.2%	1.9%
20	194,769	530,039	36.7%	3.3%	1.2%	2.1%

Table 1: Volume of 'Fast' and 'Non-Fast Reserve' BOAs flagged (duration from 10-20 minutes)

Table 1 shows that at the current 15 minute CADL, 43.0% of CADL flagged actions are Fast Reserve, with 57.0% classed as Non-Fast Reserve. Only by reducing the CADL to 10 minutes does the percentage of Fast Reserve CADL flagged actions exceed Non-Fast Reverse actions (50.8% vs 49.2%).

Next, NG plotted the count of Fast and Non-Fast BOAs, and showed these as cumulative percentages by time band (**Graph 1**). Increasing the CADL above 15 minutes (for Fast BOAs) leads to the cumulative percentage curve flattening, capturing lower numbers of Fast actions. It also leads to a greater number of non-Fast BOAs being flagged. Therefore, the effectiveness of CADL decreases as the CADL value increases past 15 minutes.

[1] Note there is ongoing investigation by National Grid into the data behind the calculation; however it is not expected to have a material impact on the figure. For the avoidance of doubt, the data issue only affects this figure.

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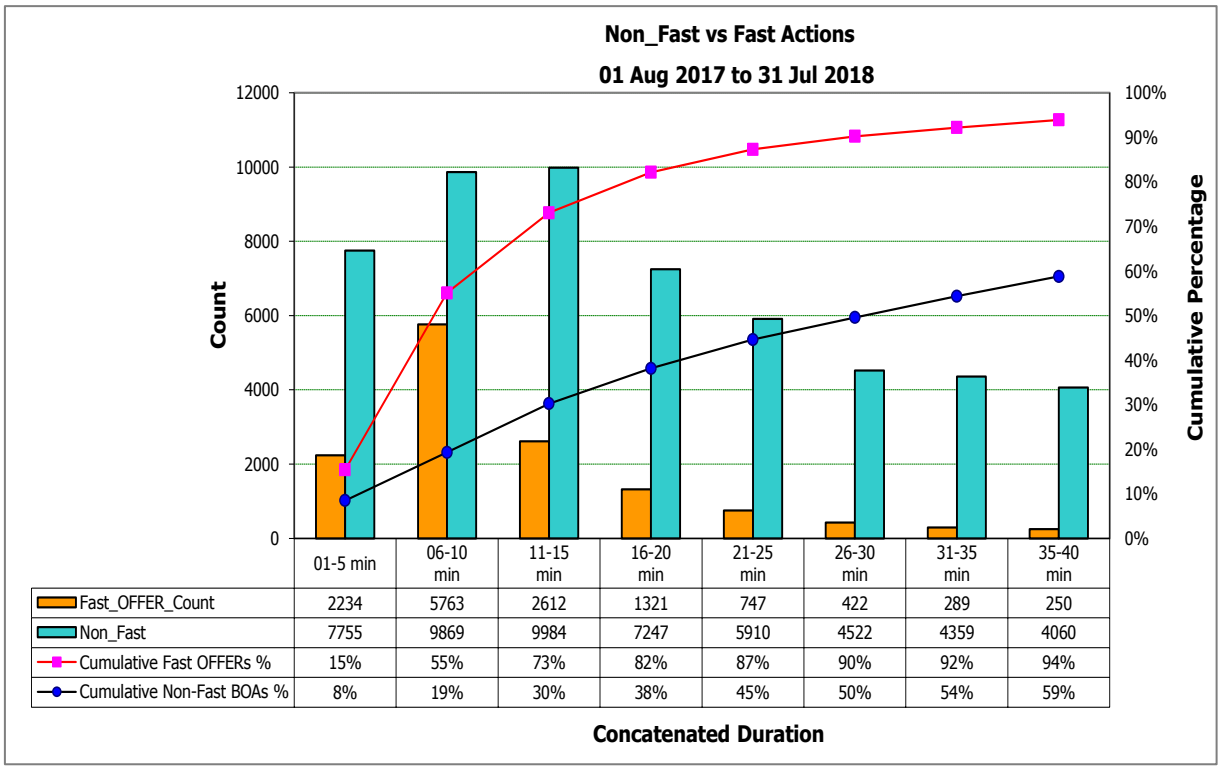


	01-5 min	06-10 min	11-15 min	16-20 min	21-25 min	26-30 min	31-35 min	35-40 min
Fast_OFFER_Count	2234	5763	2612	1321	747	422	289	250
Non_Fast	7755	9869	9984	7247	5910	4522	4359	4060
Cumulative Fast OFFERs %	15%	55%	73%	82%	87%	90%	92%	94%
Cumulative Non-Fast BOAs %	8%	19%	30%	38%	45%	50%	54%	59%

Graph 1: Graphical representation of the count of 'Fast' and 'Non-Fast Reserve' BOAs concatenated between 1 minute and 40 minutes duration.

