I-SEM TRIALLING OF EUPHEMIA:

COMMERCIAL PHASE REPORT

31/05/2016

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2 EXECUTIVE SUMMARY

The I-SEM Trialling of EUPHEMIA is an analysis project conducted by SEMO at the request of the Regulatory Authorities (RAs). The project involves trialling the EUPHEMIA[1] algorithm using orders (bids and offers) implemented within the system. The overall goal of the trialling is to develop the understanding of SEMO, industry, the RAs and any other relevant stakeholders with respect to the functioning of the algorithm. The trialling was divided into two phases:

- **The Initial Phase –** trials performed by SEMO and reported on in the Initial Phase report[2]
- **The Commercial Phase –** trials performed by SEMO in conjunction with industry

This document outlines the methodologies, assumptions, analysis and findings of the Commercial Phase. The goal of the Commercial Phase was to expand on the findings of the Initial Phase report, to allow for direct participation by participants in creation of order data, through the I-SEM EUPHEMIA working group, and to arrive at a view as to the implementation of the day-ahead market for the I-SEM. The views expressed in this document are the combined views of SEMO and I-SEM EUPHEMIA working group. If, following the publication of this report, individual working group members have additional views on the I-SEM Trialling of EUPHEMIA which they wish to be published, these will be published by SEMO alongside this report.

Analysis in the I-SEM trialling of EUPHEMIA has involved taking SEM commercial and technical data and converting these into EUPHEMIA orders, executing day-ahead market simulations based on these orders as well as the other European order books and analysing the results of the EUPHEMIA sessions. While orders in EUPHEMIA can be used for any unit type, SEM units were represented in the trials in the following manner:

- **Simple orders –** price quantity pair (PQ pair) values with no attached conditions used for a range of units;
- **Complex orders –** PQ pair values with commercial and technical conditions used for thermal units;
- **Linked block orders –** interlinked blocks of energy used for thermal and storage units; and
- **Exclusive group orders –** groups of mutually exclusive blocks of energy used for thermal units.

For simple orders, the trials have found that these may be appropriate for a range of units in the I-SEM including hydro units, wind units, peaker thermal units and supplier units. However, simple orders do not provide sufficient representation of unit operation and risk mitigation measures for mid-merit or baseload thermal units and do not allow for the preferred modelling of storage units.

For complex orders, the trials have found that these may be appropriate for baseload and mid-merit thermal units. While these orders could be used for other unit types, the conditions which make complex orders differ from simple orders are likely to be required by mid-merit and baseload thermal units only. Due to the specific technical and commercial data of these units in the I-SEM, the commercial conditions (fixed and variable minimum income condition) were of greater importance than the technical characteristics. The commercial phase has shown that units can alter PQ pair values in their complex orders to account for profiling and to help mitigate risks of adverse scheduling. Complex orders also consistently provided more stable market results reflective of the underlying conditions of the market.

For block orders (both linked block and exclusive group orders), the findings have indicated that these orders

[1] EUPHEMIA is the day-ahead market algorithm currently in use to calculate energy allocations and prices across Europe developed by the Price Coupling of Regions (PCR) initiative.

[2] http://www.sem-o.com/Publications/General/I-SEM%20Trialling%20of%20EUPHEMIA%20-%20Initial%20Phase%20Report.pdf

provide advantages to participants in representing their units as they can exert a good level of control over their scheduling and cost recovery.

However, EUPHEMIA sessions which only used block orders for thermal units showed a lack of stability in price formation in some cases. This was mitigated in sessions which had full access to the interconnectors and which had a high liquidity of price making simple orders (e.g. demand and wind orders). While the level of interconnection for the I-SEM is predictable, the level of liquidity of simple orders is not known at this time. In the absence of a measure to ensure adequate liquidity of simple orders to support stable price formation with block orders, it is the view of SEMO and the I-SEM EUPHEMIA working group that a solution using block orders and simple orders only may not be the most appropriate for the I-SEM. However, due to the positive attributes of block orders in representing units, a solution using block orders and complex orders could provide an appropriate I-SEM solution. There is evidence from the trials that a solution using complex orders, block orders and simple orders in combination will allow for the maximum flexibility to I-SEM participants while still providing appropriate pricing and scheduling outcomes.

It is the view of SEMO and the I-SEM EUPHEMIA working group that the following EUPHEMIA order types should be implemented in the I-SEM day-ahead market:

- Simple orders;
- Complex orders (including all complex conditions);
- Block orders;
- Linked block orders; and
- Exclusive group orders.

Note that this is subject to the caveat that the final implementation of the day-ahead market for the I-SEM will be subject to testing and approval of the price coupling of regions (PCR) initiative.

3 INTRODUCTION

EUPHEMIA is the day-ahead market (DAM) pricing algorithm currently in use throughout Europe. It was developed by the Price Coupling of Regions (PCR) initiative, an organisation of European power exchanges. The use of EUPHEMIA for the DAM in the I-SEM is outlined in the SEM Committee's decision on the high level design (HLD) for the I-SEM (SEM-14-015A). While the use of EUPHEMIA is mandated by the HLD, the precise application is to be decided in the implementation phase.

EUPHEMIA allows for a number of different formats of bids and offers, collectively referred to as orders, each of which has related characteristics and limitations. The Regulatory Authorities (RAs) requested SEMO, in their role as market operator of the SEM, member of EUROPEX and associate member of the PCR, to investigate the feasibility of possible applications of EUPHEMIA orders for the I-SEM DAM.

The trails were broken into an Initial Phase, being those performed by SEMO with passive industry engagement, and the Commercial Phase, being those trials performed by SEMO with active industry engagement. In September 2015, SEMO published the I-SEM Trialling of EUPHEMIA Initial Phase Report[3]. This outlined the assumptions, inputs, results and findings of all trials completed as part of the Initial Phase.

This report describes the Commercial Phase of the I-SEM trialling of EUPHEMIA including process, assumptions, inputs, results, analysis and conclusions. The findings and conclusions contained herein have been agreed between SEMO and the I-SEM EUPHEMIA working group and represent the consensus opinion of parties involved. This report concludes with the view of SEMO and the I-SEM EUPHEMIA working group in relation to the implementation of EUPHEMIA for the I-SEM DAM.

4 GOAL OF TRIALS

The primary goal of the I-SEM trialling of EUPHEMIA is for market participants and SEMO to gain first-hand experience in the formation of orders and related strategies for EUPHEMIA and to share the key learnings gained with all relevant stakeholders. This will involve investigating the feasibility and quality of the algorithm using different order types, noting that:

- By feasibility, we mean whether certain characteristics of the I-SEM can be represented in EUPHEMIA;
- By quality, we mean the degree that the algorithm produces an outcome that aligns with the policy objectives of the I-SEM in terms of efficiency of prices and volumes, stability of prices and volumes, etc.

While this is subject to the order formats and other characteristics of EUPHEMIA and their limitations, the objective of this trail is to, as best as possible, represent SEM data in EUPHEMIA orders and assess the results of doing so. This is not to be considered that this is an objective of the I-SEM design decisions of the SEM Committee.

While the I-SEM will have multiple market timeframes, and the liquidity of each timeframe is currently unclear, the trials assessed the I-SEM DAM on the assumption that it is fully liquid based on the SEM values (i.e. all generators and suppliers in the SEM will be represented with orders in the trials). As the trials looked at DAM results only, assessment of the effects of DAM liquidity and clearance on other market timeframes was not investigated though the results should be considered in this context.

[3] http://www.sem-o.com/Publications/General/I-SEM%20Trialling%20of%20EUPHEMIA%20-%20Initial%20Phase%20Report.pdf

The Commercial Phase is broken into two subsections, namely the Scripted Trials and the Unscripted Trials. The key distinction between these subsections is the nature of the involvement of the I-SEM EUPHEMIA working group[4]. During the Scripted Trials, all input data is prepared by SEMO in accordance with the relevant trial scripts. A trial script is a high level outline of the assumptions to be used in a particular trial, or set of trials, and is agreed in advance with the I-SEM EUPHEMIA working group.

During the Unscripted Trials, working group members prepare their own input data which is not subject to a shared set of assumptions (i.e. each working group member can apply their own bespoke strategy). While the overall goal of the trials is shared, the Scripted and Unscripted Trials have distinct goals which are outlined below.

It is the goal of the Scripted Trials to expand on the learnings of the Initial Phase, increase the understanding of the implications of different order types among working group members and to prepare working group members for successful participation in the Unscripted Trials.

It is the goal of the Unscripted Trials to allow working group members to actively participate in the process of creating order types and to assess how working group members choose to use these to interact with EUPHEMIA.

5 SCOPE OF TRIALS

As the I-SEM Trialling of EUPHEMIA is an analysis project performed by SEMO, in conjunction with industry, on behalf of the RAs, the scope of trials needed to be agreed between SEMO and the RAs to ensure the goals of the project were adequately delivered. To accommodate the goals outlined in section 4, and to deliver the project in a timeframe which would allow for informed participation in the I-SEM implementation phase by all parties, a scope of work was discussed with industry and agreed between SEMO and the RAs. This scope of work took into account the following:

- The feedback of the I-SEM EUPHEMIA working group on SEMO proposals for scope;
- Available time and resources to deliver the work;
- The complexity of the tasks involved;
- Availability of EUPHEMIA through SEMO's interactions with APX; and
- The timeliness of final delivery of the project.

The Commercial Phase was divided into two sections, the Scripted Trials, being those trials completed subject to a trial script[5], and the Unscripted Trials, being those trials which were not subject to a trial script. To allow for sufficient trial datasets (referred to as sessions in EUPHEMIA), 350 datasets were assigned to the Scripted Trials while 28 datasets were assigned to the Unscripted Trials. To maximise the access to EUPHEMIA, multiple datasets were executed in EUPHEMIA at the same time in a trial batch. The Scripted Trials were broken into four batches (one of 50 datasets and three of 100 datasets) and the Unscripted Trials were broken into two trial batches (each of 14 datasets).

[4] The I-SEM EUPHEMIA working group was set up in April 2015 and has representatives from 17 companies and the Regulatory Authorities. Terms of reference are available here:
http://www.sem-o.com/Publications/General/Terms%20of%20referrence%20- %20ISEM%20EUPHEMIA%20Working%20Group.pdf

[5] A trial script is a document which outlines assumptions and methods to be followed in executing a trail to an agreed set of parameters, usually with an expected outcome

For each batch, the following steps were performed:

- Create order data for all units in the SEM according to the agreed process for that batch;
- Convert order data into a format which can be uploaded to EUPHEMIA;
- Execute the order data in EUPHEMIA and extract the results;
- Convert the results from EUPHEMIA format [6]to a non-anonymous format;
- Perform price, schedule and cost analysis on the market results for all days in the trial batch; and
- Assess the analysis against any expected results.

The scope agreed took account of these tasks, their complexity, any communication and planning activities between SEMO and the I-SEM EUPHEMIA working group and relevant contingency. The individual goals of each trial batch were agreed between SEMO and the I-SEM EUPHEMIA working group at the start of that batch and analysis was targeted at assessing these goals. While some supplementary analysis was performed (outlined in section 7.9.1), analysis performed was subject to this scope and should be considered in relation to the goals of the project and of each trial batch. For any issues encountered during analysis, the issue was assessed against its effects on assessment of the goals. Where the effect caused a significant effect to assessment of the goal, the batch (or relevant datasets) was rerun subject to the contingency built into the scope. Where the effect caused an insignificant effect to the desired assessment, the effect was noted in the trial script[7] and communicated to the I-SEM EUPHEMIA working group. For issues with insignificant effects, it was considered out-of-scope to investigate solving the encountered issue.

6 ASSUMPTIONS

This section outlines the overarching assumptions used across all trial batches in the Commercial Phase. As a general rule, the overarching assumptions are the same as those outlined in section 5 of the Initial Phase report. Where the findings of the Initial Phase, or insights drawn from discussions with PCR members, have led to a change to an overarching assumption, this is outlined in section 5 of this report.

6.1 REPRESENTATION OF THE I-SEM

As outlined in section 5.1 of the Initial Phase report, an assumption of the Initial Phase was that SEM costs would be represented in the orders used in the I-SEM trialling of EUPHEMIA. This included representing costs in a manner in line with the SEM bidding code of practice (BCOP) and attempting to structure orders in such a way that cost recovery was guaranteed, as best possible.

As outlined in the Initial Phase report, using BCOP compliant orders reduced the potential risk mitigation strategies which could be employed using EUPHEMIA order types. To allow for better understanding of how these EUPHEMIA order types can be best used, and to account for the fact that the I-SEM DAM will inherently carry more risk than the SEM, the following principles which were represented in the Initial Phase were not applied in all cases in the Commercial Phase:

- Generators orders are based on COD and TOD submitted for the Trading Day; and
- The bidding code of practice (BCOP) is applied, as best possible, through use of commercial data from the SEM.

[6] In EUPHEMIA orders are entered anonymously. However, for use by market participants, the orders need to be converted after EUPHEMIA is executed to allow for analysis and comparison to unit based inputs

[7] The trial script for all batches of the Scripted Trials will be published alongside this report as an addendum along with inputs and outputs

This assumption was relaxed in order to allow for identified areas for further study from the Initial Phase which required a deviation from the SEM BCOP and was not included to assess the SEM BCOP itself. While the commercial and technical data of the SEM still forms the basis of the orders created to represent units, other factors may be taken into account as further outlined on a case by case basis in section 7. As the SEM COD is not the only factor in prices and quantities, orders may not adhere to the BCOP (e.g. offer prices may reflect elements other than a unit's short run marginal cost).

6.2 SUMMARY OF KEY ASSUMPTIONS

A summary of the key assumptions used throughout the project are presented in table 1, below.

Assumption	Detail
Generators will use a range of orders	Use simple orders, block orders and complex orders as applicable in the scenario. Accordingly, the full volume of generator orders will be split among these order types
Suppliers will use simple orders only	All supplier unit orders will be entered as simple orders. As opposed to generators, the full volume of supplier orders will be included in the aggregated curve
Blocks will be limited per day	A generator may submit a maximum of twelve blocks per day. These are divided into eight hour segments and by number of price quantity pairs (i.e. a unit with two price quantity pairs will be split into 6 blocks of 8 hours each)
Generators will use one complex order	Relevant generators will use one complex order per day and will use all conditions available
Mid-merit and baseload will use complex/block orders	Mid-merit thermal and baseload thermal plant will use complex or block orders as the scenario requires. This accounts for approximately 20 to 25 units depending on the day (i.e. approximately 20 to 25 complex orders or 200 to 250 blocks)
Storage units will use linked blocks	Storage units will use a series of linked blocks which link sell orders in later hours to buy orders in earlier hours to account for their ability to buy and sell energy
Generators will seek to recover their costs	Generator orders will be created to attempt to recover the unit's costs subject to the assumptions of the trial scenario
Interconnectors will use SEM values	Where applicable, interconnectors will be represented using the values for ramping, capacity and losses applicable in the SEM on the historical day investigated
SEM trading days will be used	Data will be entered on a 06:00 – 06:00 basis with hour one in EUPHEMIA being 06:00. Generators will take their initial position from the end of the previous SEM trading day
Historical order book information will be used	Other markets will be represented by coupling the I-SEM order book to their historical order book. No changes will be made to these order books

Table 1: summary of key assumptions used throughout the project

7 SCRIPTED TRIALS

The Scripted Trials represent those trials which followed a trial script, a high level document outlining assumptions to be used in creation of data, which has been agreed between SEMO and the I-SEM EUPHEMIA working group.

There were a total of 350 trial datasets investigated as part of the Scripted Trials, amounting to the largest number of trial datasets investigated in either the Commercial Phase or the Initial Phase. The 350 trial datasets were broken into four trial batches with batch one containing 50 trial datasets and each other batch containing 100 trial datasets.

The process for creation of data followed the below steps.

