The Merit Order Constraints Explanation

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nationalgridESO

Introduction to this document

In the design phase of the Frequency Response Auction Trial algorithm (i.e. HELENA), one series of specific constraints which are called “merit order constraints” were required to be added to the algorithm. The stated ambition was to minimise total cost in the long-term by maximising competition through maximising transparency. At that time, we believed this rule will encourage participants to use the simple bidding strategy and lead to better market transparency.

This document aims at explaining how these constraints work and illustrate their consequences with the real market results from FFR weekly auctions.

What are Merit Order Constraints?

Merit order constraints aim at giving priority to specific orders, named “basic blocks”, and at defining priorities among those “basic blocks”. Those priorities were also assumed to limit the number of Paradoxically Rejected Blocks (PRB).

Key Concepts

To explain how merit order constraints are defined, we need to detail the below concepts:

- Basic and Non-Basic blocks
- Merit order ID
- Lower and upper bids

Basic and Non-Basic blocks

Basic blocks are defined as either:

a. Non-curtailable single period block
    - Modelled as a single period C01 block

b. Partially curtailable single period block
    - Modelled as a single period C01 block linked to a C02 block
    - C01 and C02 blocks are each considered as a basic block
    - Both blocks must have the same period and the same price. Otherwise, they are not considered as basic blocks

Example:

As shown in Figure 1 below, assume 9 orders (Order A-I) are received in EFA1.

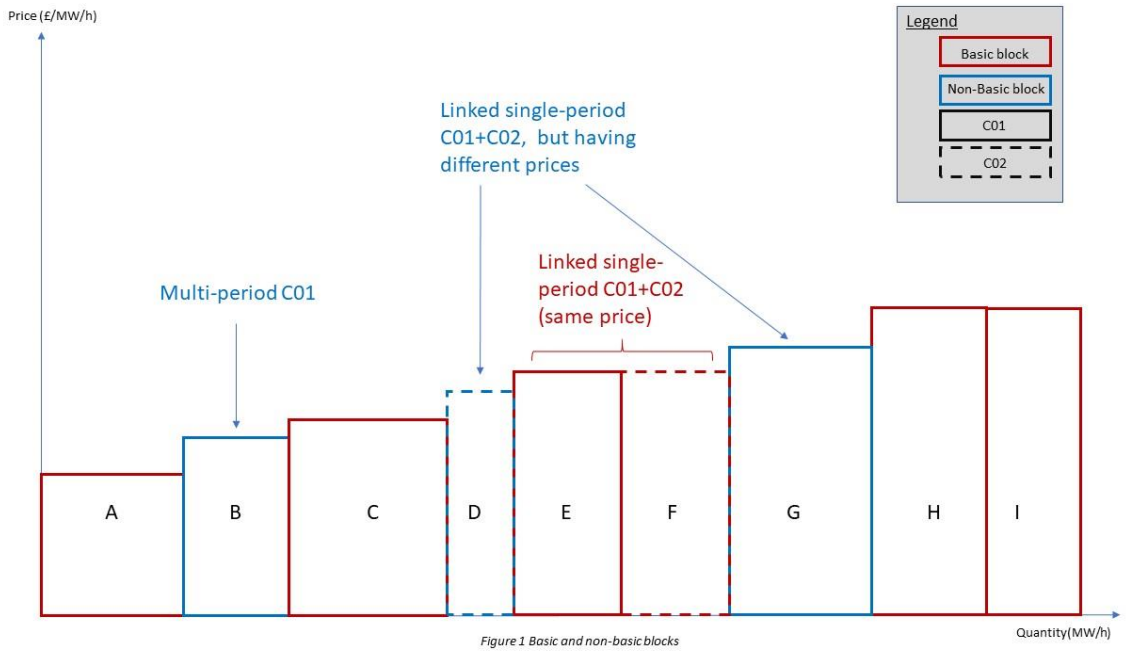


Figure 1 Basic and non-basic blocks

There are 6 basic blocks in this example (outlined in red): A, C, E, F, H, I. Order B, D, and G are non-basic blocks (outlined in blue)

Order A, C, H, and I are non-curtailable single period blocks (definition a).

Order E and F are partially curtailable single period block (definition b), modelled as a single period C01 block (E) linked to a C02 block (F) and having the same EFA period and same price, thus they can be treated as basic blocks.

Order B is a multi-period C01 block. Thus, it is a non-basic block.

Order D and G are partially curtailable linked family blocks that are in the same EFA period but having different prices, thus cannot be considered as basic blocks.