From **Graph 1**, we can conclude:

- The count of 'Fast Reserve' BOAs peaked at 5,763 in the 06 – 10 minutes interval, with the count of Non-Fast Reserve BOAs peaking in the 11 - 15 minutes interval (9,984).
- With a CADL of 10 minutes, 55% of Fast BOAs would be correctly flagged, and 19% of Non-Fast BOAs would be incorrectly flagged as CADL.
- In the 11-15 minutes interval, the percentage of correctly flagged Fast Reserve BOAs rises to 73%; however, the percentage of Non-Fast BOAs incorrectly flagged would rise to 30%.
- The 'Fast Reserve' BOAs decreases rapidly when CADL rises above 10 minutes.
- Increasing the CADL above 15 minutes leads to a much higher number of 'Non-Fast' actions flagged, compared with 'Fast' actions.

The data provided by the Transmission Company suggests a CADL of between 10 and 15 minutes, with evidence supporting a reduction to 10 minutes.

3. ELEXON Analysis of CADL

Given the impact changing the CADL could have on Industry, ELEXON undertook further analysis of the CADL. This analysis used data for period 1 August 2016 to 31 July 2018. Our main findings were:

- The percentage of CADL flagged actions, as a proportion of total actions, has consistently been higher for Buy actions. Although the percentage of CADL flagged actions has been consistent over the analysis period, it did peak in March 2017 (see **Graph 3**).
- Once the CADL increases above 10 minutes, the volume of Non-Fast BOAs flagged exceeds the volume of Fast BOAs flagged; increasing the CADL above 10 minutes decreases effectiveness.
- When comparing the Cumulative Fast and Non-Fast Reserve actions by duration, the volume of Non-Fast BOAs flagged is higher than the volume of Fast BOAs flagged above 10-minute duration (see **Graph 4**). This supports the view that CADL values above 10 minutes decrease the effectiveness of this parameter.
- The volume of flagged Fast Reserve BOAs has decreased slightly from the review in 2016; in contrast, the volume of Flagged Non-Fast Reserve BOAs has increased rapidly (see **Graph 5**).
- Over time, the cost of Fast Reserve has increased to above Frequency Response. As actions are chosen based on merit order, it has become more likely for plants offering Frequency Response to be called before plants offering Fast Reserve (see **Graph 6**).
- There has been significant increase in BM and Non-BM STOR (see **Graph 7**).

As changing the CADL duration will affect the Imbalance Price, the impact of various scenarios (setting the CADL at 0, 10, 12 or 20 minutes) were analysed for both Live and post 1 November 2018 parameters (see **Tables 4 and 5**). We concentrated on changing the CADL from 15 to 10 minutes in duration, using data for period 1 August 2016 to 31 July 2018, and our main findings were:

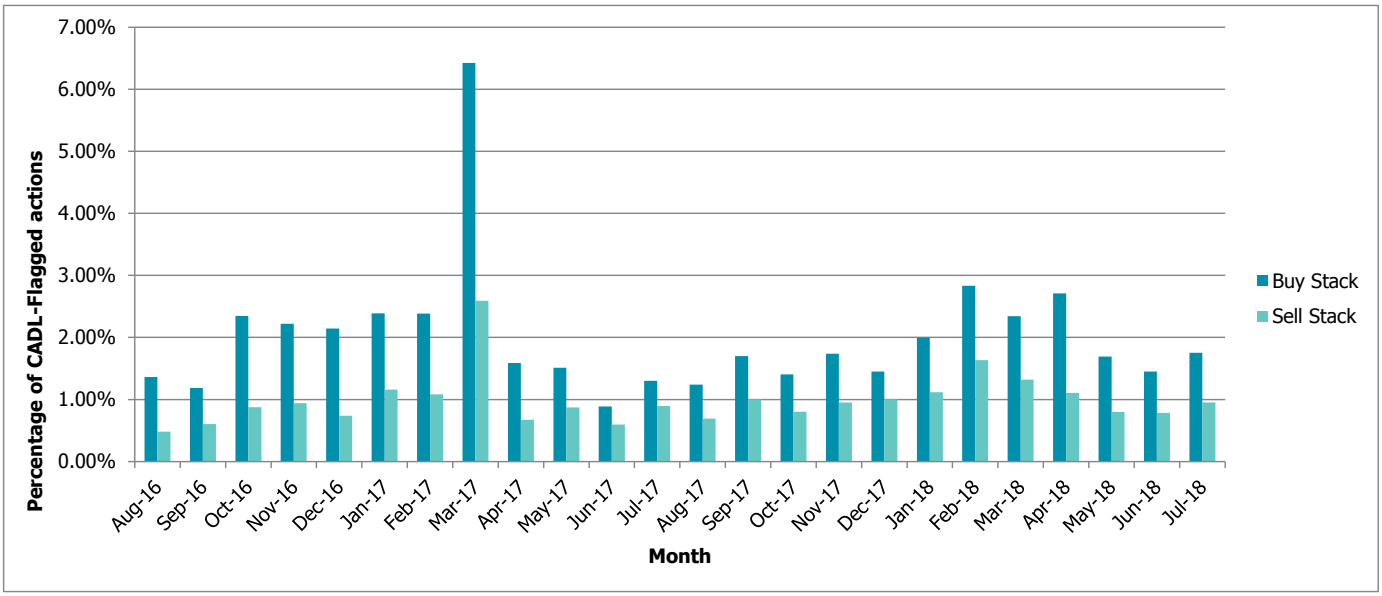
- Reducing the CADL from 15 to 10 minutes would have resulted in 2.4% of Imbalance Prices changing under both the Live scenario and post November 2018 scenarios. Therefore, Imbalance Prices would remain unchanged in 97.6% of Settlement Periods.
- Where the Imbalance Price would change under the Live scenario, 39.9% of these price changes were within +/- £1/MWh of the original price. For the post 1 November 2018 scenario, this fell to 30.2%.
- The average price would have increased by £6.30 in the Live scenario (£10.69 post 1 November 2018), with the maximum change in Imbalance Price being £109.70 (£195.00 post 1 November 2018).