- SEMO and the I-SEM EUPHEMIA working group review the findings of the previous trials and agree high level set of assumptions for the next batch which is codified as a trial script.
- SEMO creates the necessary input data following this trial script, converts this to the necessary formats for execution in EUPHEMIA and sends these files to APX for execution.
- APX execute the received files, and other files necessary to represent the order books of other relevant power exchanges (PXs), in EUPHEMIA and provide SEMO with the relevant algorithm outputs.
- SEMO converts the EUPHEMIA data to a format which can be analysed by the working group.
- SEMO and the I-SEM EUPHEMIA working group analyse outputs and discuss findings at the next working group meeting.

This process was performed for each batch in the Scripted Trials with the results of the previous batch informing the trial script of the current batch. An illustration of this process, and the actors involved in each step, is included as figure 1 below.

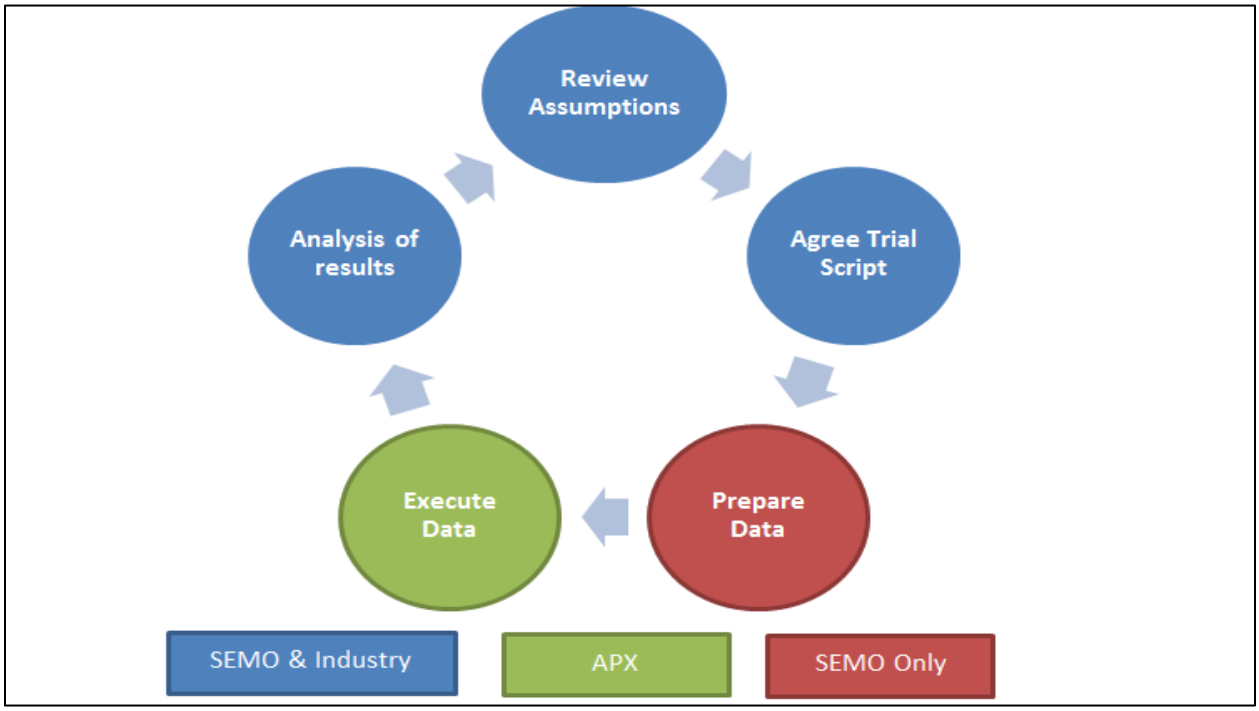


Figure 1: Illustration of the process for Scripted Trials

For the Scripted Trials, it was decided to investigate a number of historical SEM trading days which represented a range of conditions (e.g. high wind, low demand etc.) across the year. To allow for a number of days for comparison, and avoid bias towards a particular set of conditions, ten historical days were chosen for batch one. The list of days chosen is outlined in table 2 below.

Date	Condition
22/06/2014	Summer Weekend – Low Demand/Low Wind
06/07/2014	Summer Weekend – Low Demand/Average Wind
24/01/2015	Winter Weekend – High Demand/High Wind
03/11/2014	Winter Weekend – High Demand/Average Wind
25/12/2014	Winter Weekday – Average Demand/Average Wind
25/11/2014	Winter Weekday – High Demand/Low Wind
19/09/2014	Autumn Weekday – Average Demand/Low Wind
05/10/2014	Autumn Weekday – Average Demand/High Wind
11/04/2015	Spring Weekend – Average Demand/High Wind
14/03/2015	Spring Weekend – Average Demand/Low Wind

Table 2: List of trading days investigated in the Scripted Trials

To allow for the efficiencies required to deliver the agreed number of batches within the timeframe of the programme, datasets investigated in subsequent batches of the Scripted Trials were required to be drawn from the same historical trading days. This allowed for orders (and other data) which had already been created to be reused. However, for subsequent trials it was decided to reduce the number of historical days investigated per batch to allow for different iterations of order type conditions to be investigated. The list of trading days investigated in batches two, three and four are presented in table 3 below.

Date	Condition
22/06/2014	Summer Weekend – Low Demand/Low Wind
24/01/2015	Winter Weekend – High Demand/High Wind
25/11/2014	Winter Weekday – High Demand/Low Wind
11/04/2015	Spring Weekend – Average Demand/High Wind
14/03/2015	Spring Weekend – Average Demand/Low Wind

Table 3: List of trading days investigated in the Unscripted Trials

It should be noted that the range of dates which could be investigated was subject to the agreement required with PCR to allow use of order book data from other PXs. Any historical days investigated were required to be at least three months in the past at the time of trialling; consequently, a greater range of dates was available at the start of the Unscripted Trials than at the start of the Scripted Trials and the dates used were updated accordingly as outlined in section 8.

7.1 BATCH ONE – INPUTS

The primary purpose of batch one of the Scripted Trials was to build on the findings of the Initial Phase and begin to investigate the identified areas for further study. The main areas of focus were:

- Investigation of the effects of price making demand;
- Investigation of the effects of mixing complex and block orders; and
- Investigation of the effects of price making wind.

To allow for this, a trial script was devised and agreed with the I-SEM EUPHEMIA working group. Detail of the assumptions used for batch one are outlined below.

7.1.1 PRICE MAKING DEMAND

Due to the lack of data on price making demand, it was agreed that batch one would act, primarily, as a proof of concept for price making demand. Consequently, the assumptions used were chosen in order to show the effects of demand setting the price rather than to assess a scenario which is necessarily reflective of I-SEM behaviour.

In the Initial Phase, one of the primary issues encountered related to the number of price makers represented by the assumptions used. Essentially, as wind and demand were entered as price takers, there were situations where there were insufficient price making orders to support stable price formation in block order datasets, as the units represented by block orders could not directly set the price themselves. Additionally, having price taking demand represented a single sided auction and did not investigate the possibilities of the doubled sided auction supported by EUPHEMIA.

To account investigate this, for batch one 50% of the demand was entered as price taking orders and 50% as price making orders; this was chosen to provide a large volume of demand and to assess if this provided sufficient price making volume for appropriate block order price formation.

The price used was based on the average SEM system marginal price (SMP) with a multiplier, on the assumption that suppliers would want to curtail themselves in the DAM if the price moved too far away from the average price. The bid price used was chosen to be 1.2 times the average SMP for the day. The bids of demand are outlined in table 4 below.

Demand Share	Price
50%	€3,000 (price cap)
50%	1.2 * Daily Average SMP

Table 4: Demand bids for batch one of the Scripted Trials

7.1.2 MIX OF COMPLEX AND BLOCK ORDERS

Block orders, either linked block or exclusive group order, as appropriate, were used for the following list of units was submitted using block orders in batch one:

- GU_400270 – GU_400272;
- GU_400850;
- GU_400930;
- GU_500822; and
- GU_500823.

Complex orders were used for the remaining non-peaker thermal units. This was used to provide a mix of units using each type of order. For block orders, a portion of the baseload plant (outlined above) was chosen to allow for sufficient block orders without having full block representation to allow for assessment of mixing with complex orders.

7.1.3 PRICE MAKING WIND

For price making wind orders, a price of €0 was used with volumes continuing to be taken from the wind forecast. This was based on the assumption that wind units in the I-SEM would be unlikely to want exposure to negative prices. This marks a move away from SEM based bidding as in the SEM wind units would be exposed to any price in the relevant range (-€100 to €1,000 for the SEM) which includes exposure to negative prices.

If wind units wish to participate in the DAM, they will need to actively enter orders based on their forecast volumes. Therefore, it is reasonable to assume that at least some wind participants will want to manage the prices entered. In the absence of reliable cost information, as the units are entered as price takers in the SEM, it was agreed to trial these units on the basis of incurring no costs.

The goal of entering the units at a price of €0 (i.e. the units will clear at any price above €0) was to assess if these units acting as price makers at a low price would have a material effect on the results.

7.2 BATCH ONE – RESULTS

7.2.1 PRICE MAKING DEMAND

The price making demand entered had a large effect on price formation in batch one of the Scripted Trials. Across all sessions in the batch, 54% of trading periods had partial clearance of demand; this means that in a majority of trading periods the price was set by the demand price.

As a single price was used per day, this meant that the market clearing price was the same in multiple hours within a given trading day. This is illustrated in figure 2 below.

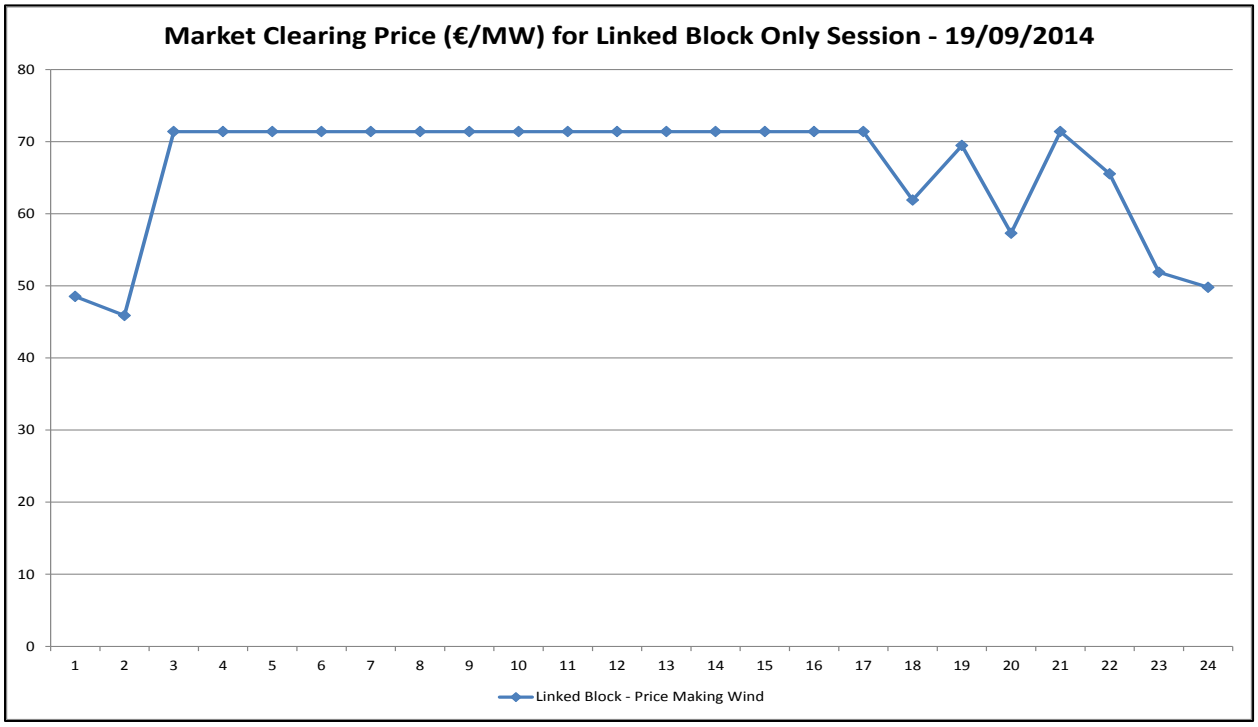


Figure 2: Market Clearing Price for Linked Block Only Session – 19/09/2014

As can be seen in figure 2, demand set the price in 16/24 trading periods based on a single bid. While this effect was most commonly seen in sessions using linked block orders only for thermal units, it was also observed in sessions using a mix of complex and block orders for thermal units.

The frequent occurrence of partial clearing of demand was caused by two main factors:

- The relatively low bid price due to the use of a daily average; and
- The large availability of volume in all hours.

As the bid price was based on a daily average of SMP, demand set the price more commonly at peak hours when the price rises above the daily average. This is illustrated in figure 3 below which shows the level of demand which is cleared in each hour across all sessions in batch one.

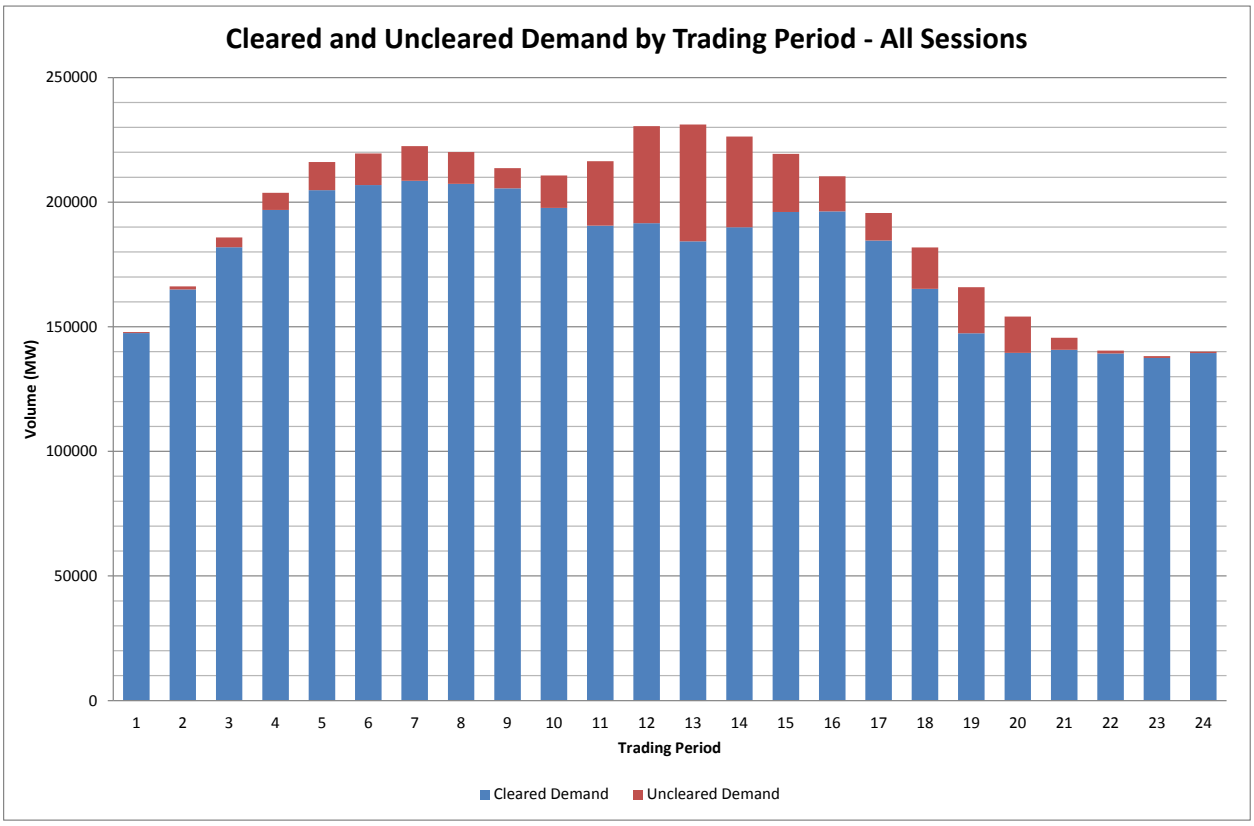


Figure 3: volumes of cleared demand per trading period in batch one of the Scripted Trials

As can be seen in figure 3, full demand is remains uncleared across all trading periods. However, there is a higher volume of uncleared demand between hours 6 (12:00) and 20 (02:00) with the highest volumes occurring over the evening peak in load (i.e. hours 12 to 14).