To sum up:

Block type	Basic block	Non-basic block
Single period C01 block	✓	
Multi-period block		✓
Linked C01+C02 with same EFA period and same price	✓	
Partially curtailable single period block (i.e. linked C01+C02 with same EFA period) with different prices		✓
Multi-period linked family with a single period parent + a single period child (before or after its parent's EFA period [not represented in figure 1]		✓

Merit order ID

A Merit order id (MO id) is set for each **basic block** by the algorithm (non-basic block doesn't have merit order id). In the below example (Figure 2), only order A, C, E, F, H and I are basic blocks and being given MO ids.

For partially curtailable single period block, both blocks that constitute this basic block, C01 and C02, have the same MO id (order E &F in below example).

Description of the merit order id:

- Merit order ids are positive integers
- Merit order ids are defined by the EFA period
- Merit order id increases with the price of the block (as only sell orders are considered here)

MO id of basic block "A" < merit order id of basic block "C", this means order A is "better" than order C. Thus, A will be given priority over C.

When multiple basic blocks have the same price, their merit order ids will be given **randomly** (while still being lower than more expensive blocks and higher than less expensive blocs). Please see order H & I in the below figure as an example.

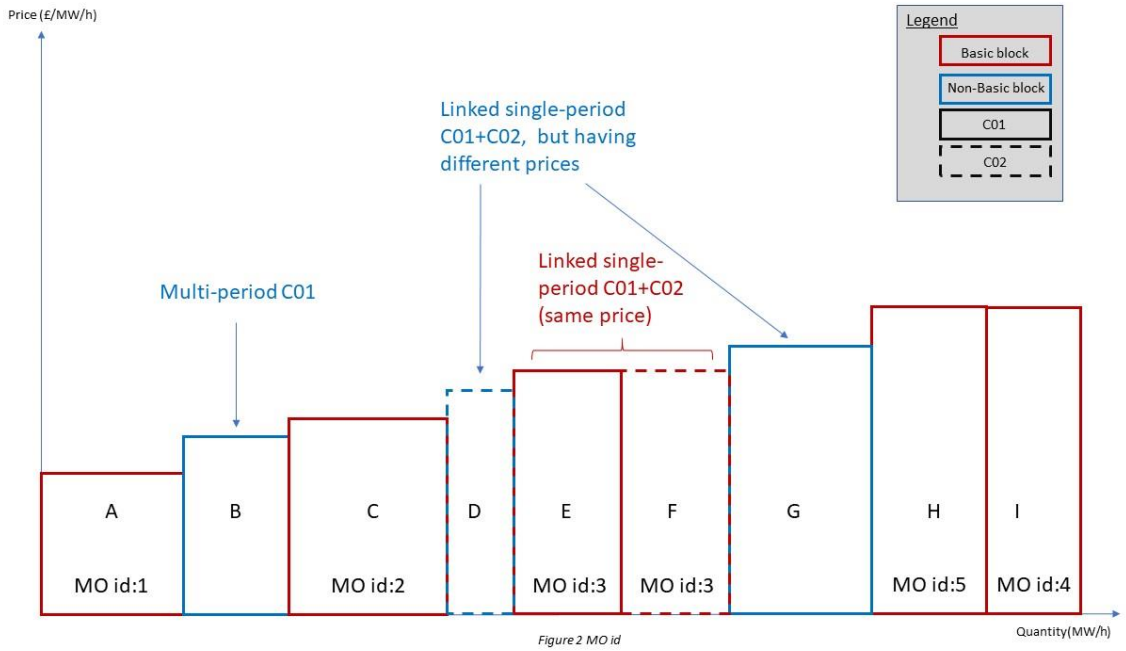


Figure 2 MO id

Lower and Upper bids

Assume we have a reference block, Block "R" (only basic block can be the reference block)

Lower bids: a set of bids defined in the same period as block "R", including:

- All basic blocks with merit order id strictly lower than the merit order id of "R"
- The parent C01 block of "R", if "R" is a C02 block
- All non-basic C01 blocks with a price strictly lower than the price of "R"

- All non-basic C02 blocks that both its price and its parent C01 block price are strictly lower than the price of “R”

Note: the parent C01 block price is only considered if this C01 block is also defined in the same period “R”. Otherwise, only the C02 block price is considered.