4. The impact of TERRE and MARI products on CADL

We have also examined the potential impact of Trans European Replacement Reserve Exchange (TERRE) and Manually Activated Reserves Initiative (MARI) products on the CADL. It appears TERRE will not have an impact, as ELEXON do not use TSO Acceptance Data to calculate volumes, and so it does not have an associated price. As MARI is scheduled to occur from 2022, and is likely to follow a similar process to TERRE, it seems unlikely that it will negatively impact the CADL.

5. Historic Data

We have looked at the CADL-Flagged actions as a proportion of all actions (CADL-Flagged, CADL-Unflagged, SO-Flagged and SO-Unflagged actions) for the period August 2016 to July 2018, in order to gain some appreciation for the amount of CADL-Flagged actions. This is summarised in **Graph 3** below:

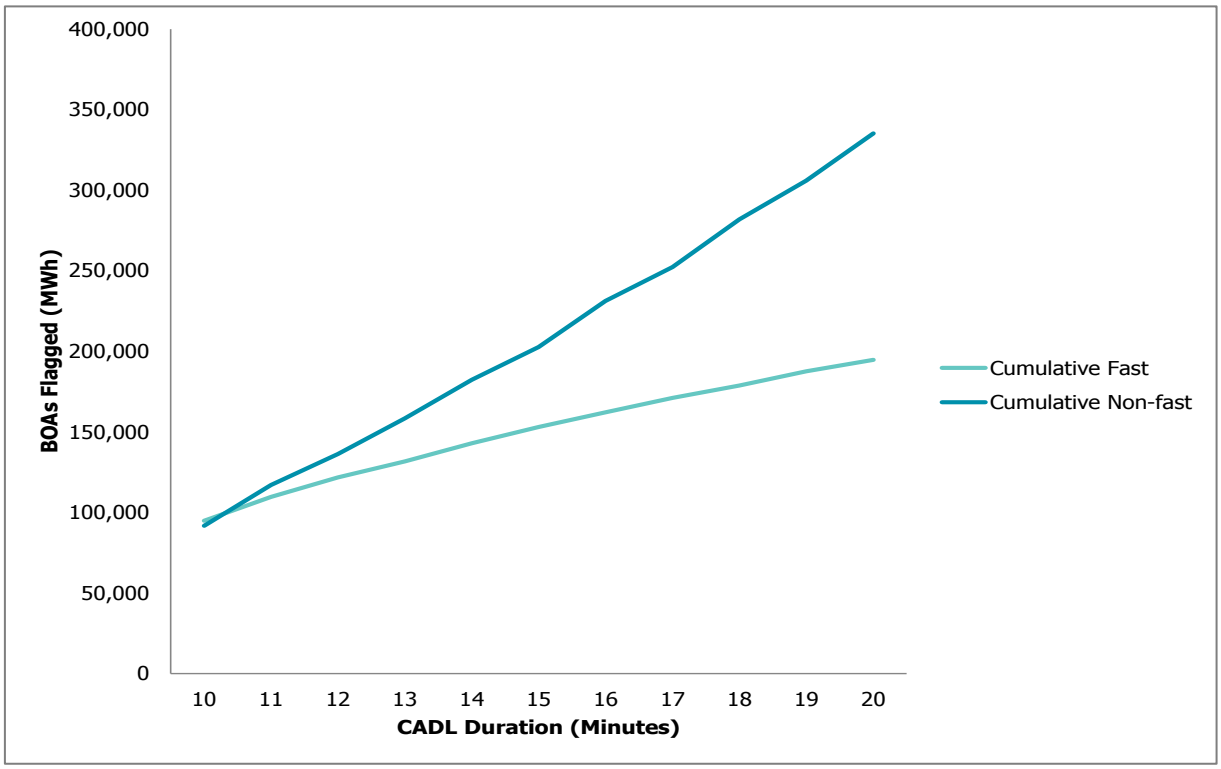


Graph 3: The proportion of CADL-Flagged actions as a percentage of all actions for 1 August 2016 to 31 July 2018.

As can be seen the proportion for both the buy and sell stack peaked in March 2017 of 6.42% and 2.59% respectively. More recently, the proportion has stayed relatively constant.

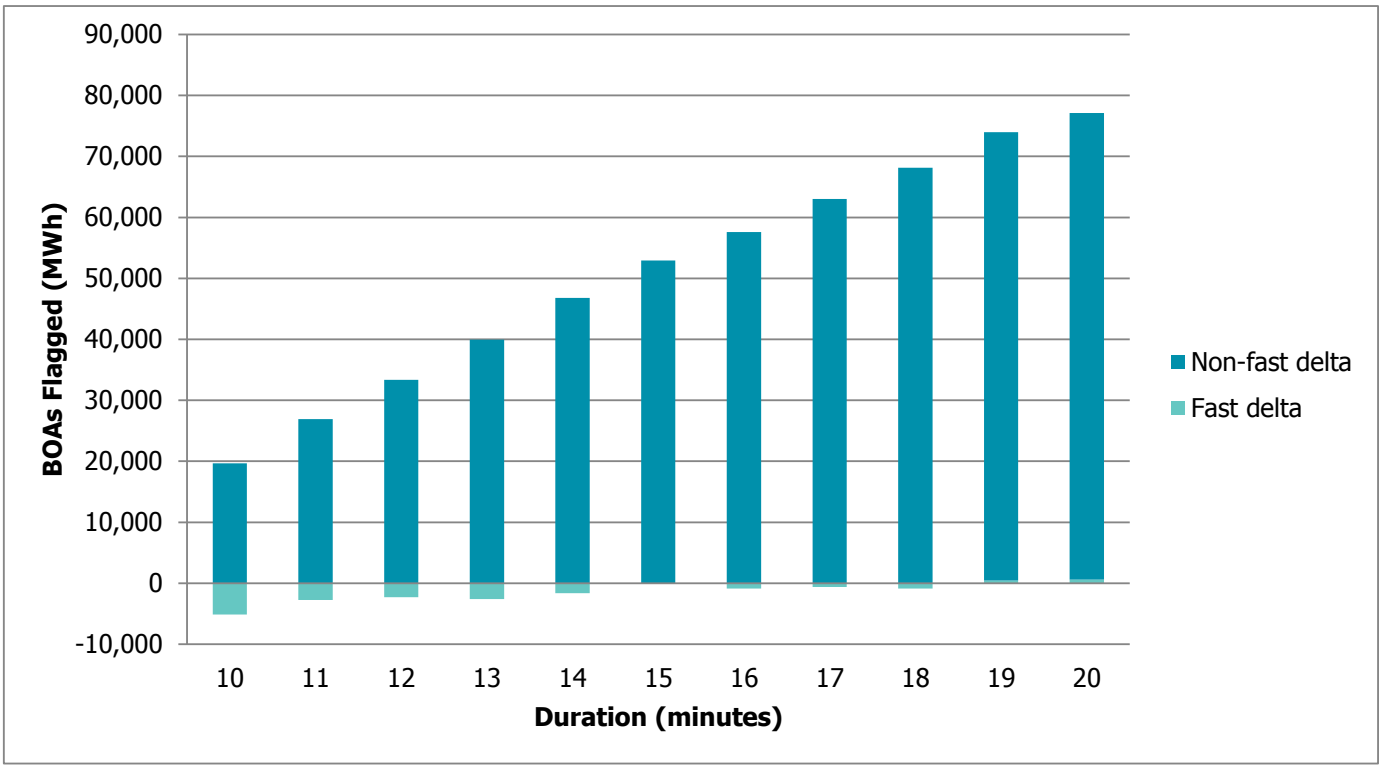
6. ELEXON analysis using National Grid data

Using the data from **Table 1,** a graphical representation of the Cumulative Fast and Non-Fast Reserve actions has been created (**Graph 4**). This shows that once the CADL duration increases above 10 minutes, the volume of Non-Fast BOAs flagged is higher than the volume of Fast BOAs flagged. This implies that CADL values above 10 minutes decrease the effectiveness of this parameter.