It should be noted in reviewing the level of cleared demand that, the full load forecast (which is assumed to be representative of the total load for this exercise) was entered as either a price maker or as a price taker. Consequently, any demand which does not clear in the DAM would need to clear in other market timeframes (e.g. if a supplier does not secure their forecast position in the DAM, they would need to do so in intraday or be in imbalance).

While demand was partially cleared in the majority of trading periods (demand was partially cleared in 54% of all trading periods), it was not curtailed for the full 50% of total volume available at this price. The total volume of uncleared demand across sessions with price making demand was [7.3% of the total demand]. As per EUPHEMIA's objective function, demand (and supply) is in all cases cleared to the point which maximises social welfare across all bidding zones. Figure 4 below shows the total level of cleared demand per session in batch one of the Scripted Trials.

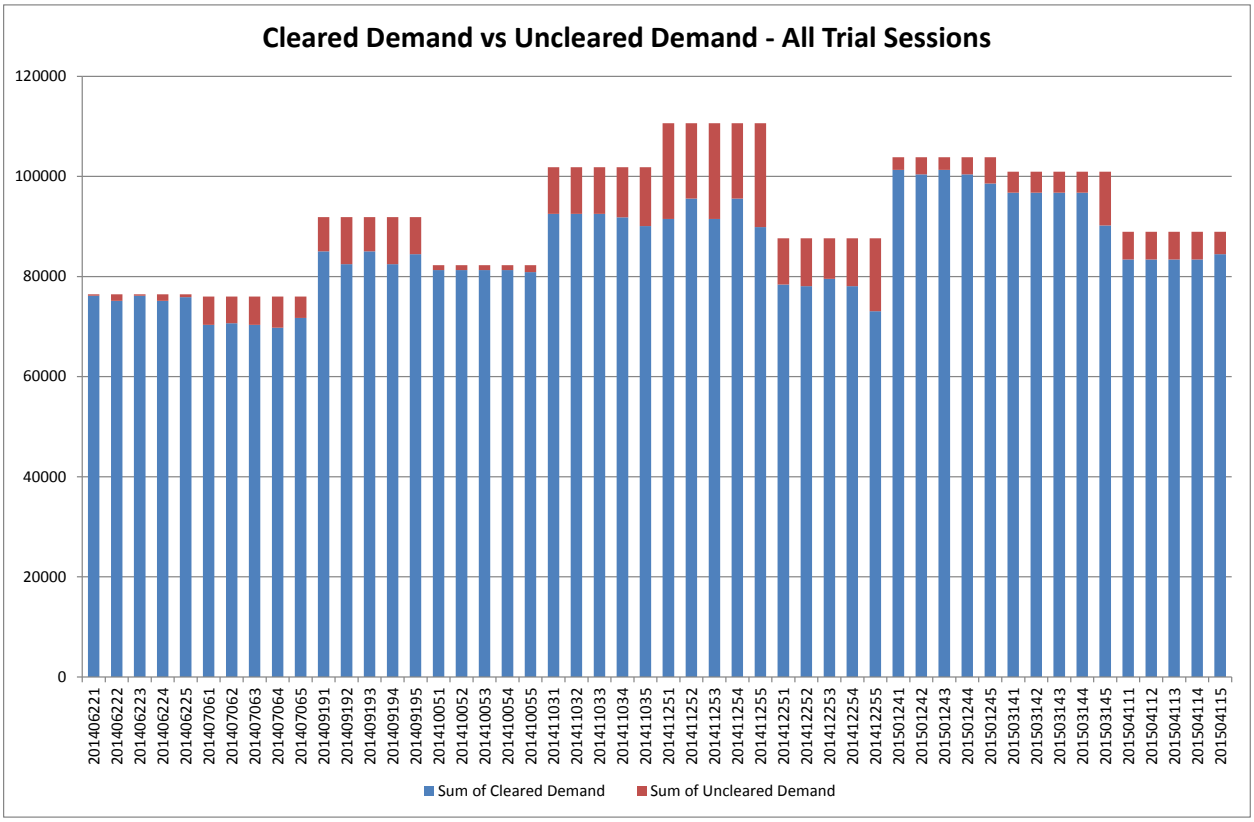


Figure 4: volumes of cleared demand per session in batch one of the Scripted Trials

As can be seen in figure 4, sessions which relate to the same trading day have a similar overall level of cleared demand. While variations can be seen based on the order type used for sessions on the same trading day, figure 4 indicates that the level of cleared demand in batch one is more closely linked to the underlying wind and load conditions of the trading day than to the order types used by market participants.

A further effect of the price entered for demand was that peaker thermal units were not scheduled in any trading periods in batch one of the Scripted Trials. Due to the average price used for calculation of the demand price (1.2 times average SMP), demand was consistently priced below the offer price of peaker units (typically approximately €250 to €300). Due to the low price and high volume of demand, peaker units were not scheduled across any of the sessions in batch one of the Scripted Trials.

Following discussion with the I-SEM EUPHEMIA working group, it was agreed that the volume and price of demand would be altered for subsequent batches to allow for a more appropriate representation of supplier behaviour. The agreed adjustments were:

- A smaller proportion of demand would take part as a price maker;
- Average prices would be on a per trading period basis (i.e. each hour would use the average price of SEM trading periods relating to that hour) to represent the cost of scarcity; and
- More than one price interval would be investigated.

7.2.2 MIX OF COMPLEX AND BLOCK ORDERS

There were no significant effects on the use of different order types as trialled in batch one of the Scripted Trials. Figure 5, below, shows the hourly prices observed across all sessions for a single trading day using multiple different order type representations.

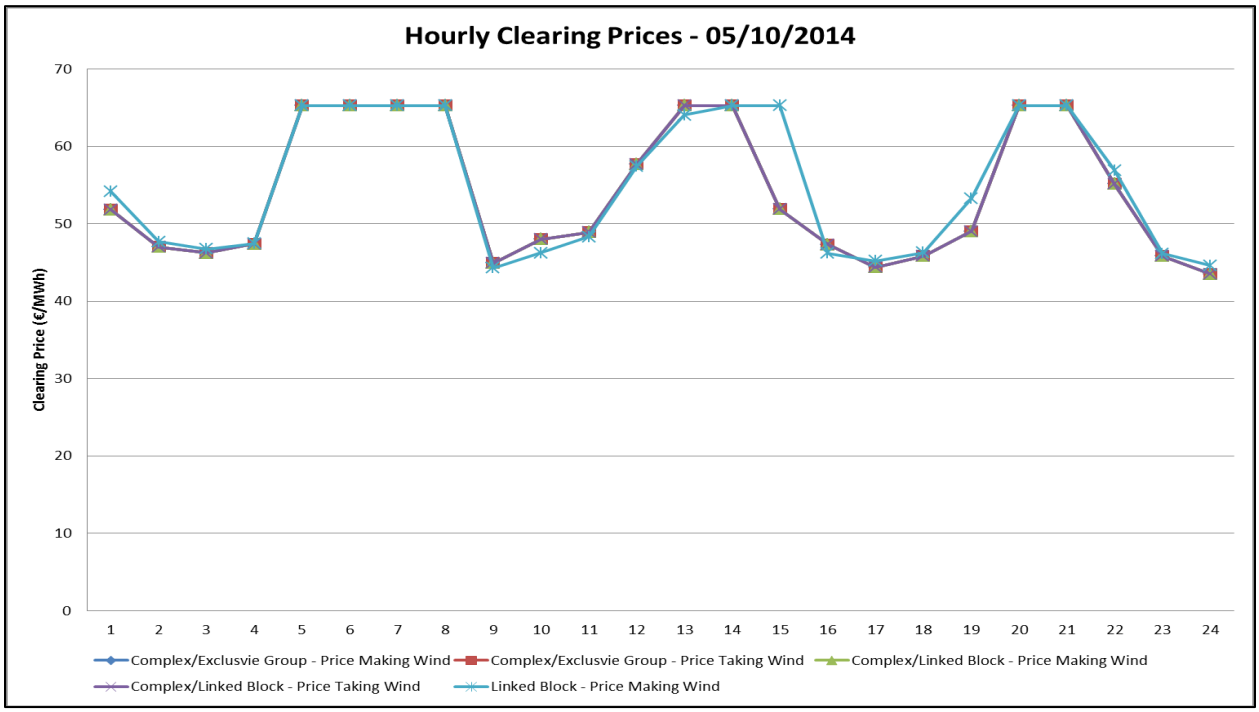


Figure 5: Hourly clearing prices for all sessions relating to 05/10/14 in batch one of the Scripted Trials

As can be seen in figure 5, the prices observed are very similar regardless of the orders used. As demand set the price in a number of hours in each session (8 periods per session and an additional period in the linked block only session), the price volatility in batch one of the Scripted Trials was low.

Following discussion with the I-SEM EUPHEMIA working group, it was decided to further investigate mixes of linked block and complex orders as well as continuing to investigate solutions using each in isolation from the other.

7.2.3 PRICE MAKING WIND

Wind did not directly set the price in any trading periods in batch one of the Scripted Trials and cleared fully in all trading periods. This was due to the fact that the price did not drop below the offer price of €0 in any trading period in any of the sessions. It should be noted that an offer price of €0 is still a price making order (i.e. the full range of prices -€500 to €3000 is not offered) even where this is accepted in all trading periods. The results seen for wind at an offer price of €0 are consistent with the results seen from hydro orders which offer at a similar price (i.e. where pricing results are stable, prices do not drop below zero in most cases and these orders will be fully accepted).

Following discussion with the I-SEM EUPHEMIA working group, there was a desire from wind representatives in the working group to investigate a more commercially focused pricing strategy for wind (i.e. prices based on wanting to receive a floor price based on market averages) and the effect this has on the scheduling of wind.

7.3 BATCH TWO – INPUTS

The primary purpose of batch two of the Scripted Trials was to build on the findings of the batch one and to further investigate the identified areas for further study. The main areas of focus were:

- Further investigation of price making demand including comparison to price taking demand;
- Investigation of including different cost elements in the variable term of complex orders;
- Investigation of the effects of manipulating price quantity pairs in complex orders to mitigate scheduling risk; and
- Investigation of the effects of using a minimum acceptance ratio[8] (MAR) level below 100%.

To allow for this, a trial script was devised and agreed with the I-SEM EUPHEMIA working group. Detail of the assumptions used for batch two is outlined below.

7.3.1 PRICE MAKING DEMAND

Following the results in relation to price making demand from batch one of the Scripted Trials, it was decided to further investigate the effects of this with a smaller volume and different pricing. In order to isolate the effects of price making demand, corresponding price taking demand sessions were included for comparison. The approach taken was as follows:

- Each scenario (i.e. shared set of assumptions across numerous EUPHEMIA sessions) would be completed with a price taking and price making demand scenario (i.e. each change to an assumption on block or complex orders would be trialled with price making and price taking demand separately);
- Any prices would be based on an hourly SMP average (i.e. the price in hour 12 would be based on the average SMP of 18:00 and 18:30[9]);
- For price making sessions, 90% of demand would be price taking with the other 10% price making; and
- The 10% price making volume would be split into 1% increments in a price range of 1.6 to 2.5 times SMP.

[8] A minimum acceptance ratio is a value between 0 and 1 denoting the minimum percentage of the volume of a block which must be accepted for the block to be accepted.

[9] As outlined in the Initial Phase report, the baseline approach is that the SEM trading day (06:00 to 06:00) is used such that hour 1 in EUPHEMIA aligns with 06:00 in the I-SEM as represented.

The increase in the price at which demand bid was due to the large number of trading periods in which demand was price setting in batch one as well as the batch one prices being lower than peaker thermal units, thereby effectively excluding those units.

The increased number of increments with different prices was chosen due to the single price being set throughout several trading days in batch one. Furthermore, an hourly average was used to reflect scarcity in certain hours which is not reflected using a single daily average.

This approach was taken on the assumption that the above measures would provide a more accurate representation of demand than in batch one of the Scripted Trials and allow for assessment of the effect of price making demand beyond the proof of concept values used in batch one. Finally, comparison to price taking versions of each session would allow the effects of price making demand to be isolated from other observed effects.

7.3.2 PRICE MAKING WIND ORDERS

Following the results of batch one of the Scripted Trials, it was agreed to investigate the implications of wind units participating in a commercially focused manner. In this regard, while the majority of wind would participate as a price taker, a portion would participate on a price making basis. The following arrangements were used to represent wind:

- 80% of the wind portfolio would participate on a price taking basis;
- The remainder would participate as price makers with a number of price intervals;
- The intervals would each have 1% of remaining demand;
- The first 15% would increase in increments of €7 from -€100 to €5; and
- The last 5% would increase in increments of €6 from €5 to €35.

This is illustrated in figure 6, below, which shows an illustrative example of the aggregate supply curve used for batch 2 of the Scripted Trials. As this is the range in which hydro units offer into the DAM, the volumes of wind and hydro are aggregated in the price range -€100 to €35.

Figure 6: illustration of the aggregate simple order supply curve used for batch two of the Scripted Trials

The main goal with this treatment was to see what the effect on the DAM would be if wind units were to enter in the DAM with prices which may exclude them from the schedule in certain hours. The rationale here is that, as wind units will be able to participate in the IDM and have priority dispatch, they may not wish to commit to low prices in the DAM. Without clear indications of how wind will be incentivised, or the relative prices across market timeframes, this was viewed as a possible outcome of the DAM.

7.3.3 COMPLEX ORDER MINIMUM INCOME CONDITON [10](MIC) VALUES

For the Initial Phase and batch one of the Scripted Trials, complex orders were created with no-load costs being assumed to be a fixed cost and included in the fixed term of complex orders. To account for this, an assumed number of no-load costs must be included as the profile of the unit is unknown at the time of creation of orders. The assumption made was that 24 no-load costs be included; this allowed for the highest possible cost representation to help mitigate the risk of cost under-recovery. However, this high level of cost representation may result in units, which could otherwise run for a small number of hours over the peak, not being committed. While this is the outcome of the market, subject to input values, certain units may benefit from using different assumptions about no-load costs in terms of their scheduling.

Following discussion with the I-SEM EUPHEMIA working group, it was decided to investigate ways to include the no-load cost in the variable term rather than the fixed term of the minimum income condition (MIC) of complex orders. The advantage of this approach would be that are if certain units were only in-merit for a small number of hours, the total MIC considered would be lower (i.e. the no-load would be for running hours only, rather than 24 as a baseline) while still representing the underlying costs.

The variable term (VT) MIC is a per MW cost value. There is no per start or per hour cost which applies to complex orders; therefore, in order to include the no-load cost in the variable term, a method for applying no-load costs based on volume was required. To account for this, two methods were investigated:

- Divide the no-load cost by the minimum stable generation, providing full cost representation at low volumes (option 1); and
- Divide the no-load cost by the maximum availability of the unit for the trading day, providing the lowest representation of no-load cost to allow for more flexible scheduling (option 2).

Altering the costs being represented in EUPHEMIA would alter the schedules and prices produced as well as affecting the risks faced by the units. Two items were of primary interest in this regard:

- The effect on prices and scheduling of altering the VT without changing other elements; and
- The effect on cost recovery of scheduled units of altering the VT.

7.3.4 COMPLEX ORDER PRICE QUANTITY PAIRS

The Initial Phase report outlined the risks which can be encountered in using SEM price quantity pairs in complex orders. In short, as less detailed information can be explicitly represented in complex orders than in the SEM, without implicitly including this information the schedules (and their costs) produced may be considered adverse.

[10] The minimum income condition (MIC) of a complex order is a condition attached to the order which denotes a minimum amount of income which must be received for the order to be accepted. A MIC has a fixed term, entered on a per order basis, and a variable term (VT), entered on a per MW basis.