Upper bids: a set of bids defined in the same period as “R”, including:

- All basic blocks with merit order id strictly greater than the merit order id of “R”
- The child C02 block of “R” if “R” is a C01 block
- All non-basic C01 blocks with a price greater than or equal to the price of “R”
- All non-basic C02 blocks such that either its price or its parent C01 block price is greater than or equal to the price of “R” if defined in the period of “R”.

Note: the parent C01 block price is only considered if this C01 block is also defined in the same period “R”. Otherwise, only the C02 block price is considered.

Example 1: If the reference block “R” is a C01 block

Assume order E is our reference block “R”.

Order A, and C are its lower bids as their merit order ids are strictly lower than “R”.

Order B as it’s a non-basic C01 blocks with a price strictly lower than the price of “R”.

Even though order D’s price is lower than “R”, order D is the upper bid. That is because order D is the non-basic C02 block, price of its parent C01 block (order G) is greater than “R”’s price.

Order G is a non-basic C01 block with a greater price than “R”, so G is the upper bid as well.

Order F is the child block of “R”. Even it has the same MO id as “R”, it is “R”’s upper bid.

Order H and I are the upper bids as their merit order ids are strictly higher than “R”.

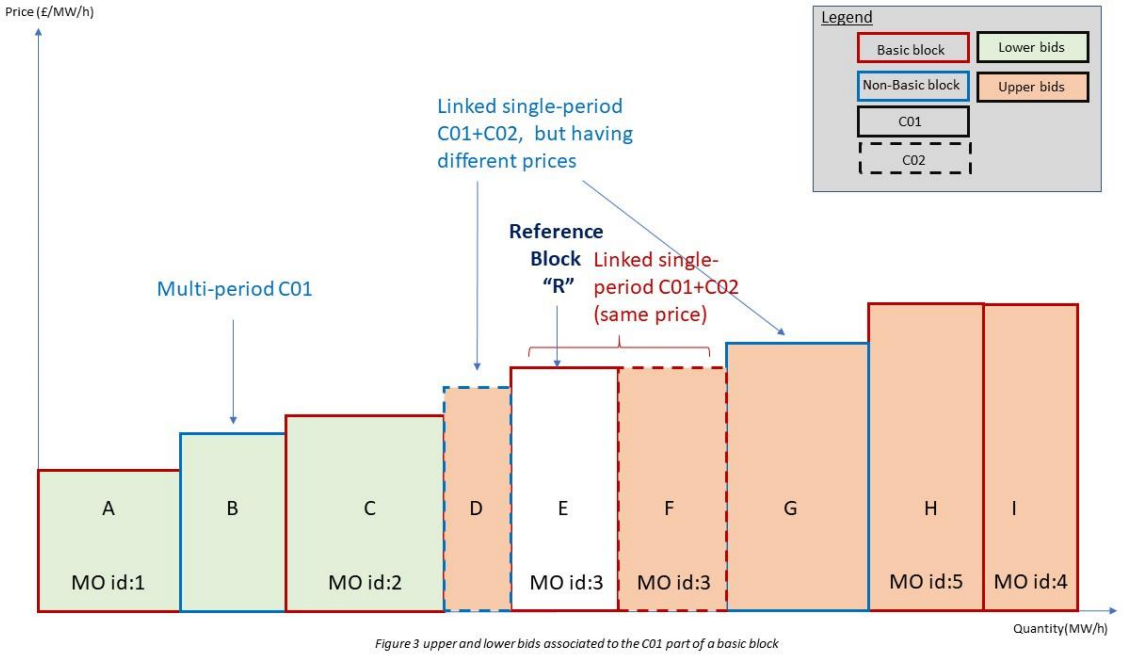


Figure 3 upper and lower bids associated to the C01 part of a basic block

Example 2: If the reference block "R" is a C02 block

Assume order F is our reference block "R".

Order A, and C are its lower bids as their merit order ids are strictly lower than "R".

Order B as it's a non-basic C01 blocks with a price strictly lower than the price of "R".

Order E is the parent block of "R". Even it has the same MO id as "R", it is "R"'s lower bid.

Even though order D's price is lower than "R", order D is the upper bid. That is because order D is the non-basic C02 block, price of its parent C01 block (order G) is greater than "R"'s price.

Order G is a non-basic C01 block with a greater price than "R", so G is the upper bid as well.

Order H and I are the upper bids as their merit order ids are strictly higher than "R".