Graph 4: Volume of 'Fast' and 'Non-Fast Reserve' BOAs between 10 and 20 minutes duration.

We have also compared the cumulative Fast and Non-Fast Reserve data for this analysis period with the data used in the 2016 review (2016 review based on data 1 August 2014 – 31 July 2016), for a CADL duration of between 10 and 20 minutes (**Graph 5**).



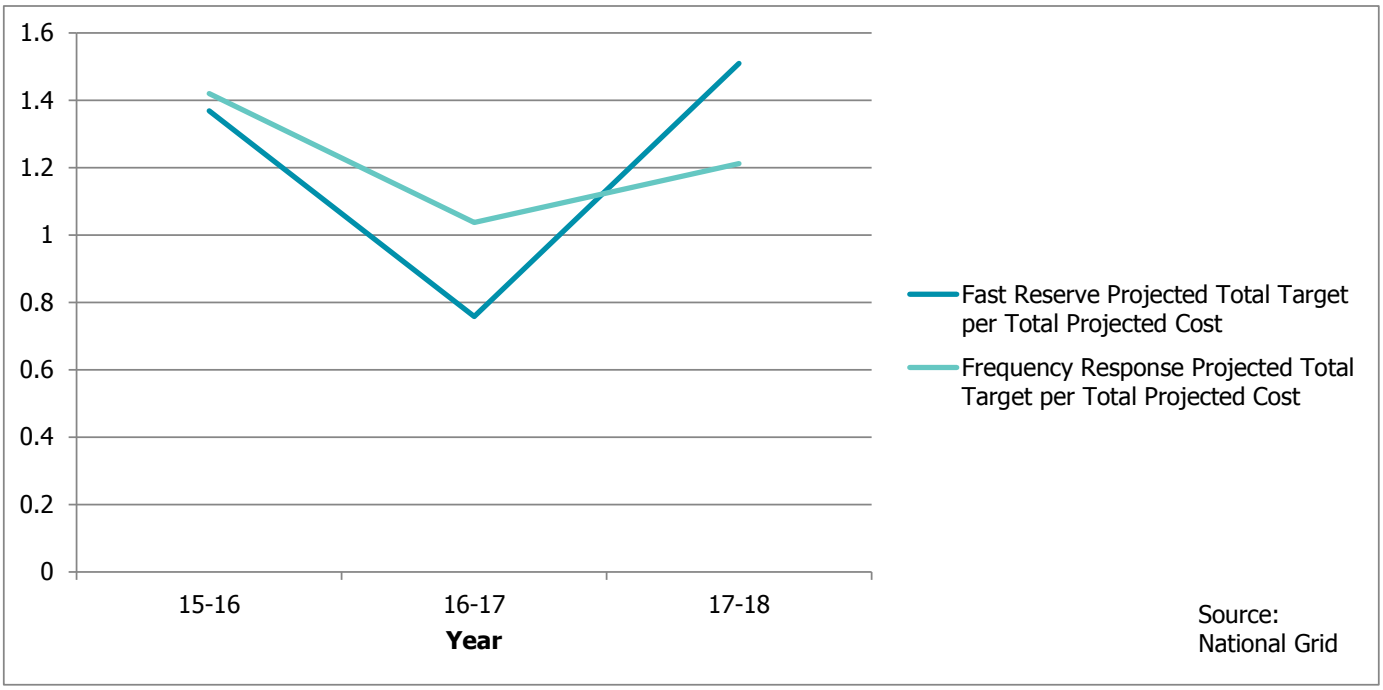
Graph 5: The cumulative difference of Fast Reserve and Non-Fast Reserve, for 2018 versus 2016 review.

This analysis shows that whilst the flagged volume of Fast Reserve BOAs has decreased slightly from the review in 2016, the volume of Flagged Non-Fast Reserve BOAs has increased rapidly. At the current 15-minute CADL level, there are 52,788 more flagged Non-Fast BOAs in the 2018 review than there was in the 2016 review, whilst the number of Fast BOAs has fallen by 133.

