

THE NATIONAL GRID COMPANY plc

Imbalance Price Calculations - BSC Modification Proposal Eliminating imbalance price spikes caused by truncating effects (Paper by National Grid)

The paper describes two options for modifying the BSC to remove imbalance price spikes that can occur as a result of spurious Bid/Offer Acceptances caused by truncating National Grid instructions to a whole number of minutes or an integer volume of megawatts. The first option targets these spurious effects by removing Bid/Offer acceptances of less than 1 minute in duration. This is our preferred solution but requires complex modifications to the BSC and the associated settlement software.

The second option removes Bid/Offer acceptances with a total volume less than 1 MWh. This solution should eliminate the spurious effects, provided by a very simple modification to the BSC and associated settlement software. The disadvantage of this option is that it could also eliminate any genuine, albeit unlikely, Bid/Offer acceptances with a volume less than 1MWh. However, given the need for a short-term solution to remove price spikes, we propose that the BSC be modified in accordance with this option.

I. INTRODUCTION

The truncating of National Grid acceptances to a whole number of minutes or an integer volume of megawatts can result in the settlement software registering a “spurious” Bid/Offer Acceptance of a very small Bid/Offer volume in addition to the intended acceptance. If this is the only volume 'accepted' in that direction, an extreme Bid/Offer price combined with a very small volume (typically a fraction of a MWh) can lead to a price spike that is totally unrelated to the economics of system balancing. For example, a volume of 50kWh at £1000/MWh might be registered, implying a balancing cost of £50, but the imbalance price would be set to £1000/MWh.

As with the price spikes caused by BSAD data which are currently being addressed, we do not regard such spikes as providing the correct economic message for participants to self-balance, and instead may create an artificial incentive for participants to adjust their position avoid exposure to imbalance price spikes. This paper describes two options for modifying the BSC to remove these effects.

II. OPTION 1 - REMOVE BID/OFFER VOLUMES < 1 MINUTE

The spurious Bid/Offer Acceptance volumes resulting from truncating National Grid instructions to the nearest minute or megawatt are themselves typically less than 1 minute in duration. Our preferred approach to the eliminating associated price spikes is to remove all individual Bid/Offer Acceptances less than 1 minute in duration from the calculation of imbalance prices. This could be achieved by modifying Section T of the BSC in accordance with Appendix A.

Under this option, Section T, Paragraph 3.8 of the BSC would be modified to identify the duration of all Bid and Offer Acceptances as the Price Period Accepted Offer Flag Volume

($FLAGO^{kn}_{ij}$) and Price Period Accepted Bid Flag Volume ($FLAGB^{kn}_{ij}$). The Imbalance Price Period Offer Volume ($QAOP^{kn}_{ij}$) or Imbalance Price Period Accepted Bid Volume ($QABP^{kn}_{ij}$) would be set to the volume of the corresponding Bid/Offer Acceptance unless the corresponding Flag Volume is less than 1 minute in duration, in which case it would be set to zero. The Imbalance Price Period Offer Volume ($QAOP^{kn}_{ij}$) or Imbalance Price Period Accepted Bid Volume ($QABP^{kn}_{ij}$) would be used to calculate Imbalance Prices SSP and SBP in Paragraph 4.4, replacing the Period Accepted Offer Volume (QAO^{kn}_{ij}) and Period Accepted Bid Volume (QAB^{kn}_{ij}).

The key features of this option are:

- All spurious Bid/Offer Acceptances caused by truncating National Grid instructions should be removed from the calculation of imbalance prices.
- The de minimis check would be applied on an acceptance-by-acceptance basis, not all acceptances of a particular Bid-Offer Pair in a half-hour.
- Genuine Bid/Offer Acceptances with a duration of < 1 minute are highly unlikely, therefore this option is unlikely to eliminate any genuine Bid/Offer Acceptances.
- De minimis Bid/Offer Acceptances would be excluded from price calculation, but payments associated with Bid/Offer Acceptances would be unaffected.
- Complex modification to both the BSC and the associated settlement software would take time to implement, thus allowing price spikes relating to this effect to continue in the short-term.

III. OPTION 2 - REMOVE BID/OFFER VOLUMES < 1MWh

Spurious Bid/Offer Acceptances are typically very small in volume, and only make a notable impact on imbalance prices when they are the only Bid/Offer registered in a given direction. A simple approach to removing the resulting price spikes is to disregard total acceptance volumes < 1MWh when calculating imbalance prices, and set the imbalance price to a default value.