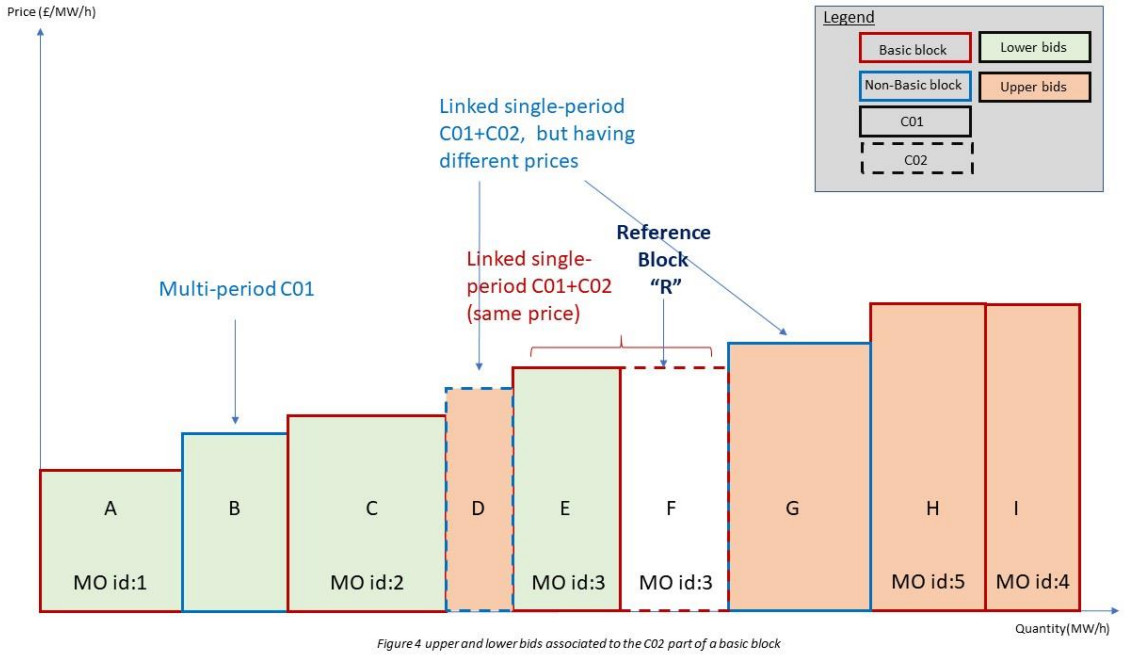


Figure 4 upper and lower bids associated to the C02 part of a basic block

How merit order constraints work

For any basic blocks, two constraints will be applied in case of rejection:

1. Satisfaction of the merit order constraints within the block orders
2. Maximization of the traded volume regarding basic blocks

Non-curtailable basic C01 block

If a non-curtailable basic C01 block gets rejected, below 2 constraints will be triggered:

1. The **sum** of accepted quantities of the upper bids must be less than the block quantity.
2. The demand at the block price or more expensive than the block price minus the sum of accepted quantities of the Lower bids must be less than the block quantity.

Example:

Let's add a 2-step NGESO buy curve to Figure 3. Assume the reference block "R" (i.e. order E) is rejected.

To satisfy the first constraint, only order I can be accepted because it's the only upper block with a less volume than "R". But this situation is not feasible because the order I's selling price is greater than ESO's buy price (segment 2's price), thus it cannot be paradoxically accepted (i.e. Paradoxically Accepted Blocks constraint). Order D cannot be accepted as it is the child block of order G which is rejected.

We observe that accepting "R" does not add any surplus/welfare to the auction (because its price is the same as NGESO's buy price on segment 2). So, from a pure welfare maximization point of view, at optimality it could be either accepted or rejected.

But because of the second constraint, only when the demand at the block price or more expensive than the block price (segment 2 + segment 1's volume) is less than the sum of

accepted quantities of the lower bids + reference block "R"'s volume (Vol. A + Vol. B), the "R" can be rejected. In this example, it isn't the case. Thus, we must accept "R".