The primary issue encountered in the Initial Phase results in this regard was the issue of units being scheduled for multiple starts within a single trading day which, as the cost of only a single start was included in the fixed term, led to the unit under-recovering their costs in the DAM.

To account for this risk in the DAM, participants would need to implicitly account for the costs/risk they face in putting together their complex orders. This would involve accounting for the cost of shutting down and starting up in the offered prices outlined in the price quantity pairs, i.e. a unit may be willing receive a low price to remain on at their minimum stable generation level and avoid a shutdown despite running below their marginal cost in some hours. As outlined in section 6.1, this required relaxing the assumption that the SEM BCOP was applied to orders. The price quantity pairs can be altered in this way at low risk to cost recovery as the MIC will ensure that the unit overall is recovering the required cost, based on the assumptions used to create the MIC.

For example, Generator A offers into the DAM at €30 for 100MW. For simplicity we assume that, Generator A is scheduled for 100MW in the hours at which the cleared price is above €30 and is scheduled for zero MW when the price is below €30. This is illustrated in figure 7 below.

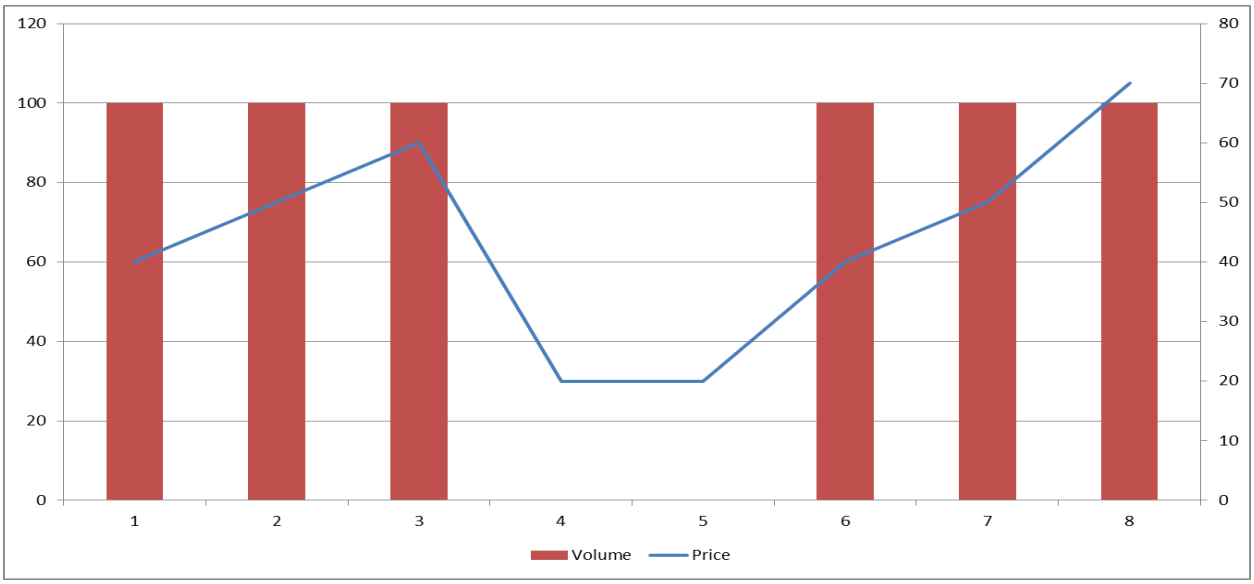


Figure 7: Illustrative example of unit scheduling with one price quantity pair

As Generator A has not accounted for the cost of the shutdown seen in figure 7 in their MIC, they will not be guaranteed to recover this cost and, if the cost of the shutdown and start-up is greater than the revenue received, may not recover all of their costs. As Generator A receives revenue above their €30 offer price in most hours, they would be willing to receive less revenue when the price drops to €20 in order to avoid the shutdown as their expected variable and fixed costs will be covered by their MIC ensuring recovery of these costs.

To account for this, Generator A introduces a new price quantity pair to their curve. This is at a price of zero and a quantity of their minimum stable generation. This will ensure that when the clearing price drops in hours 4 and 5, the unit is not shutdown but instead moved to their minimum stable generation. This is illustrated in figure 8 below.

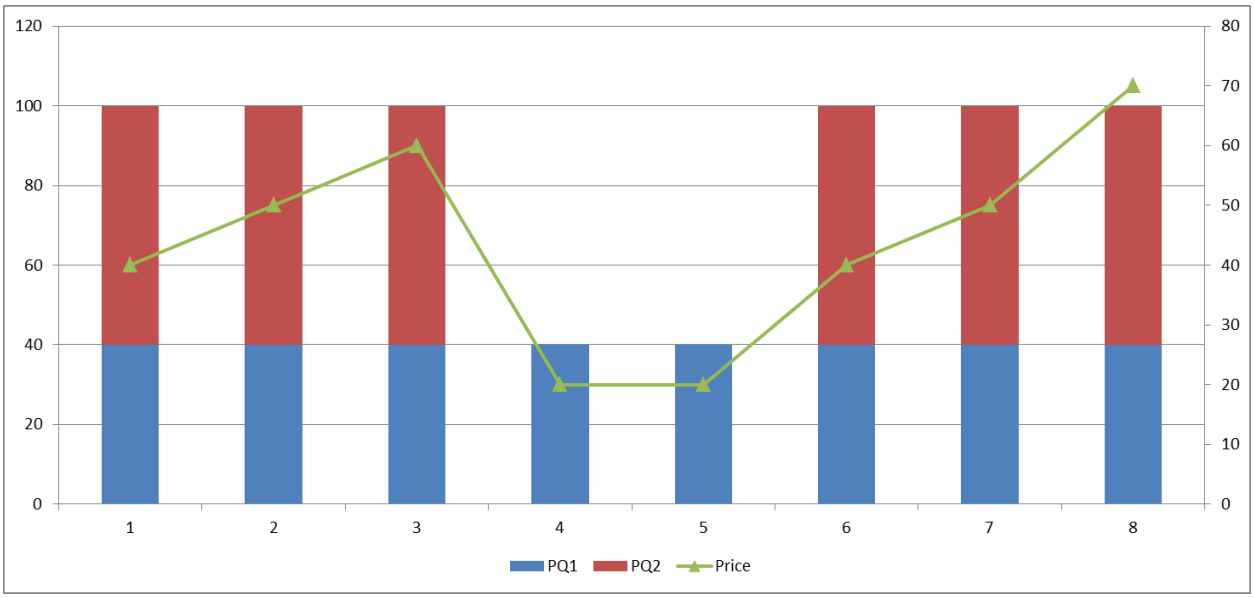


Figure 8: Illustrative example of unit scheduling with two price quantity pairs

Following discussion with the I-SEM EUPHEMIA working group, sessions which involved entering price quantity pairs which were adjusted in an attempt to avoid the risk of prices unexpectedly decreasing were investigated. The goal of the investigation was to assess the effects on the overall price and schedule as well as to assess the risks facing participants. The following approach was agreed:

- Each complex order would have the first price quantity pair be at a price of -€500 (price floor) and a quantity of the unit's minimum stable generation as per the TOD;
- Other price quantity pairs included in the unit's complex order would not be altered; and
- Fixed term and variable term MIC values would not be altered.

7.3.5 LINKED BLOCK ORDERS

In batch one of the Scripted Trials, units using a linked block order were entered with a minimum acceptance ratio (MAR) of 100%. This meant that the profile represented by the block could either be full accepted or was rejected. After discussion with the I-SEM EUPHEMIA working group, it was decided to investigate the effects of lowering the MAR of linked block order to see if this could result in a more flexible scheduling of units resulting in a better set of results. The following approach was taken to investigate this:

- Linked blocks with a MAR of 95%;
- Linked blocks with a MAR of 75%; and
- Linked blocks using a mix of 75% and 95% MAR values.

All linked blocks used a standard MAR level for all parent and child blocks.

7.3.6 MIXES OF LINKED BLOCK AND COMPLEX ORDERS

Following the results of batch one, it was agreed to continue exploration of datasets which mixed complex and linked block orders. These would be explored in addition to sessions with linked block and complex orders in isolation to allow for effects of individual orders to be compared to the mix of orders.

Further to the study of batch one, in which the same mix was applied in all sessions, batch two would alternate the mix of units using order types. Sessions would explore all baseload plant using complex orders while all mid-merit plant used linked block orders and vice versa. All other orders would remain unchanged.

7.4 BATCH TWO – RESULTS

7.4.1 PRICE MAKING DEMAND

The goal in adjusting the price making demand data in batch two was to have a lower number of instances of demand partially clearing and to have demand clear at a number of different prices rather than setting a single price. Figure 9, below, shows the number of periods in which demand set the price across the range of prices set.

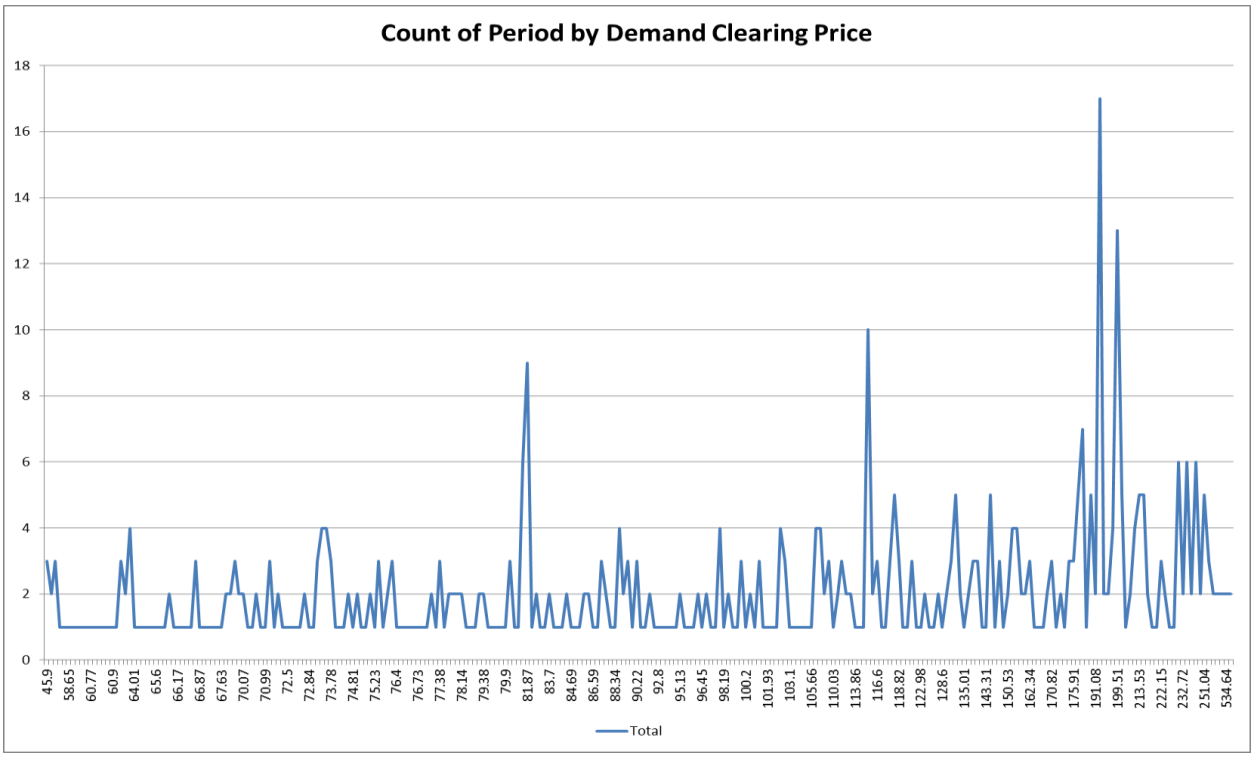
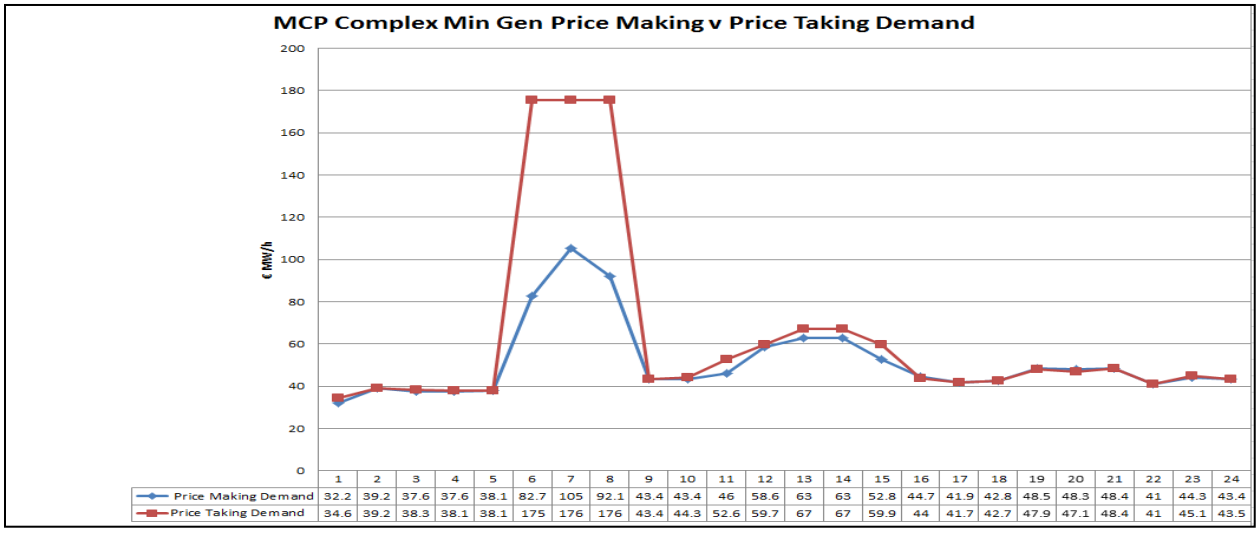


Figure 9: Number of trading periods in which demand was the marginal unit by price

As the price bid by demand was based on the hourly average price, a number of prices could be set within the same trading day. Overall, demand set the price in 546 trading periods (22.75%) which is down from the 54% rate from batch one of the Scripted Trials. Additionally, as the prices were higher at times of scarcity, demand did not artificially price higher cost generators out of the market.

There was also evidence that demand affected prices positively providing bids at a price between mid-merit generation and peaker generation which caused reductions to spikes in prices in some cases. An example of such a case is presented in figure 10, below.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Price Making Demand	32.2	39.2	37.6	37.6	38.1	82.7	105	92.1	43.4	43.4	46	58.6	63	63	52.8	44.7	41.9	42.8	48.5	48.3	48.4	41	44.3	43.4
Price Taking Demand	34.6	39.2	38.3	38.1	38.1	175	176	176	43.4	44.3	52.6	59.7	67	67	59.9	44	41.7	42.7	47.9	47.1	48.4	41	45.1	43.5

Figure 10: Market clearing price for price making and price taking demand for complex order session

It should be noted in review of price making demand that any benefits received solely from partial clearance of demand (such as in figure 10 above) would only be in the DAM. If the load forecast in the DAM is accurate, this load would need to clear in later market timeframes and this study has no indication of the prices, or liquidity, which may apply in these timeframes. Figure 11, below, shows the level of uncleared demand per trading period across all trading days.