7. Cost Analysis

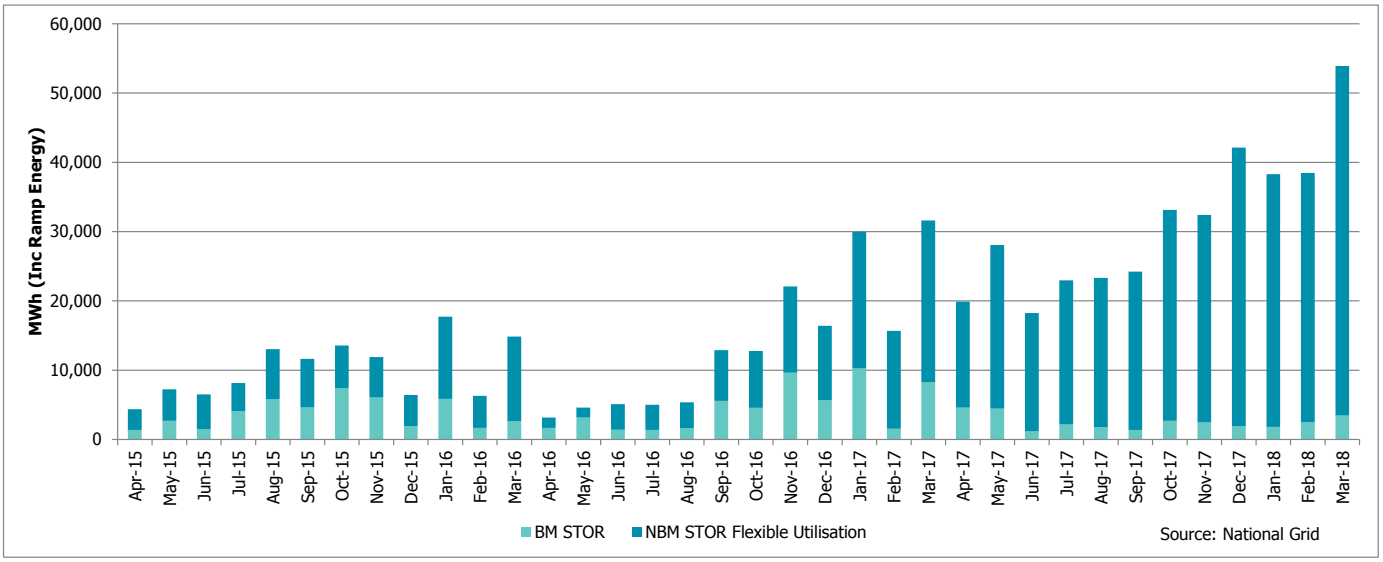
Using data provided by NG and their Monthly Balancing Services Summary (MBSS) documents for the period 2015/2016 to 2017/2018, ELEXON carried out a cost analysis of BM Frequency Reserve against Fast Reserve to gain an understanding of the possible commercial positioning going forward. Operationally, these two BM services can be utilised alternatively to manage peak periods, and correct frequency deviations, due to generation shortfalls or demand ramp.

Graph 6 shows the projected total target (i.e. the budget for the year per projected unit cost). This highlights that over time, Fast Reserve has become more expensive to utilise than Frequency Response. As actions are dispatched using the "least cost principle of merit order", Frequency Response actions could be more likely to be called than Fast Reserve.



Graph 6: Projected total target per total unit cost for BM Frequency Reserve and BM Fast-Reserve

Furthermore, there has been significant increase in BM and Non-BM STOR (**Graph 7**). This could explain the reason for the decreased utilisation of Fast Reserve generation units, since the short duration actions that CADL flags could be met by STOR (including Demand-Side STOR).



Graph 7: BM STOR and Non-BM STOR, with Flexible Utilisation

8. Analysis of actions CADL-Flagged, but not SO-Flagged

This section looks at the number of CADL-Flagged but not SO-Flagged actions. This allows us to identify those actions that are purely picked up by the CADL mechanism. This has been analysed across various scenarios split into buy and sell actions. The results can be seen in **table 3** below (analysis period 1 August 2016 to 31 July 2018).

CADL Value	Count of Buy Actions	Count of Sell Actions
10 minutes	25,345	13,905
15 minutes	52,118	35,405
20 minutes	73,962	55,941

Table 3: Actions CADL-Flagged, but not SO-Flagged (where PAR = 50MWh and VoLL = £3,000/MWh)

9. Impact on Imbalance Prices of changing the CADL (under Live and post 1 November 2018 scenarios)

Table 4 shows the impact on Imbalance Prices to changes in the CADL value. This shows the impact of changing the CADL to 0, 10, 12, and 20 minutes, for both Live and post Nov-18 scenarios (analysis period 1 August 2016 to 31 July 2018):