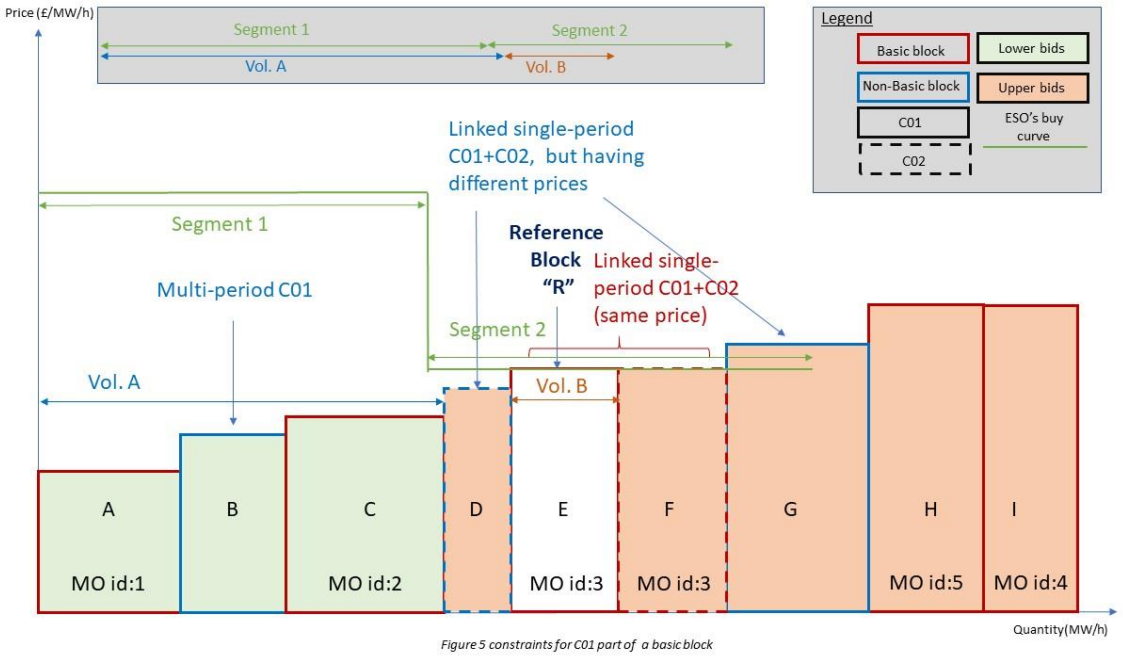


Figure 5 constraints for C01 part of a basic block

As a conclusion, in this case the application of merit order constraints led to accept the reference block (E), even if it does not generate any market welfare.

Fully curtailable basic C02 block

If a fully-curtailable basic C02 block gets rejected or partially accepted while its parent C01 block is accepted, below 2 constraints will be triggered:

1. All its Upper bids must be rejected.
2. The unserved demand at the block price must be 0

Example:

Let's add a 2-step NGESO buy curve to Figure 4. Assume the reference block "R" (i.e. order F) is rejected while its parent order E is accepted.

To fulfil constraint 1, all its upper bids (blocks in orange colour- order D, G, H, and I) will be rejected.

We observe that accepting this reference block does not add any surplus/ welfare to the auction (because its price is the same as NGESO's buy price on segment 2). Thus, from a pure welfare maximization point of view, "R" could be either accepted or rejected.

But using constraint 2, rejecting is only possible if the "unserved demand at the block price" equals zero. In other words, segment 2 should be totally accepted. This situation is unfeasible without breaching other constraints of the algorithm (e.g. Paradoxically Accepted Blocks constraints, which means order G cannot be accepted at a price lower than its selling price). Therefore, the reference block "R" will be fully accepted.