Modification to the SBP Calculation

Under Section T, Paragraph 4.4 of the BSC, System Buy Price is calculated as follows:

$$SBP_j = \left\{ \sum_i \sum^n \{ QAO^{n}_{ij} * PO^{n}_{ij} * TLM_{ij} \} + BCA_j \right\} / \left\{ \sum_i \sum^n \{ QAO^{n}_{ij} * TLM_{ij} \} + BVA_j \right\}$$

If there are no actual Offer acceptances or energy purchases, $\sum_i \sum^n \{ QAO^{n}_{ij} * TLM_{ij} \} + BVA_j$ should equal zero and default rules for calculating SBP apply. However, the truncating of Bid Acceptance times can lead to the spurious acceptance of very small Offer volumes being registered by the settlement software. The equation above then applies, potentially setting the imbalance price to the price of the spurious Offer accepted.

This could be overcome by modifying Paragraph 4.4.5 as detailed in Appendix B to increase the de minimis volume for which the default rules apply from zero to 1 MWh. This should eliminate the spurious acceptance of Offer volumes and avoid the associated price spikes.

Modification to the SSP Calculation

It is also possible for the spurious acceptance of very small Bid volumes to occur and to affect the calculation of SSP. This could be overcome by modifying Paragraph 4.4.5 as detailed in Appendix B to increase the de minimis volume for which the default rules apply from zero to 1 MWh.

The key features of this option are:

- All spurious Bid/Offer Acceptances caused by truncating National Grid instructions should be removed from the calculation of imbalance prices.
- The de minimis check would be applied the aggregate of all acceptances in a given half-hour rather than on a more sophisticated acceptance-by-acceptance basis.
- Genuine Bid/Offer Acceptances with a volume of < 1MWh , although unlikely, would also be removed from the imbalance calculation.
- Payments associated with Bid/Offer Acceptances would be unaffected
- The required minor modifications to the BSC and associated settlement software could be implemented quickly, thus eliminating price spikes caused by these distortional effects in the short-term.

IV. PROPOSAL

Option 1 provides a more sophisticated solution in identifying spurious Bid/Offer Acceptances and removing these from the imbalance calculations. It carries very little risk of removing genuine Bid/Offer Acceptances. Option 2 is far simpler, applying a default price if the total volume of Acceptances in a given half-hour is less than 1MW. However, this option would remove genuine Bid Offer Acceptances from the imbalance price calculation. For this reason Option 1 is our preferred option.

Although both options run the risk of excluding genuine Bid/Offer Acceptances, and not excluding all spurious Bid/Offer Acceptances, we regard Option 1 as being marginally more effective.

However, Option 1 is complex and will take time to implement. Rather than allowing these distortional effects and associated price spikes to continue, we propose that the more straightforward Option 2 modification be adopted as soon as possible.

In the longer-term, it should be considered whether Option 1 should be pursued, or whether National Grid's operational systems could be modified to remove the truncating effect altogether.

APPENDIX A - OPTION 1 MODIFICATION PROPOSAL

Under the Option 1 proposal, Section T, Paragraph 3.8 of the BSC would be replaced as follows:

3.8	Determination of Period Accepted Offer Volume (QAO^{kn}_{ij}) and Period Accepted Bid Volume (QAB^{kn}_{ij})
3.8.1	In respect of each Settlement Period, for each BM unit i, each Bid-Offer Pair n and each Acceptance k, the Period Accepted Offer Volume (QAO^{kn}_{ij}) shall be established by integrating the accepted Offer Volume ($qAO^{kn}_{ij}(t)$) over all spot times in the Settlement Period.
3.8.1	In respect of each Settlement Period, for each BM unit i, each Bid-Offer Pair n and each Acceptance k, the Period Accepted Bid Volume (QAB^{kn}_{ij}) shall be established by integrating the accepted Bid Volume ($qAB^{kn}_{ij}(t)$) over all spot times in the Settlement Period.
3.8A	Determination of Price Accepted Offer Volume ($qAOP^{kn}_{ij}(t)$) and Price Accepted Bid Volume ($qABP^{kn}_{ij}(t)$)
3.8A.1	If, in relation to each Bid-Offer Acceptance k and Bid-Offer Pair n, for any spot time t
(i)	$qAO^{kn}_{ij}(t) \neq 0$, then, $qAOP^{kn}_{ij}(t) = 1$, otherwise
(ii)	$qAOP^{kn}_{ij}(t) = 0$.
3.8A.2	If, in relation to each Bid-Offer Acceptance k and Bid-Offer Pair n, for any spot time t
(i)	$qAB^{kn}_{ij}(t) \neq 0$, then, $qABP^{kn}_{ij}(t) = 1$, otherwise
(ii)	$qABP^{kn}_{ij}(t) = 0$.
3.8B	Determination of Price Period Accepted Offer Flag Volume ($FLAGO^{kn}_{ij}$) and Price Period Accepted Bid Flag Volume ($FLAGB^{kn}_{ij}$)
3.8B.1	In respect of each Settlement Period, for each BM Unit i, each Bid-Offer Pair n and each Acceptance k, the Price Period Accepted Offer Flag Volume ($FLAGO^{kn}_{ij}$) shall be established by integrating the Price Accepted Offer Volume ($qAOP^{kn}_{ij}(t)$) over all spot times in the Settlement Period.
3.8B.2	In respect of each Settlement Period, for each BM Unit i, each Bid-Offer Pair n and each Acceptance k, the Price Period Accepted Bid Flag Volume ($FLAGB^{kn}_{ij}$) shall be established by integrating the Price Accepted Bid Volume ($qABP^{kn}_{ij}(t)$) over all spot times in the Settlement Period.
3.8C	Determination Imbalance Price Period Accepted Offer Volume ($QAOP^{kn}_{ij}$) and Imbalance Price Period Accepted Bid Volume ($QABP^{kn}_{ij}$)
3.8C.1	In respect of each Settlement Period, for each BM Unit i, each Bid-Offer Pair n and each Acceptance k, the Imbalance Price Period Accepted Offer Volume ($QAOP^{kn}_{ij}$) shall be established as follows:
(i)	if $FLAGO^{kn}_{ij} > 1/30$ hours, then Imbalance Price Period Accepted Offer Volume ($QAOP^{kn}_{ij}$) shall be determined by integrating the Accepted Offer Volume

($qAO_{ij}^{kn}(t)$) over all spot times in the Settlement Period; otherwise

- (ii) the Imbalance Price Period Accepted Offer Volume ($QAOP_{ij}^{kn}$) shall be set to zero.

3.8C.2 In respect of each Settlement Period, for each BM Unit i, each Bid-Offer Pair n and each Acceptance k, the Imbalance Price Period Accepted Bid Volume ($QABP_{ij}^{kn}$) shall be established as follows:

- (i) if $FLAGB_{ij}^{kn} > 1/30$ hours, then Imbalance Price Period Accepted Bid Volume ($QABP_{ij}^{kn}$) shall be determined by integrating the Accepted Bid Volume ($qAB_{ij}^{kn}(t)$) over all spot times in the Settlement Period; otherwise
- (ii) the Imbalance Price Period Accepted Bid Volume ($QABP_{ij}^{kn}$) shall be set to zero.

3.8D Determination of Price Period BM Unit Total Accepted Offer Volume ($QAOP_{ij}^n$) and Price Period BM Unit Total Accepted Bid Volume ($QABP_{ij}^n$)

3.8D.1 In respect of each Settlement Period, for each BM Unit i, the total MWh volume each Offer accepted from all Acceptances shall, for the purposes of determination of energy imbalance prices, be the Price Period BM Unit Total Accepted Offer Volume ($QAOP_{ij}^n$) and shall be established as follows:

$$QAOP_{ij}^n = \sum^k QAOP_{ij}^{kn}$$

where \sum^k represents the sum over all Acceptances within the Settlement Period.

3.8D.2 In respect of each Settlement Period, for each BM Unit i, the total MWh volume each Bid accepted from all Acceptances shall, for the purposes of determination of energy imbalance prices, be the Price Period BM Unit Total Accepted Bid Volume ($QABP_{ij}^n$) and shall be established as follows:

$$QABP_{ij}^n = \sum^k QABP_{ij}^{kn}$$

where \sum^k represents the sum over all Acceptances within the Settlement Period.

Section T, Paragraphs 4.4 of the BSC would require modification to replace QAO_{ij}^n with $QAOP_{ij}^n$ and QAB_{ij}^n with $QABP_{ij}^n$, as follows:

4.4 Determination of Imbalance Prices (SBP_i and SSP_i)

4.4.1 In respect of each Settlement Period, the System Total Accepted Offer Volume will be determined as follows:

$$TQAO_j = \sum_i \sum^n QAOP_{ij}^n$$

where \sum_i represents the sum over all BM units and \sum^n represents the sum over all Bid-Offer Pair Numbers for the BM Unit.