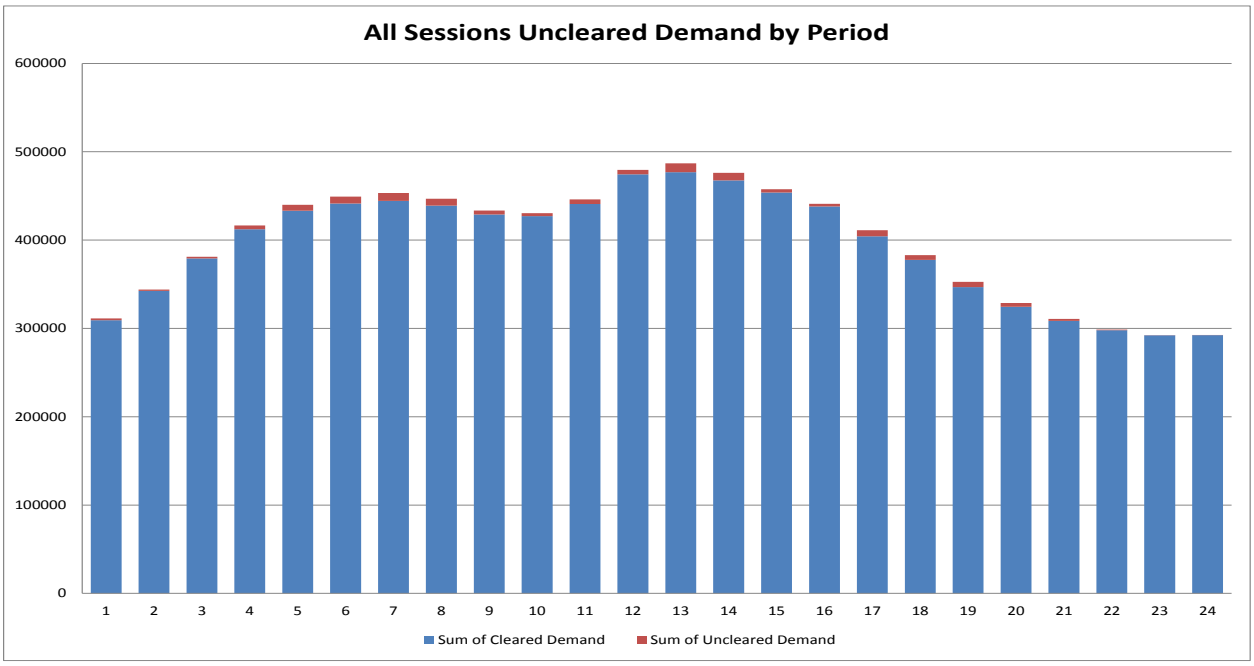


Figure 11: Cleared and uncleared demand by trading period across all batch two sessions

This shows a similar distribution in terms of trading periods as that seen in batch one. The proportion of demand which remains uncleared compared to cleared demand is decreased from batch one of the Scripted Trials, as expected due to the higher bid prices.

7.4.2 PRICE MAKING WIND ORDERS

In batch two of the scripted trials, wind set the price (and was therefore partially cleared) in 42 trading periods. This is an increase over the zero trading periods in which wind set the price in batch one with a price of €0. The list of prices at which wind was the marginal unit is presented in table 5 below:

Wind Unit	Price	Marginal Periods	% Clearance of wind
GU_Wind_3	-86	2	81% - 82%
GU_Wind_5	-72	2	83% - 84%
GU_Wind_7	-58	4	85% - 86%
GU_Wind_9	-44	4	87% - 88%
GU_Wind_10	-37	2	88% - 89%
GU_Wind_11	-30	1	89% - 90%
GU_Wind_12	-23	2	90% - 91%
GU_Wind_15	-2	2	93% - 94%
GU_Wind_16	5	2	94% - 95%
GU_Wind_18	17	8	96% - 97%
GU_Wind_19	23	6	97% - 98%
GU_Wind_20	29	4	98% - 99%
GU_Wind_21	35	3	99% - 100%

Table 5: number of trading periods in which wind set the price in batch two of the Scripted Trials

It should be noted that, the actual cleared volume will depend on how much is cleared at the marginal price in each trading period and also that, all wind units which are priced above the marginal price will be fully uncleared as they are out-of-the-money. The column "% Clearance of wind" denotes the range of wind cleared at each clearing price.

7.4.3 COMPLEX ORDER MIC VALUES

Altering the MIC of a complex order changes the amount of revenue the unit must recover in order to be scheduled; thus, moving cost elements between the fixed and variable terms in the MIC will change how EUPHEMIA sees the underlying costs. Consequently, there was a noticeable effect of altering the MIC of units using a complex order. Figure 12, below shows a comparison of the maximum, minimum and average prices from sessions using an altered VT MIC.

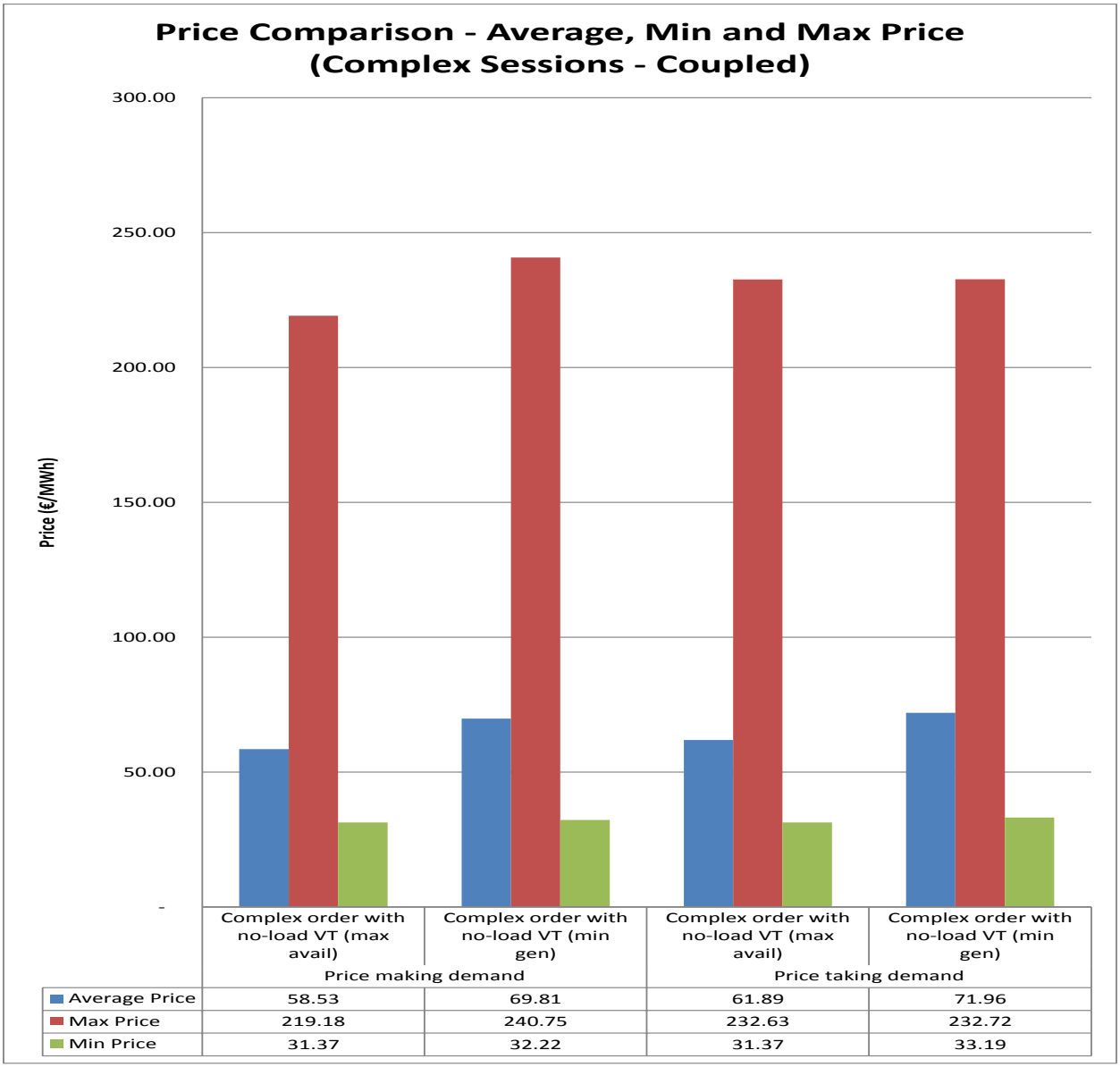


Figure 12: comparison of prices from complex order sessions using different VT assignments

As can be seen in figure 12, those sessions using a VT which is based on dividing the no-load cost by the minimum stable generation (option 1) have higher costs (min, max and average) than those using the method which divides the no-load cost by the maximum availability (option 2). Given that the price quantity pairs were unchanged for each method and the same fixed cost was used, this would mean that option 1 delivered a higher price based on the VT MIC which was used.

The reason for this is that, while option 1 provides full recovery of no-load costs at minimum stable generation, option 1 accounts for extra costs at higher output. For example, if Generator A has a minimum stable generation of 100 MW and maximum availability of 200 MW, at maximum output the value of no-load cost accounted for in the MIC would be double that at minimum stable generation (i.e. the point at which the cost is fully accounted for).

In such a situation, Generator A is representing a higher overall MIC than their production cost. This will prevent them from being scheduled in the DAM if this higher cost cannot be recovered. As this cost is beyond their production costs, Generator A is risking forgoing on a schedule which they could receive if their production costs were correctly represented.

Option 1 and 2 each had the desired effect of allowing participants to account for their no-load cost as a variable cost rather than a fixed cost. This means that, if this approach is appropriate to the needs of the participant, these options would allow participants to account for their no-load cost without needing to make an assumption about the number of hours the unit will be scheduled. However, option 1 caused a risk of over-representation of the no-load costs of a unit which introduced a risk of units not being committed due to an artificially inflated MIC which had the knock-on effect of causing higher prices. Option 2 provided a better method for assigning no-load costs to the VT MIC than option 1. It should be noted that option 1 and option 2 presented here represent the minimum and maximum level of apportioning no-load costs over the output but no-load costs could be divided by any output level; dividing the no-load cost over any output level other than the maximum output would cause an over representation of this cost at high output levels.

Any manipulation of the MIC value will directly affect the risks which participants are facing, i.e. a lower MIC will guarantee a lower revenue level which may make it more difficult to recover costs. There were four instances of units under recovering their production costs in batch two of the scripted trials. All of these instances related to sessions using option 2 (i.e. dividing no-load costs by maximum availability). These instances are outlined in table 6 below with the relevant details.

Session ID	Unit ID	Revenue	Production Cost	Total MIC
201502038	GU_500140	79,698.04	86,159.69	73,575.13
201502040	GU_500140	80,824.61	92,665.50	79,666.15
201502009	GU_500280	182,511.93	207,990.31	175,970.43
201502009	GU_500282	217,070.26	217,696.67	215,190.61

Table 6: Revenue, cost and MIC values for units using complex orders which under recovered costs in batch 2

In the first three instances outlined in table 6, the unit incurred more than one start having accounted for only one start in their fixed term MIC. For illustration of this point, an example of the schedules produced which resulted in these multiple starts is provided in figure 13 below.

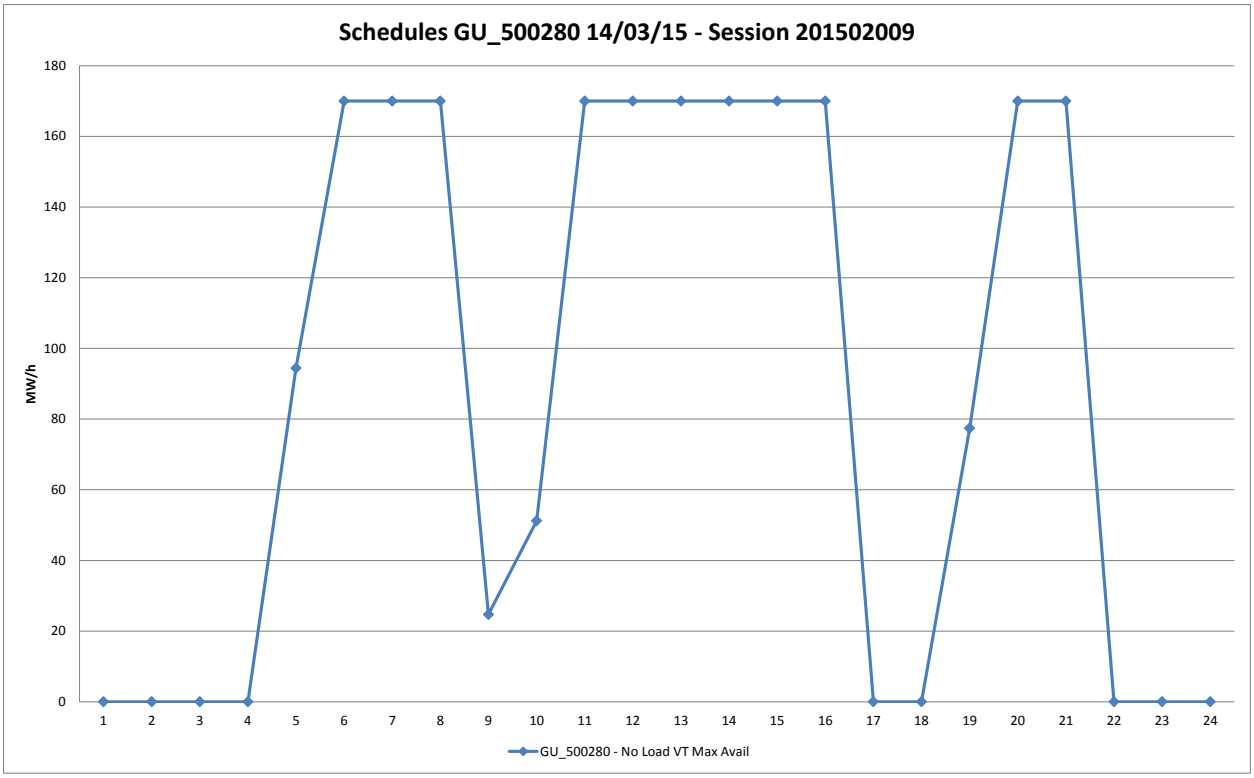


Figure 13: schedule data for GU_500280 for session 201502009

The value of the under recovery in each of these cases is roughly equal to the cost of incurring the additional start; therefore, were the unit to avoid the start, either through altering price quantity pairs in the DAM or adjusting position in the IDM, costs would be recovered.

In the case of GU_500282 in session 201502009, costs were under recovered but the unit incurred only one start up. As the unit had one price quantity pair, the variable term accounted fully for the fuel cost rather than accounting for an average fuel cost. Additionally, the start-up cost was correctly accounted for in the fixed term. The values of costs in the MIC and incurred costs are outlined in table 7 below.

Cost Element	MIC representation	Outturn cost
Fuel Cost	164,349.86	164,349.86
Start-up Cost	33,258.63	33,258.63
No-load Cost	17,582.12	20,088.18

Table 7: costs and their MIC representations GU_500282 session 201502009

As can be seen in table 7, the under recovery seen here is linked to the assignment of no-load costs to the variable term MIC. Using option 2, when the unit is scheduled below their max availability the no-load cost is under represented. For this unit, there were a number of trading periods where it was run below their maximum availability. The schedule data for this unit and session are presented in figure 14 below.