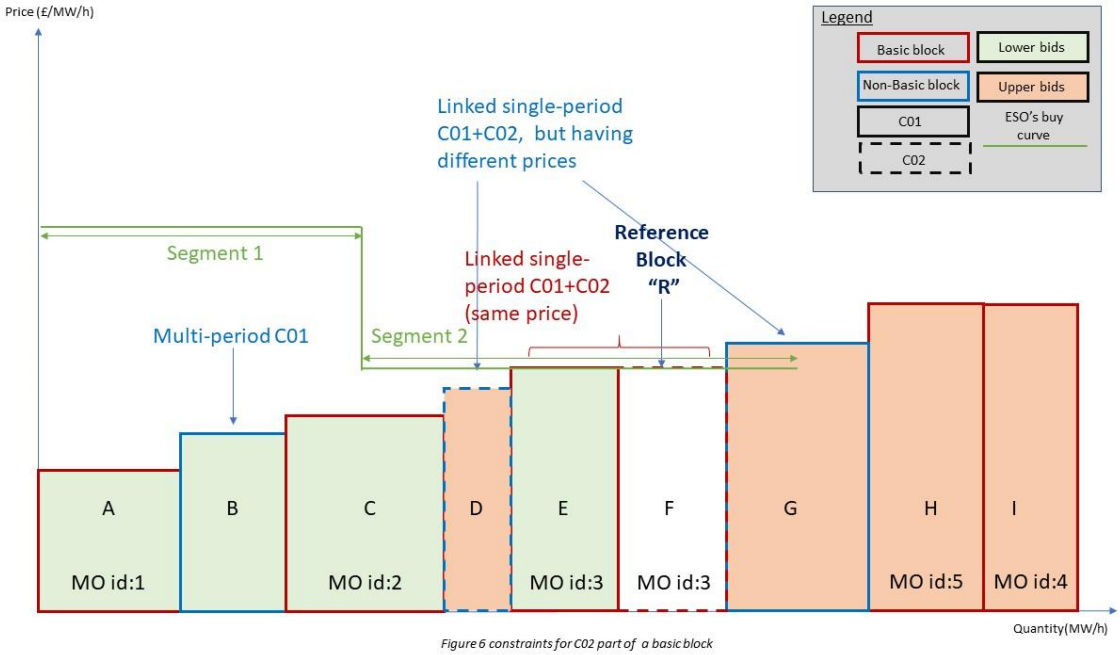


Figure 6 constraints for C02 part of a basic block

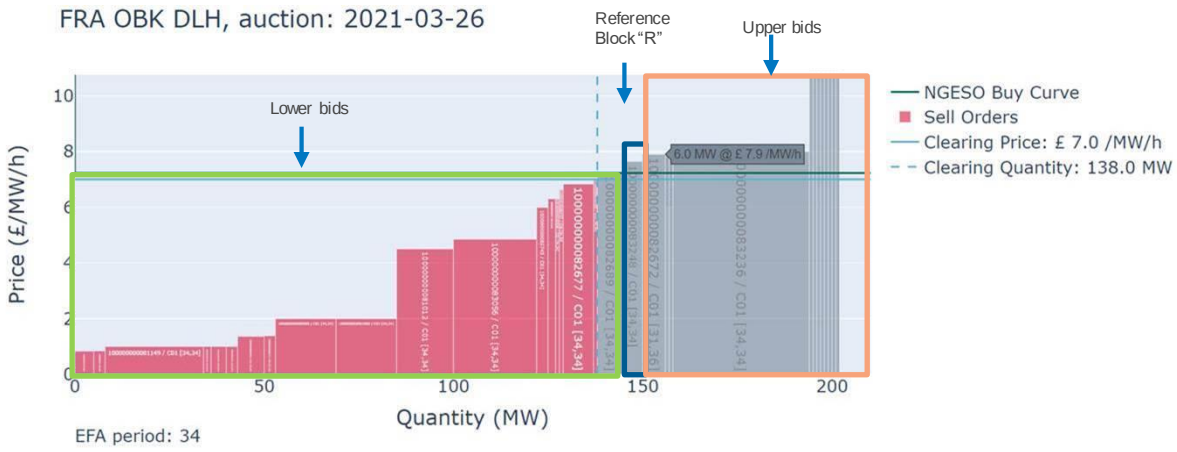
As a conclusion, in this case the application of merit order constraints led to accept the reference block (F), even if it does not generate any market welfare.

Example from the FFR weekly auctions

Let's have a look at the DLH results of the March 26th 2021 auction, EFA day 6.

Order 82672 was a multi-period block order across EFA periods 31 to 36 with a sell price of £7.9. ESO's average cap price for that day was £8.29. And volume constraint was not an issue. In theory, this order could be accepted. However, it got rejected due to the Merit Order Constraints.

In EFA period 34:



The reference block ("R"), a single period non-curtailable order- order 83248 (5MW @7.64/MW/h), was rejected due to its sell price was higher than ESO's cap price in that period (£7.23) and ESO buy order cannot be paradoxically accepted.

Order 82672 was part of the upper bids of the reference block ("R"), as order 82672 was a non-basic block (mult-period order) and it was more expensive than order 83248.

According to the constraint that was mentioned on page 6: if a non-curtailable basic block is rejected, the sum of accepted quantities of the upper bids must be less than the block quantity. In this case, the block quantity of the basic block was 5WM. So, the maximum volume the algorithm can accept from its upper bid was 5MW. The size of order 82672 (6MW) was bigger than that allowance. Rejection of 83248 means 82672 cannot be accepted otherwise merit order constraints would be breached.

Also order 82672 was spanning across multiple periods. Because it was rejected in EFA period 34 and multi-period blocks must be accepted or rejected in all periods in which they are defined, it was rejected in all EFA periods 31 to 36.