4.4.2 In respect of each Settlement Period, the System Total Accepted Bid Volume will be determined as follows:

$$TQAB_j = \sum_i \sum^n QABP_{ij}^n$$

where \sum_i represents the sum over all BM units and \sum^n represents the sum over all Bid-Offer Pair Numbers for the BM Unit.

4.4.3 Unchanged

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4.4.5 In respect of each Settlement Period, if $\{\sum_i \sum^n \{QAOP_{ij}^n * TLM_{ij}\} + BVA_j\}$ not equal to zero then the System Buy Price will be determined as follows:

$$SBP_j = \left\{ \sum_i \sum^n \{QAOP_{ij}^n * PO_{ij}^n * TLM_{ij}\} + BCA_j \right\} / \left\{ \sum_i \sum^n \{QAOP_{ij}^n * TLM_{ij}\} + BVA_j \right\}$$

Where \sum_i represents the sum over all BM Units and where \sum^n represents the sum over those accepted Offers that are not Arbitrated Accepted Offers and not Trade Tagged Offers.

If for any Settlement Period $\{\sum_i \sum^n \{QAOP_{ij}^n * TLM_{ij}\} + BVA_j\}$ is equal to zero, then :

- (a) if for that Settlement Period $\{\sum_i \sum^n \{QABP_{ij}^n * TLM_{ij}\} + SVA_j\}$ is equal to zero, the System Buy Price for that Settlement Period will be equal to zero;
- (b) otherwise, the System Buy Price will be determined as the maximum of System Sell Price and:
 - (i) the Offer Price of the cheapest Offer available in that Settlement Period:
 - (1) which has a positive Bid-Offer Pair Number; and
 - (2) which has an Offer Price greater than the Offer Price of any Offer which is an Arbitrage Accepted Offer in respect of that Settlement Period; and
 - (3) for which the value of Bid-Offer Volume (qBO_{ij}ⁿ(t)) is greater than zero for all spot times t in that Settlement Period;
 - (ii) or, if no such Offer exists, zero.

4.4.6 In respect of each Settlement Period, if $\{\sum_i \sum^n \{QABP_{ij}^n * TLM_{ij}\} + SVA_j\}$ is not equal to zero then the System Sell Price will be determined as follows:

$$SSP_j = \left\{ \sum_i \sum^n \{QABP_{ij}^n * PB_{ij}^n * TLM_{ij}\} + SCA_j \right\} / \left\{ \sum_i \sum^n \{QABP_{ij}^n * TLM_{ij}\} + SVA_j \right\}$$

Where \sum_i represents the sum over all BM Units and Where \sum^n represents the sum over those accepted Bids that are not Arbitrated Accepted Bids and not Trade Tagged Bids.

If for any Settlement Period $\{\sum_i \sum^n \{QABP_{ij}^n * TLM_{ij}\} + SVA_j\}$ is equal to zero , then :

- (a) if for that Settlement Period $\{\sum_i \sum^n \{QAOP_{ij}^n * TLM_{ij}\} + BVA_j\}$ is equal to zero, the System Sell Price for that Settlement Period will be equal to zero;
- (b) otherwise, the System Sell Price will be determined as the maximum of System Buy Price and:

- (i) the Bid Price of the most expensive Bid available in that Settlement Period:
 - (1) which has a negative Bid-Offer Pair Number; and
 - (2) which has an Bid Price less than the Bid Price of any Bid which is an Arbitrage Accepted Bid in respect of that Settlement Period; and
 - (3) for which the value of Bid-Offer Volume ($qBO_{ij}^n(t)$) is less than zero for all spot times t in that Settlement Period;
- (ii) or, if no such Bid exists, zero.

4.4.7 In respect of each Settlement Period, the Total Accepted Priced Offer Volume will be determined as follows:

$$TQPAO_j = \sum_i \sum_{ij}^n QAOP_{ij}^n$$

Where \sum_i represents the sum over all BM units and \sum_{ij}^n represents the sum over those accepted Offers that are not Arbitrated Accepted Offers and not Trade Tagged Offers.

4.4.8 In respect of each Settlement Period, the Total Accepted Priced Offer Volume will be determined as follows:

$$TQPAO_j = \sum_i \sum_{ij}^n QABP_{ij}^n$$

Where \sum_i represents the sum over all BM units and \sum_{ij}^n represents the sum over those accepted Bids that are not Arbitrated Accepted Bids and not Trade Tagged Bids.