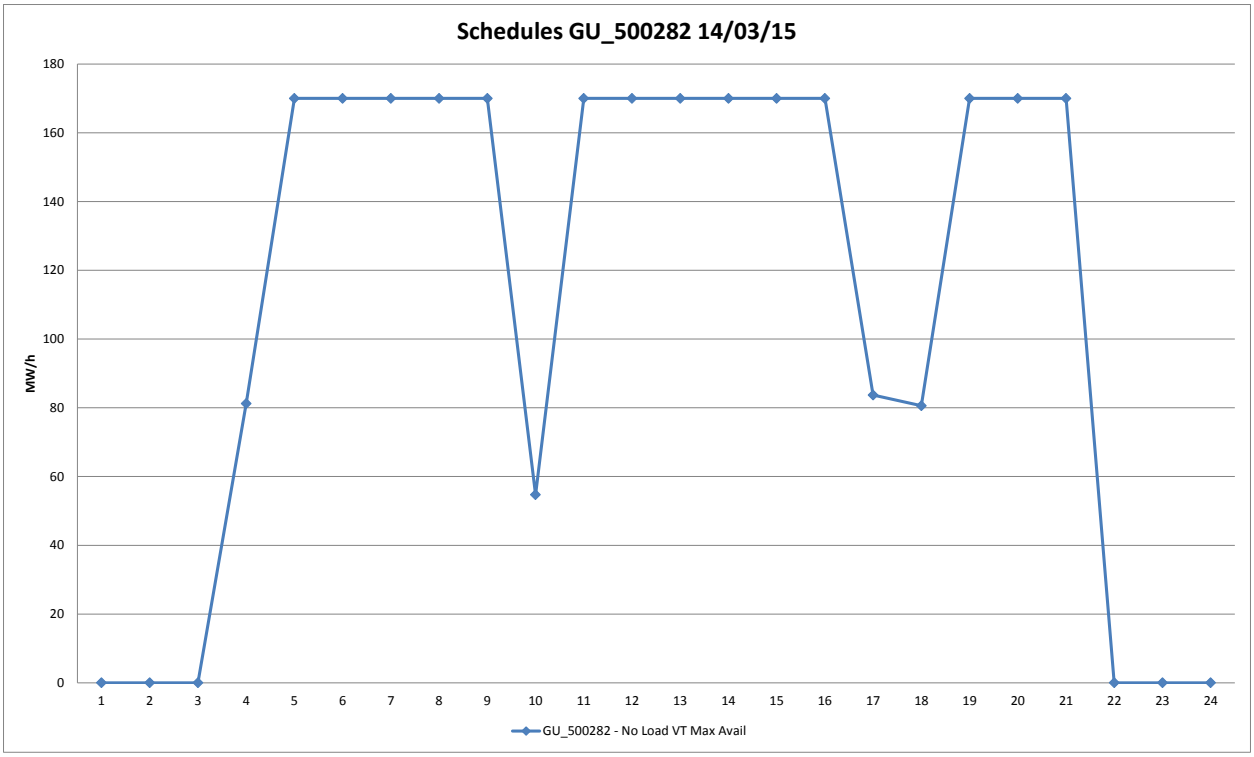


Figure 14: Scheduled data for GU_500282 for session 201502009

While this has led to under recovery of costs in the DAM for this unit and session, no-load costs for any unit will be under represented by the entered MIC value using option 2 at any point where the unit is scheduled below their maximum availability.

In most cases, this under representation is compensated for through inframarginal rent and a loss is not incurred; however, use of this methodology does introduce the risk that no-load costs will be under represented. This is the converse of the risk that no-load costs will be over represented if the unit enters the maximum possible cost (i.e. 24 no-load costs) as a fixed term MIC but is scheduled for fewer hours than 24 as was seen in the Initial Phase. It will be the responsibility of market participants to determine an appropriate risk mitigation strategy in any use of complex orders.

As the instances of under recovery are linked to the scheduling of units, these risks could be mitigated through manipulation of price quantity pairs. Results of investigation of this practice are presented in section 7.4.4.

7.4.4 COMPLEX ORDER PRICE QUANTITY PAIRS

The goal of investigating altered price quantity pairs in complex orders, i.e. where a new price quantity pair was introduced at a price of -€500 and a quantity of the unit's minimum stable generation, was to assess the effects on prices and risks. The method used had the expected result, i.e. units were moved to minimum stable generation rather than a zero output when prices were temporarily low. When the prices dropped due to temporary shifts in the wind and load, the new price quantity pair remained in-merit, due to being at a price of -€500, meaning that the unit did not shutdown in these hours as was the case without this additional price quantity pair. This had the effect of avoiding unnecessary shutdowns for units and reducing their incurred production costs accordingly. An example of this is presented in figure 15 below.

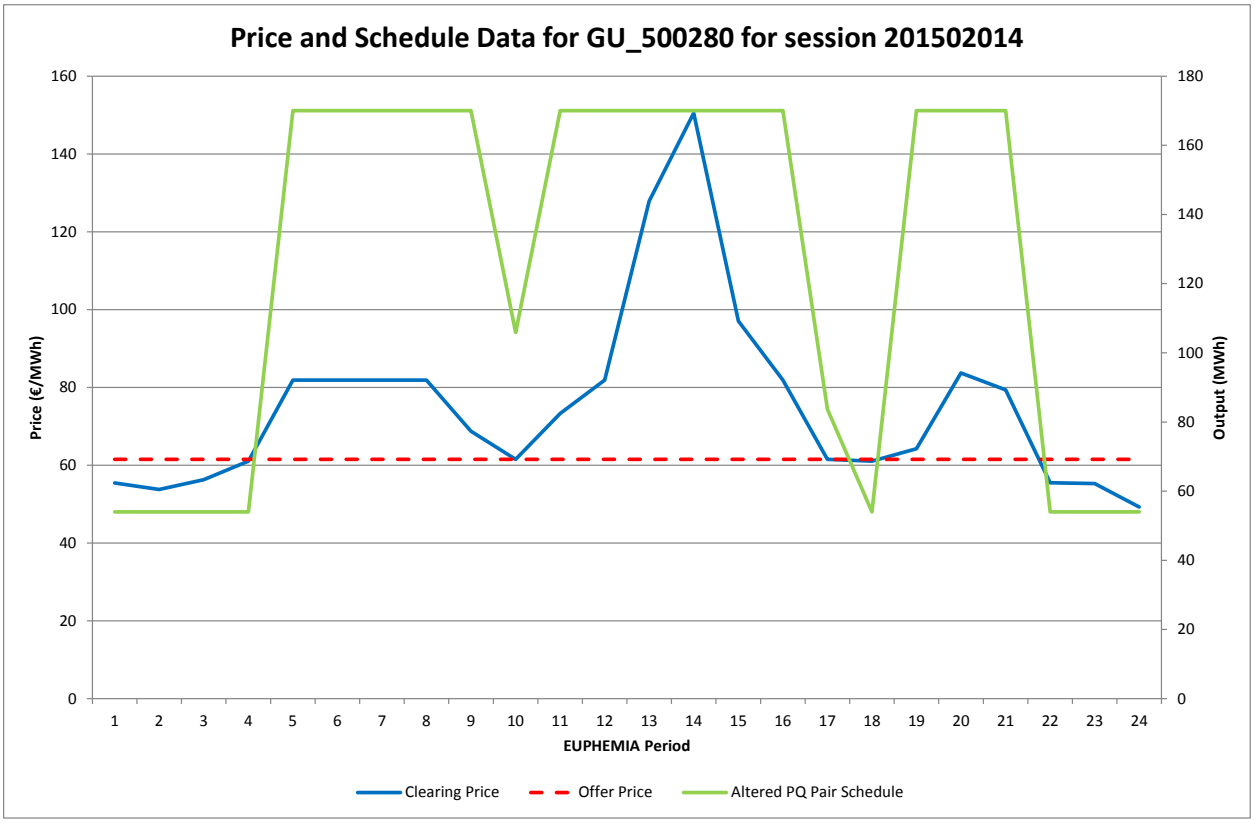


Figure 15: Price and Schedule Data for GU_500280 for Session 201502094

As figure 15 shows, in the hours where the clearing price drops below the offer price of GU_500280 (hours 1 -3; hour 18 and hours 22 - 24) the unit is moved to its minimum stable generation. If the altered price quantity pair had not been added, the unit would have been out-of-merit in these hours and been scheduled for a quantity of 0 MW.

As outlined in figure 13 from section 7.4.3, when this same unit used their SEM price quantity pairs, they ran at a loss in the DAM due to multiple starts. With the adjusted price quantity pairs, the unit does not incur these start-up costs and recovers its costs fully in the DAM. A comparison of the schedules for GU_500280 from these sessions is presented in figure 16 below.

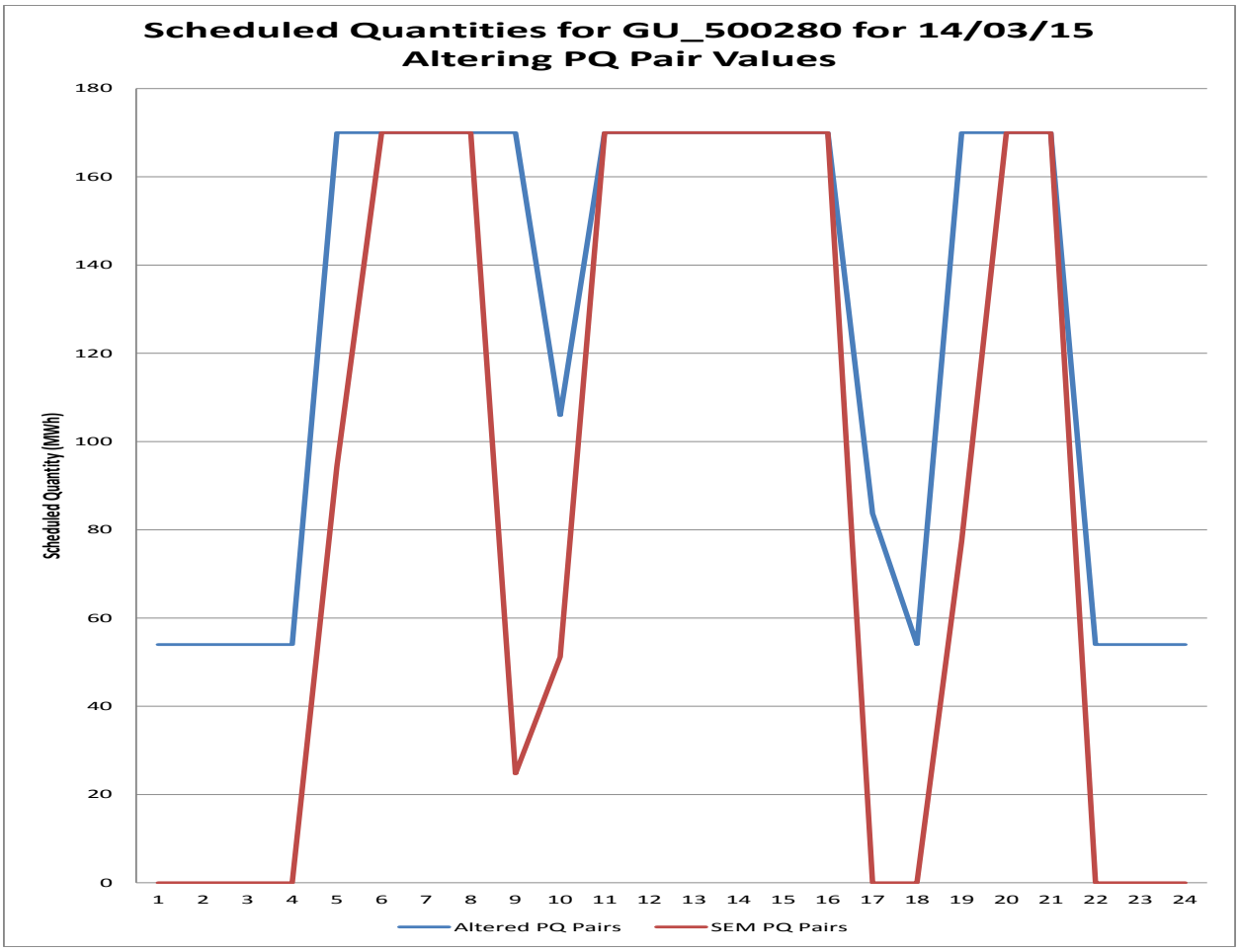


Figure 16: Schedule Quantities for GU_500280 for 14/03/15

Figure 16 shows that the profile produced for this unit using the altered price quantity pairs avoided the shutdown in hours 17 and 18 that the schedule produced using the SEM price quantity values for this unit incurred. Across all sessions using altered price quantity pairs, all units which were scheduled fully recovered their production costs.

While the sessions using the altered price quantity pair values delivered less risk, in terms of scheduling, than those using the SEM price quantity pairs, the original method for assigning no-load costs (i.e. 24 no-load costs assigned to the fixed MIC) was used. This potentially allowed for a case where the overall cost of the DAM was increased due to a higher than required representation of costs in participants MIC values, i.e. for units which ran for less than 24 hours. Values in relation to the average, maximum and minimum prices seen from these sessions are presented in figure 17 below for sessions with price making and price taking demand.

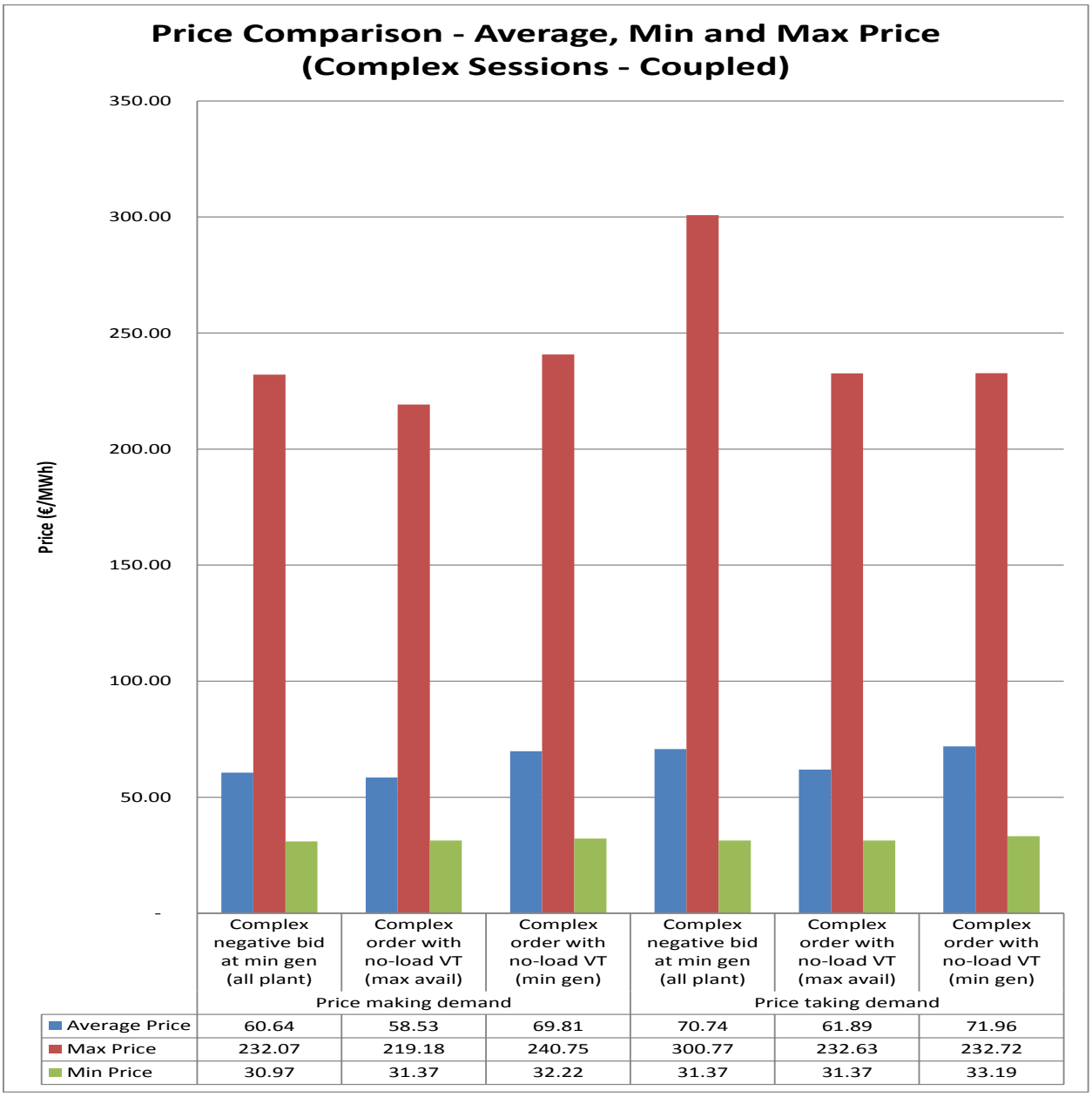


Figure 17: Price comparison of complex sessions with altering PQ pair values

While there were no significant differences between prices using the max availability method of assigning variable no-load costs and the altered price quantity pair runs with price making demand, sessions using the minimum stable generation method had a higher price. The increase to the average price was greater for sessions using altered price quantity pairs when price taking demand was used.