	CADL – Live (Current) parameters				CADL – 1 November 2018 parameters			
CADL Scenarios	**0 min**	**10 min**	**12 min**	**20 min**	**0 min**	**10 min**	**12 min**	**20 min**
Settlement Periods with change in Imbalance Price	1,524	844	527	736	1,528	848	518	739
% of Total Settlement Periods	4.35%	2.41%	1.50%	2.10%	4.36%	2.42%	1.48%	2.11%
Average Price Change (£/MWh)	£8.85	£6.30	£5.92	£5.56	£17.27	£10.69	£9.97	£8.61
Maximum Price Change (£/MWh)	£142.72	£109.70	£109.70	£77.55	£230.04	£195.00	£189.60	£135.00

Table 4: Number of Imbalance Price changes due to change in CADL (Live and post 1 November 2018 scenarios)

Reducing the CADL from 15 to 10 minutes would have resulted in 2.41% of Imbalance Prices changing under the Live scenario, and 2.42% under post November 2018 scenarios. The average price would have increased by £10.69 in the post 1 November 2018 scenario (£6.30 in the current Live scenario), with the maximum change in Imbalance Price being £195.00 in the post 1 November 2018 scenario (£109.70 in the current Live scenario).

Table 5 shows how these Imbalance Price changes are spread, by grouping the number of settlement periods changing into bands based on the change in price (for both Live and post 1 November 2018 scenarios).

		CADL – Live (Current) parameters				CADL – post 1 November 2018 parameters			
		0 min	**10 min**	**12 min**	**20 min**	**0 min**	**10 min**	**12 min**	**20 min**
Number of Settlement Periods with an Imbalance Price Change (£/MWh)	< -£20	61	37	20	20	150	68	42	45
	-£20 to -£10	63	33	22	55	75	48	31	60
	-£10 to -£5	56	27	17	73	39	22	16	76
	-£5 to -£1	81	44	32	136	34	22	14	177
	-£1 to £0	47	27	23	307	11	9	6	236
	£0 to £1	365	310	198	27	274	247	159	14
	£1 to £5	313	179	109	40	265	191	119	27
	£5 to £10	207	74	42	21	174	82	43	21
	£10 to £20	204	76	40	29	199	81	47	33
	> £20	130	37	24	28	307	78	41	50
Total of Settlement Periods changing		**1,524**	**844**	**527**	**736**	**1,528**	**848**	**518**	**739**
% of Settlement Periods changing		**4.35%**	**2.41%**	**1.50%**	**2.10%**	**4.36%**	**2.42%**	**1.48%**	**2.11%**
% of Settlement Periods with change of more than +/- £1/MWh		3.18%	1.44%	0.87%	0.34%	3.52%	1.67%	1.00%	1.38%

Note: Period 1 August 2016 to 31 July 2018 contains 35,040 Settlement Period

Table 5: Frequency analysis of Settlement Periods for period August 2016 to July 2018 (under Live and post 1 November 2018 scenarios)

This table shows that how Imbalance Prices would vary if the current 15 minute CADL parameter was change to 0, 10, 12 or 20 minutes (under both the Live and post 1 November 2018 scenarios). For the period 1 August 2016 to 31 July 2018, a CADL of 10 minutes duration would mean:

- The Imbalance Price would **not** change in 97.59% of Settlement Periods under the current Live scenario. Of the 2.41% of Settlement Periods where the different Imbalance Price does change, a large proportion of these see a change of +/- £1/MWh hour (844 Settlement Periods have a different Imbalance Price, with 337 of these within +/- £1/MWh of the current price).
- The Imbalance Price would **not** change in 97.58% of Settlement Periods under the post 1 November 2018 scenario. Of the 2.42% of Settlement Periods where the different Imbalance Price does change, a

large proportion of these see a change of +/- £1/MWh hour (848 Settlement Periods have a different Imbalance Price, with 256 of these within +/- £1/MWh of the current price).

We can conclude that, under both the current Live and post 1 November 2018 scenario, changing the CADL parameter does **not** change the Imbalance Price in 97.5% of Settlement Periods. Where the Imbalance Price does change, in most cases the change is small, with the price changing by +/- £5/MWh or more in only 0.81% of Settlement Periods.

10. Market Condition reflectiveness

This section considers the difference between the Replacement Price and the Initial price for those actions that have been CADL-Flagged but not SO-flagged. This shows what the CADL actions are repriced to, and whether they are reflective of market conditions.

Table 6 shows the averages of the Replacement price minus the Initial Price, for Buy and Sell actions, across different CADL durations:

	CADL Duration			
Average difference (£/MWh)	**10 mins**	**12 mins**	**15 mins**	**20 mins**
Buy Actions	-£30.06	-£29.16	-£27.95	-£25.23
Sell Actions	£29.40	£21.55	£16.30	£12.47

Table 6: Averages of Replacement Price minus Initial Price, across different CADL durations.