4.4.9 In respect of each Settlement Period, the Total Arbitrage Volume will be determined as follows:

$$TAQ_j = \sum_i (\sum_{ij}^n QABP_{ij}^n - \sum_{ij}^{n*} QAOP_{ij}^{n*})/2$$

Where \sum_i represents the sum over all BM units and \sum_{ij}^n represents the sum over those accepted Bids that are Arbitrated Accepted Bids and \sum_{ij}^{n*} represents the sum over those accepted Offers that are Arbitrated Accepted Offers.

4.4.9 In respect of each Settlement Period, the Total Trade Tagged Volume will be determined as follows:

$$TCQ_j = \sum_i (\sum_{ij}^n QABP_{ij}^n - \sum_{ij}^{n*} QAOP_{ij}^{n*})/2$$

Where \sum_i represents the sum over all BM units and \sum_{ij}^n represents the sum over those accepted Bids that are Trade Tagged Bids and \sum_{ij}^{n*} represents the sum over those accepted Offers that are Trade Tagged Offers.

Annex T-1 would also require modification to align with the modifications detailed above.

APPENDIX B - OPTION 2 MODIFICATION PROPOSAL

Under the Option 2 proposal, Section T, Paragraph 4.4.5 and 4.4.6 of the BSC would be modified as follows:

4.4.5 In respect of each Settlement Period, if $\{ \sum_i \sum^n \{ QAO_{ij}^n * TLM_{ij} \} + BVA_j \}$ is **greater than 1MWh** then the System Buy Price will be determined as follows:

$$SBP_j = \left\{ \sum_i \sum^n \{ QAO_{ij}^n * PO_{ij}^n * TLM_{ij} \} + BCA_j \right\} / \left\{ \sum_i \sum^n \{ QAO_{ij}^n * TLM_{ij} \} + BVA_j \right\}$$

Where \sum_i represents the sum over all BM Units and where \sum^n represents the sum over those accepted Offers that are not Arbitrated Accepted Offers and not Trade Tagged Offers.

If for any Settlement Period $\{ \sum_i \sum^n \{ QAO_{ij}^n * TLM_{ij} \} + BVA_j \}$ is **less than or equal to 1MWh**, then :

- (a) if for that Settlement Period $\{ \sum_i \sum^n \{ QAB_{ij}^n * TLM_{ij} \} + SVA_j \}$ is greater than or equal to -1MWh, the System Buy Price for that Settlement Period will be equal to zero;
- (b) otherwise, the System Buy Price will be determined as the maximum of System Sell Price and:
 - (i) the Offer Price of the cheapest Offer available in that Settlement Period:
 - (1) which has a positive Bid-Offer Pair Number; and
 - (2) which has an Offer Price greater than the Offer Price of any Offer which is an Arbitrage Accepted Offer in respect of that Settlement Period; and
 - (3) for which the value of Bid-Offer Volume ($qBO_{ij}^n(t)$) is greater than zero for all spot times t in that Settlement Period;
 - (ii) or, if no such Offer exists, zero.

4.4.6 In respect of each Settlement Period, if $\{ \sum_i \sum^n \{ QAB_{ij}^n * TLM_{ij} \} + SVA_j \}$ is **less than -1MWh** then the System Sell Price will be determined as follows:

$$SSP_j = \left\{ \sum_i \sum^n \{ QAB_{ij}^n * PB_{ij}^n * TLM_{ij} \} + SCA_j \right\} / \left\{ \sum_i \sum^n \{ QAB_{ij}^n * TLM_{ij} \} + SVA_j \right\}$$

Where \sum_i represents the sum over all BM Units and Where \sum^n represents the sum over those accepted Bids that are not Arbitrated Accepted Bids and not Trade Tagged Bids.

If for any Settlement Period $\{ \sum_i \sum^n \{ QAB_{ij}^n * TLM_{ij} \} + SVA_j \}$ is **greater than or equal to -1MWh**, then :

- (a) if for that Settlement Period $\{ \sum_i \sum^n \{ QAO_{ij}^n * TLM_{ij} \} + BVA_j \}$ less than or equal to 1MWh, the System Sell Price for that Settlement Period will be equal to zero;
- (b) otherwise, the System Sell Price will be determined as the maximum of System Buy Price and:

- (i) the Bid Price of the most expensive Bid available in that Settlement Period:
 - (1) which has a negative Bid-Offer Pair Number; and
 - (2) which has an Bid Price less than the Bid Price of any Bid which is an Arbitrage Accepted Bid in respect of that Settlement Period; and
 - (3) for which the value of Bid-Offer Volume ($qBO_{ij}^n(t)$) is less than zero for all spot times t in that Settlement Period;
- (ii) or, if no such Bid exists, zero.