Each of the methods of using complex orders allowed for different risk profiles and overall costs to the market. Depending on the desired risk profile of participants, a strategy combining a number of elements of the complex order (price quantity pairs, MIC, load gradient and scheduled stop condition) is likely to provide the best results.

The results of this batch suggest the following areas for further study:

- Combining altered price quantity pairs with variable no-load costs; and
- Trialling altered price quantity pairs with a price of €0 rather than of -€500.

These were further explored in subsequent batches of the Scripted Trials.

7.4.5 LINKED BLOCK ORDERS

In batch two, linked blocks were investigated using differing MAR levels to assess if this would alter the pricing and scheduling results. On an overall basis, the effects of altering the MAR levels without changing the other elements of the linked block had little effect on the market results. The average, maximum and minimum prices from linked block sessions are presented in figure 18 below.

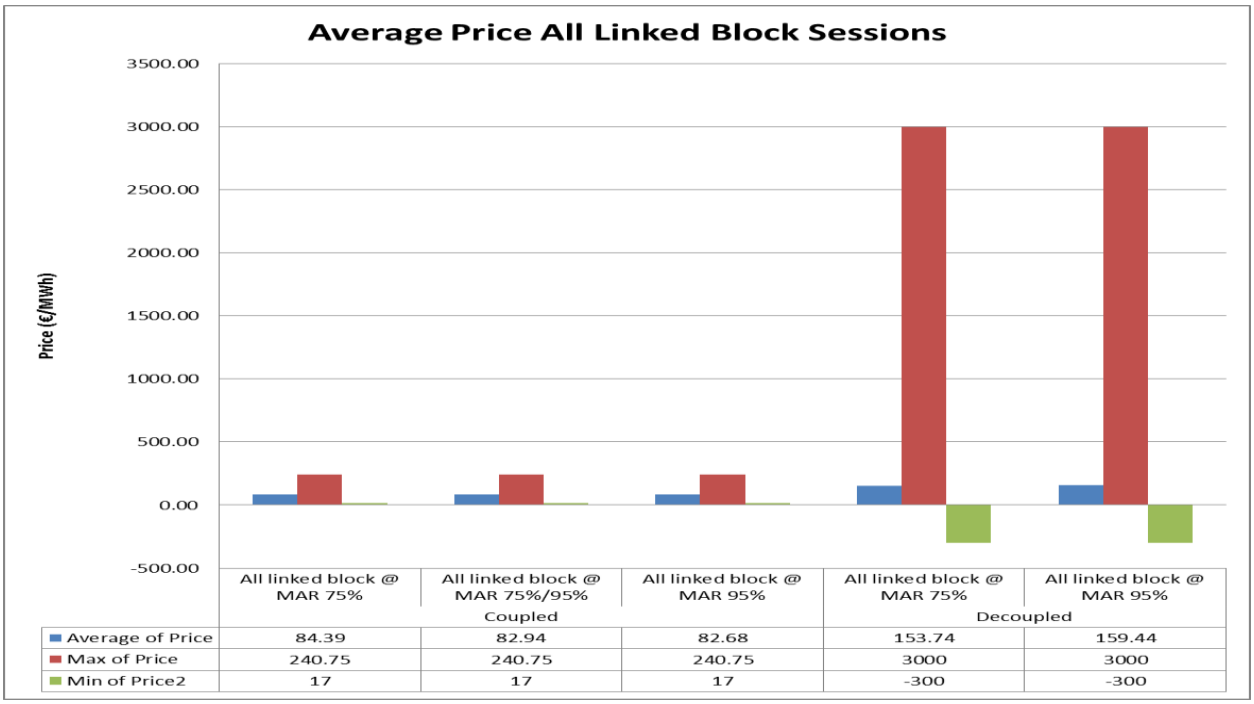


Figure 18: Price information for linked block sessions for batch two of the Scripted Trials

As can be seen in figure 18, the prices from sessions using a 95% MAR and a 75% MAR are very similar on both a coupled (left side of the graph) and de-coupled (right side of the graph) bases. This indicates there was little effect of changing the MAR without other changes on an overall basis. Comparison of the coupled and de-coupled results shows that, in the absence of price makers from GB, there are insufficient price makers given the assumptions used in batch two. Given that this was not an issue in batch one, which had a much higher volume of price making demand, this indicates that the issues encountered will only be resolved by accessing more price makers and the changing the MAR level in isolation has little effect. Further to these overall results, while some differences were evident, the hourly price values were largely the same among all linked block sessions regardless of the MAR value used. An example of hourly prices using the different MAR levels is presented in figure 19, below.

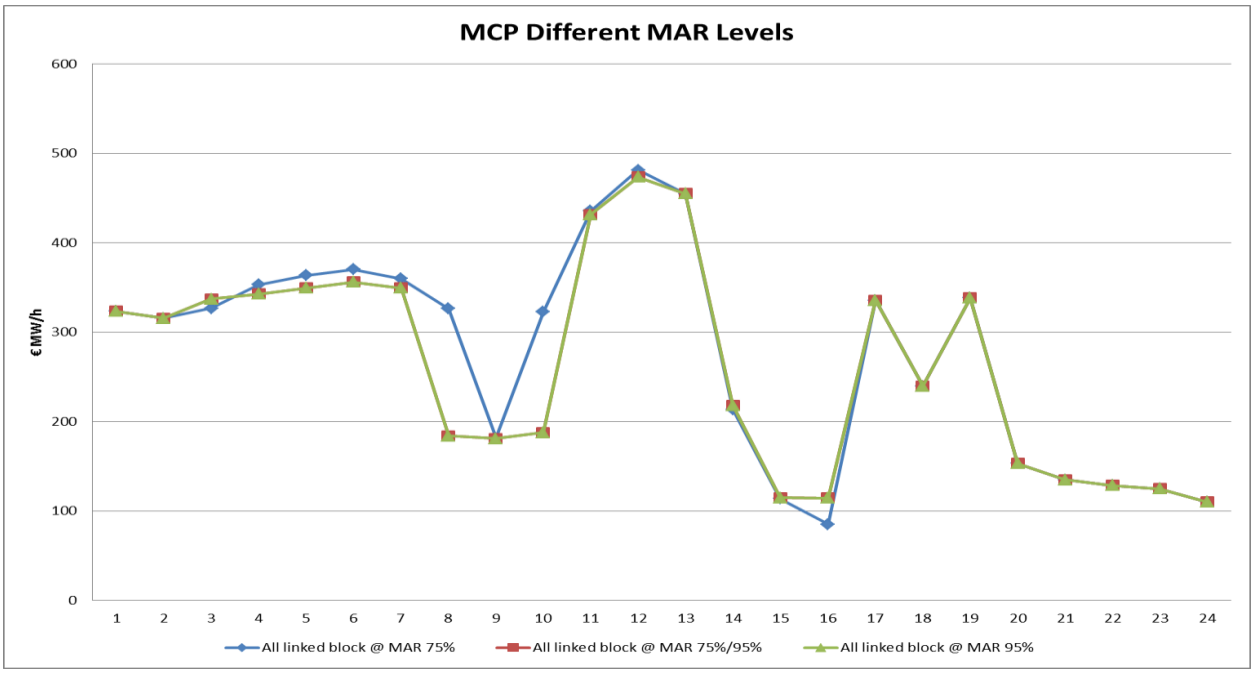
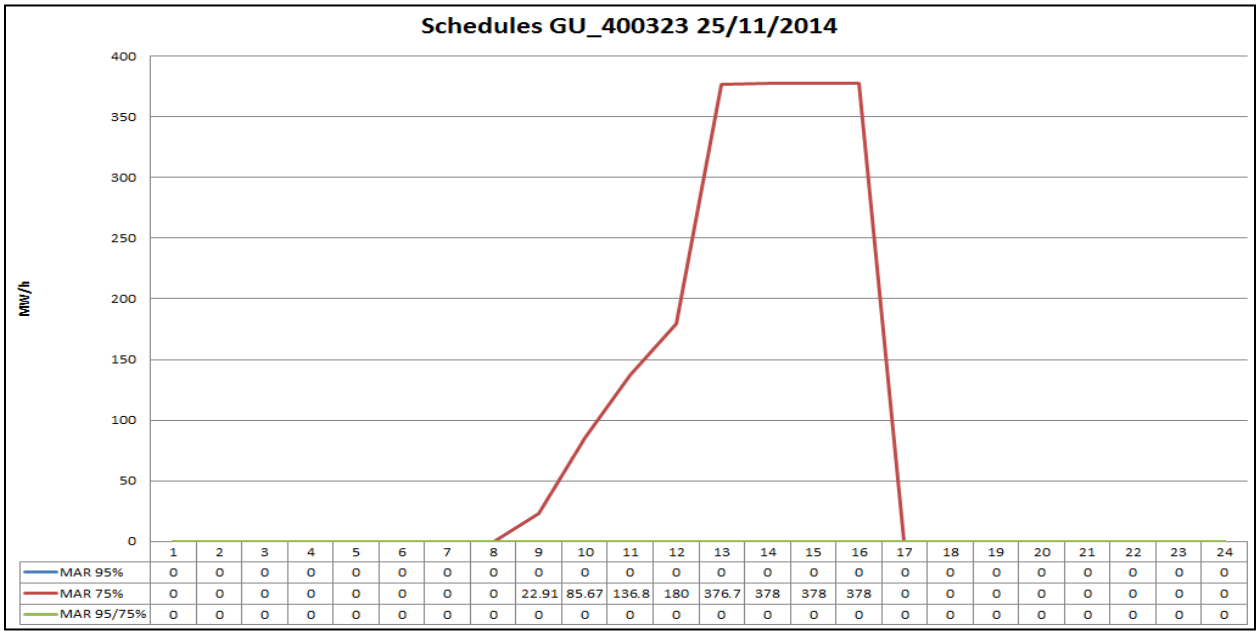


Figure 19: clearing prices for linked block sessions using multiple prices

In addition to prices, the overall scheduling of units remained similar throughout with a similar mix of fuels and units being used across sessions regardless of the MAR level used. However, the scheduling of individual units was altered by the changes to the MAR level. In some cases, a unit which did not run at a MAR of 95% was run at a MAR of 75%. An example of such an instance, with the schedules from GU_400323 from 25/11/2014, is presented in figure 20 below.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
MAR 95%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAR 75%	0	0	0	0	0	0	0	0	22.91	85.67	136.8	180	376.7	378	378	378	0	0	0	0	0	0	0	0
MAR 95/75%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 20: schedules for GU_400323 for 25/11/2014 linked block sessions

In this instance, in the mix of 95% and 75% MAR levels GU_400323 was 95%. This means that in the one session where the unit entered with a 75% MAR, it was scheduled where it otherwise, ceteris paribus, was not with a 95% MAR. These results suggest that while a unit may alter their scheduling by adjusting the MAR values, adjusting these values for all units has a small impact on overall results and that the results seen to date are more closely linked with block structure and pricing than the 100% MAR used.

The prices entered for linked blocks are based on the average cost of the profile being recovered over the volume of the profile; therefore, adjusting the MAR and allowing for a less than complete cleared volume introduces a risk that costs will not be recovered. For the purposes of assessing this risk, the price and structure of the linked blocks was not altered to allow for the risk to be quantified in isolation.

Across all linked block sessions, two units under recovered their costs in the DAM. This represents approximately 0.36% of schedules produced across all sessions. Figures on the number of sessions which under recovered costs in the DAM are presented in table 8.

Variable Name	Value
Number of units with a MAR <100%	21
Number of sessions	40
Total schedules created	548
Schedules which under recovered costs	2
Percentage of schedules which under recovered costs	0.36%

Table 8: Details of schedule cost recovery in linked block sessions

The two instances of under recovery of costs are outlined in terms of revenue and incurred production costs in table 9, below.

Session ID	Unit ID	Revenue	Costs	Net Revenue
201503071	GU_400323	€231,061.82	€259,999.23	-€28,937.40
201503082	GU_400180	€335,972.09	400,558.47	-€64,586.38

Table 9: Details of generator revenue for linked block schedules which under recovered costs

It should be noted that the approach taken adjusted all parent and child blocks to have a MAR of 95% or 75%. This was chosen in order to give participants information on the risks and impacts of such an approach but would not be a requirement. It would be possible to have a parent block representing fixed costs with a 100% and a child block with a lower MAR which represented incremental costs. Additionally, the prices of each block were unadjusted but participants may wish to enter a premium to reflect this risk should this be permitted.

A further area of interest with linked blocks was the area of price formation in decoupled scenarios. While price formation was stable in coupled sessions, there was a notable increase to prices and volatility in decoupled sessions. The cause of this is due to the lack of liquidity of price makers in the orders represented in linked block sessions.

As all of the units which typically act as the marginal unit in the majority of periods in the SEM (i.e. baseload and mid-merit thermal plant) are entered with linked blocks, and this prevents them from acting as the marginal unit, linked block sessions rely on simple orders or complex orders submitted from other sources for price formation, such as:

- Peaker thermal units;
- Hydro units and other units using simple orders;
- Supplier units;
- Wind units; and
- Units in GB which can affect the price via coupling.

In decoupled sessions, the units in GB are unavailable and the price must be set by other sources. The goal of assessing this in batch two of the scripted trials was to assess if the levels of demand and wind simple orders entered, along with existing simple orders, would provide sufficient price makers to allow for stable pricing in linked block sessions.

As noted previously, there was an increase to price and price volatility in decoupled linked block sessions. A comparison of prices from a coupled and decoupled session is presented in figure 21 below.