Where the CADL duration is set to 10 minutes, the flagged Buy actions are (on average) £30.06 more expensive than the Replacement Price, which is used as a proxy to the market conditions (where a replacement price has been applied). For the corresponding Sell actions, these are (on average) £29.40 different. This occurred in 2291 settlement periods.

DE MINIMIS ACCEPTANCE THRESHOLD (DMAT) AND CONTINUOUS ACCEPTANCE DURATION LIMIT (CADL) REVIEW 2018

SECTION 3 - IMPACT ON PRICES OF CHANGING DMAT AND CADL

1. Combined impact on Imbalance Prices

Based on the CADL and DMAT analysis in the previous sections, **we recommend a DMAT of 0.1MWh and a CADL of 10 minutes**. In this section, we examine the combined impact on Imbalance Prices of changing both parameters.

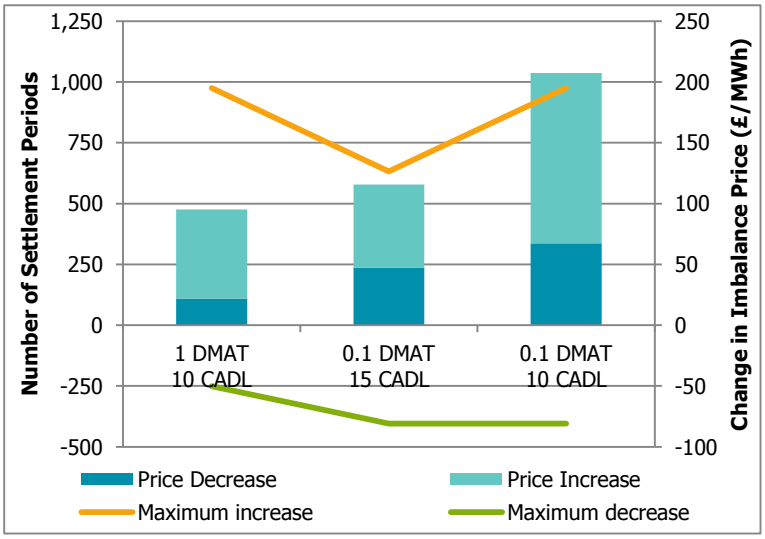
The Price Average Reference (PAR) is currently 50MWh and the Value of Lost Load (VoLL) is £3,000/MWh. The PAR will reduce to 1MWh, and the VoLL increase to £6,000/MWh, on 1 November 2018 when the second phase of BSC Modification P305 'Electricity Balancing Significant Code Review Developments' is implemented.

As we will not be taking a paper to the BSC Panel until December 2018, we have analysed any changes to DMAT and CADL under the post 1 November 2018 parameters (PAR 1MWh and VoLL £6,000/MWh).

Imbalance Prices between 1 August 2017 and 31 July 2018 have been recalculated for four scenarios:

- Current DMAT and CADL – 1MWh DMAT and 15 minute CADL
- Change to recommended CADL only – 1MWh DMAT and 10 minute CADL
- Change to recommended DMAT only – 0.1MWh DMAT and 15 minute CADL
- Change to recommended DMAT and CADL – 0.1MWh DMAT and 10 minute CADL

Graph 1 shows the number of Settlement Periods between 1 August 2017 and 31 July 2018 that would see a change to the Imbalance Price if the recommended change to DMAT or CADL, or both, was implemented.



Graph 1: Number of and maximum increases and decreases to Imbalance Prices between August 2017 and July 2018.

The change to both DMAT and CADL would result in a change to prices in 6% of Settlement Periods; this is equivalent to three Settlement Periods a day.

The Imbalance Price increased as a result of the changes in 700 Settlement Periods. The average Imbalance Price increase would be £10.78/MWh for these Settlement Periods.

The maximum price increase of £195/MWh occurred on 15 October 2017 (Settlement Period 41), when the price increased from £132.01/MWh to £327.01/MWh as a result of the reduction in CADL.

The Imbalance Price would have decreased in 337 Settlement Periods, with an average decrease of £6.05/MWh. The maximum decrease in price was £80.76/MWh on 17 August 2017 (Settlement Period 30), where the Imbalance Price decreased from £30.76/MWh to -£50/MWh. This was as a result of the reduction in DMAT, as a Bid of 0.101MWh became the most expensive unflagged action, and subsequently contributed to the Replacement Price.

Reducing only CADL would result in a change to the Imbalance Price in 2.75% of Settlement Periods, whilst reducing only DMAT would result in a change to the Imbalance Price in 3.34% of Settlement Periods.