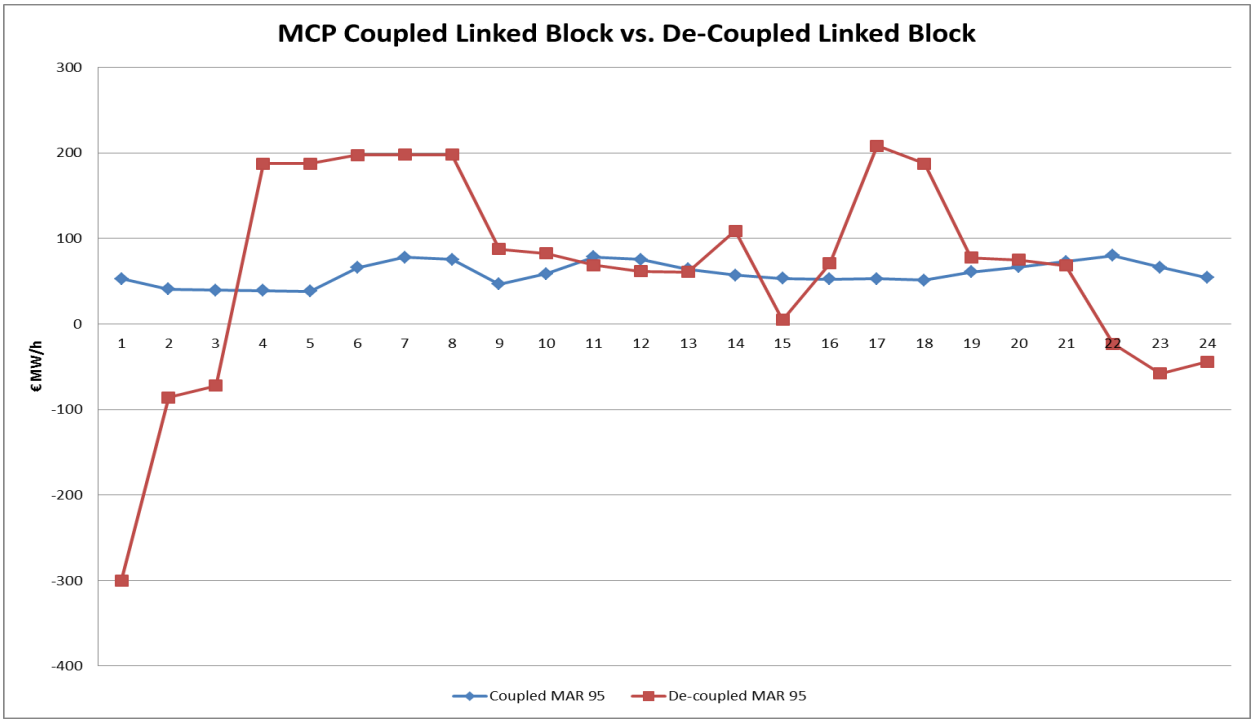
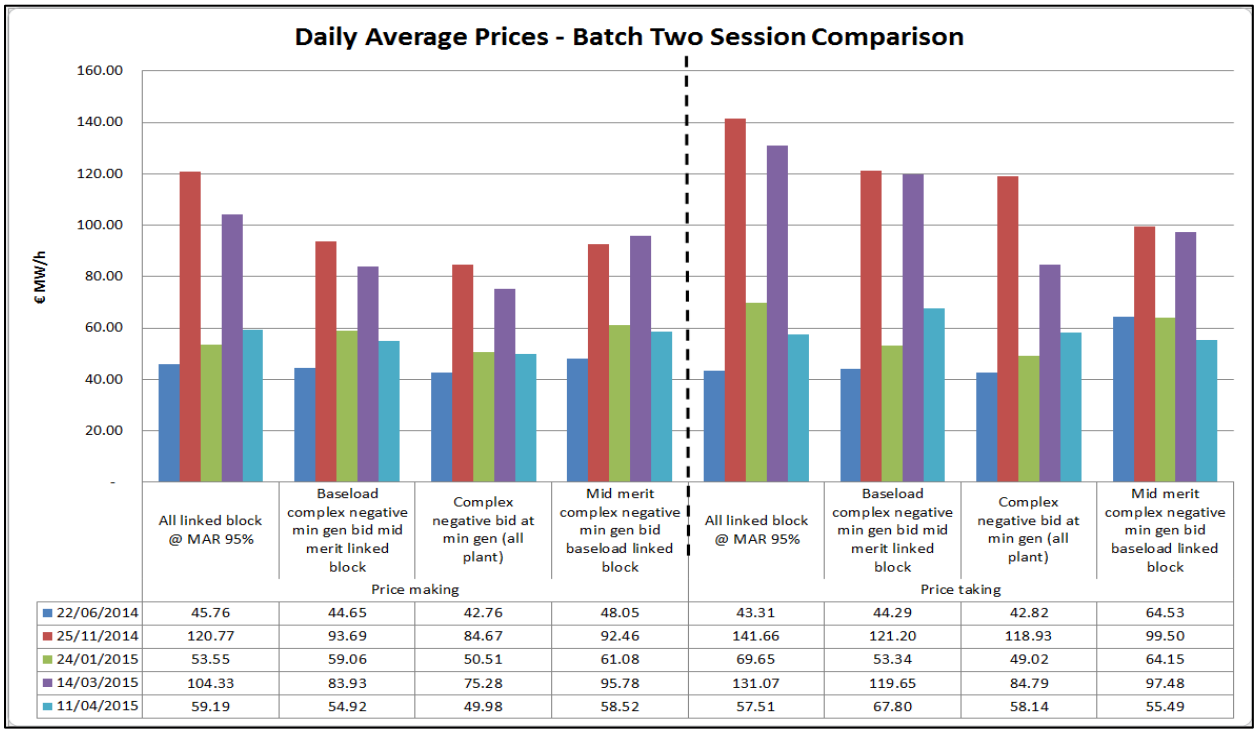


Figure 21: coupled and de-coupled prices for linked block session

The prices here provide an example of the volatility present in decoupled sessions. Without access to the GB order book through coupling, there are large variations in price between hours. This is due to the range of prices of simple orders entered to the session and the liquidity at these prices.

7.4.6 MIXES OF LINKED BLOCK AND COMPLEX ORDERS

Analysis of the pricing from sessions using mix of linked block and complex orders proved to be largely inconclusive. Average price values for each day are presented in figure 22 below.



	Price making				Price taking			
	All linked block @ MAR 95%	Baseload complex negative min gen bid mid merit linked block	Complex negative bid at min gen (all plant)	Mid merit complex negative min gen bid baseload linked block	All linked block @ MAR 95%	Baseload complex negative min gen bid mid merit linked block	Complex negative bid at min gen (all plant)	Mid merit complex negative min gen bid baseload linked block
22/06/2014	45.76	44.65	42.76	48.05	43.31	44.29	42.82	64.53
25/11/2014	120.77	93.69	84.67	92.46	141.66	121.20	118.93	99.50
24/01/2015	53.55	59.06	50.51	61.08	69.65	53.34	49.02	64.15
14/03/2015	104.33	83.93	75.28	95.78	131.07	119.65	84.79	97.48
11/04/2015	59.19	54.92	49.98	58.52	57.51	67.80	58.14	55.49

Figure 22: Daily Average Prices – Batch Two Session Comparison

Comparison of the pricing results shows that, for batch two, the prices are consistently lower for complex order only sessions than for those involving linked blocks only. This is consistent for sessions with price taking demand and price making demand. It should be noted here that an error in the application of start-up costs for units using linked block orders overstated the start-up costs in relevant units over those same units using complex orders.

For sessions involving linked blocks and complex orders, however, there is no consistent trend. Across the trading days, the method which provides the lowest price varies and it is not conclusive as to which approach may be best. It should be noted in review of these results that the mix of orders was done on the broad basis of categorising a unit as mid-merit or baseload plant and in practice, the decision of which order type will be made by participants and is likely to be better suited to their needs and may provide a more appropriate mix of order types.

7.5 BATCH THREE – INPUTS

The goal of batch three was to further trial revised assumptions based on the findings of batch two. These were primarily aimed at the following elements:

- Assessing if refinements to the approach to linked block orders could improve results;
- Refining the assumptions used for calculation of fuel costs for complex orders; and
- Further adjustment to the assumptions used for price making demand.

7.5.1 ADJUSTED PRICE MAKING DEMAND

Following discussion with the I-SEM EUPHEMIA working group, it was suggested that the values of price input for supplier unit bids in batch two may not be reflective of I-SEM activities. There was an interest from suppliers in the working group to trial prices which were lower than those of batch two (a range of 1.6 to 2.5 times SMP) and were closer to the average price. To allow for this, the supplier unit bids were adjusted as follows:

- The price range was changed to 0.6 to 1.5 times SMP; and
- Other arrangements (i.e. number of intervals and volume) would remain unchanged.

This would have the effect of lowering the prices bids by supplier units. An indicative example, showing the relevant price making intervals of the curve, of the effect of this change is outlined in figure 23 below.

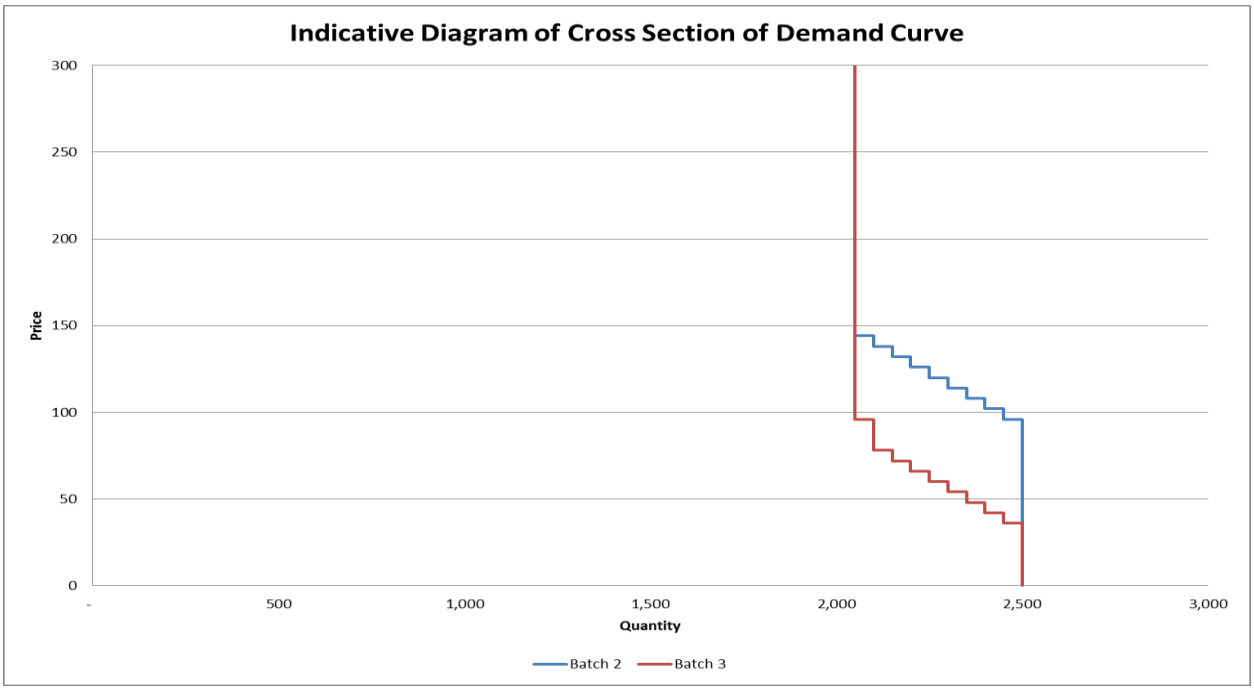


Figure 23: Indicative diagram of cross section of the demand curve for batches 2 and 3

It was expected that this lowering of the bid price would increase the level of demand which was uncleared in the sessions. The goal of investigating this in batch three was to quantify the effects of such a treatment on the DAM given the views expressed by working group members.

7.5.2 LINKED BLOCK ORDERS

Following discussion with the I-SEM EUPHEMIA working group, it was suggested that linked block orders should be further explored in order to determine the effects of the following:

- Overlapping of linked block duration so that some blocks were in six hour intervals and some were in eight hour intervals;
- Linked block orders with a MAR of 75% with a final child of 1MW in value;
- Linked blocks with a MAR of 95% and with prices multiplied by 1/MAR;
- Linked block orders with a MAR of 95% where the parent block is 40% above min gen; and
- Linked block orders with a MAR of 95% to act as a base case.

The altered treatments of linked block orders were examined to assess if they would provide any improvements to the pricing and scheduling outcomes.

Along with the changes to the order types investigated, an issue with the inputs for linked blocks, which had applied for batches one and two, was corrected. In this issue, the start-up cost of units using linked block orders was accounted for twice.

Usually in the setup used, profiles are broken into parent child block relationships with the parent block accounting for the fixed costs and the child blocks for incremental fuel costs. These are then subdivided to break the blocks into 8 hour groupings. The issue encountered was that the start-up cost was applied to multiple 8 hour groupings despite the fact that later hours could only be activated if the earlier hours (which include the start-up cost) are activated. This led to a situation where a unit may have included the cost of three starts though the profile represented by the blocks could only lead to one start. This over representation of costs was addressed for batch three.

Along with the methods outlined above, each of which was trialled over four days, a number of additional trials were performed over three days, these included:

- Adding additional PQ pairs for half of the twin plants[11];
- Having a different MAR for half of the twin plant; and
- Using a different MAR for different times of the day.

These were investigated to assess if changes to similar plant (i.e. the twin plants) would result in changes to the results from EUPHEMIA.

7.5.3 COMPLEX ORDERS

The variable term entered for complex orders is based on the average cost of fuel, as per the price quantity pairs, as well as a function of the no-load cost where relevant. For batches one and two, the following formula was used to determine the fuel cost element of the variable term.

$$VT_{Fuel}{}^{12} = \frac{\{(P_1 * Q_1) + (P_2 * Q_2) + (P_3 * Q_3) + (P_4 * Q_4)\}}{Q_1 + Q_2 + Q_3 + Q_4}$$

[11] Two units on the same trading site with the same technical and commercial characteristics

[12] Where a quantity is not used a value of zero is entered to the formula. Though ten are available in the SEM, no unit used more than four quantities

Following discussion with I-SEM EUPHEMIA working group, it was decided that this may over-represent the costs of fuel and that the weighted average of fuel costs should be applied using the following formula:

$$VT_{Fuel} = \frac{\{(P_1 * Q_1) + (P_2 * (Q_2 - Q_1)) + (P_3 * (Q_3 - Q_2)) + (P_4 * (Q_4 - Q_3))\}}{Max\ Availability}$$

While the formula used for batches one and two may have over represented the costs of fuel and thereby affected pricing of these batches, it should be noted that the treatment was consistent across all complex order methodologies and so comparison across batch one and two results is still accurate. As the goal of the trial, as outlined in section 4, is not to predict the I-SEM DAM price these batches were not compromised.

For batch three, the effect of revising this VT formula was assessed across the following complex order scenarios:

- Using batch one assumptions for MIC (i.e. no load included in MIC and SEM PQ values);
- Using option 1 of assigning no-load costs to the variable term MIC (i.e. using min stable generation);
- Using option 2 of assigning no-load costs to the variable term MIC (i.e. using max availability);
- Using altered price quantity pairs with a bid of -€500 at min stable generation; and
- Using altered price quantity pairs with a bid of €0 at min stable generation.

The goal was to assess if this had a significant effect on pricing and if any of the inferences drawn from batches one and two were altered with the revised variable term MIC calculation.

7.6 BATCH THREE – RESULTS

7.6.1 ADJUSTED PRICE MAKING DEMAND

Analysis of the cleared and uncleared demand values by period for batch three is presented in figure 24, below.

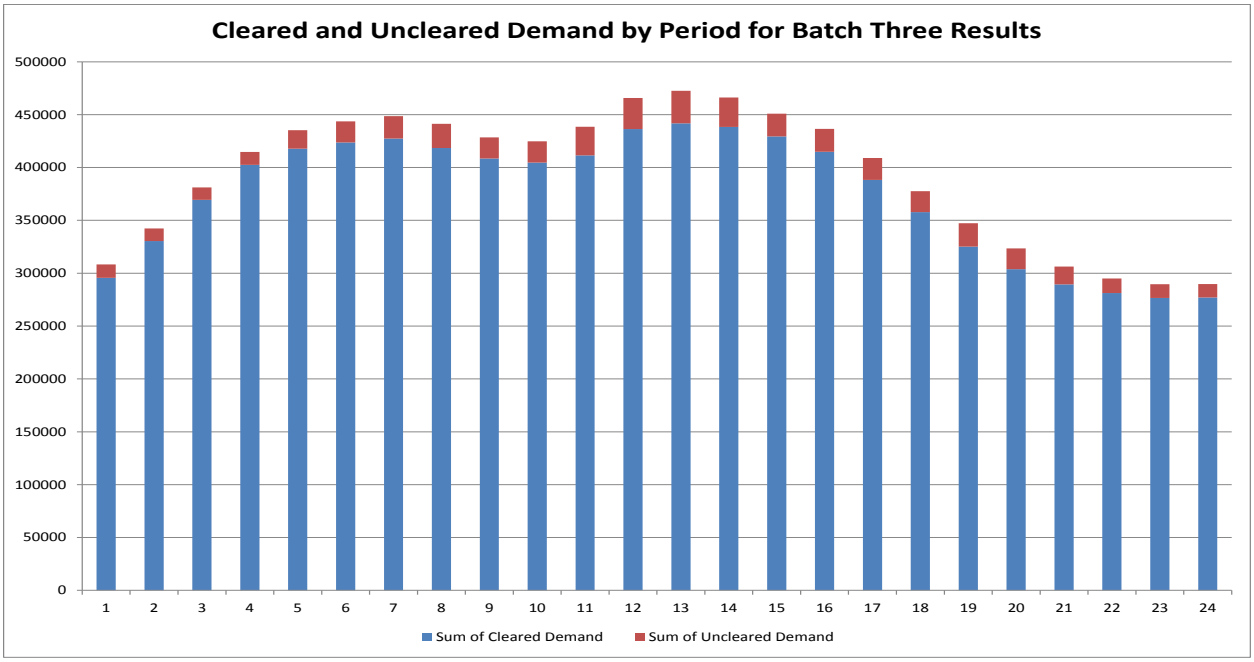
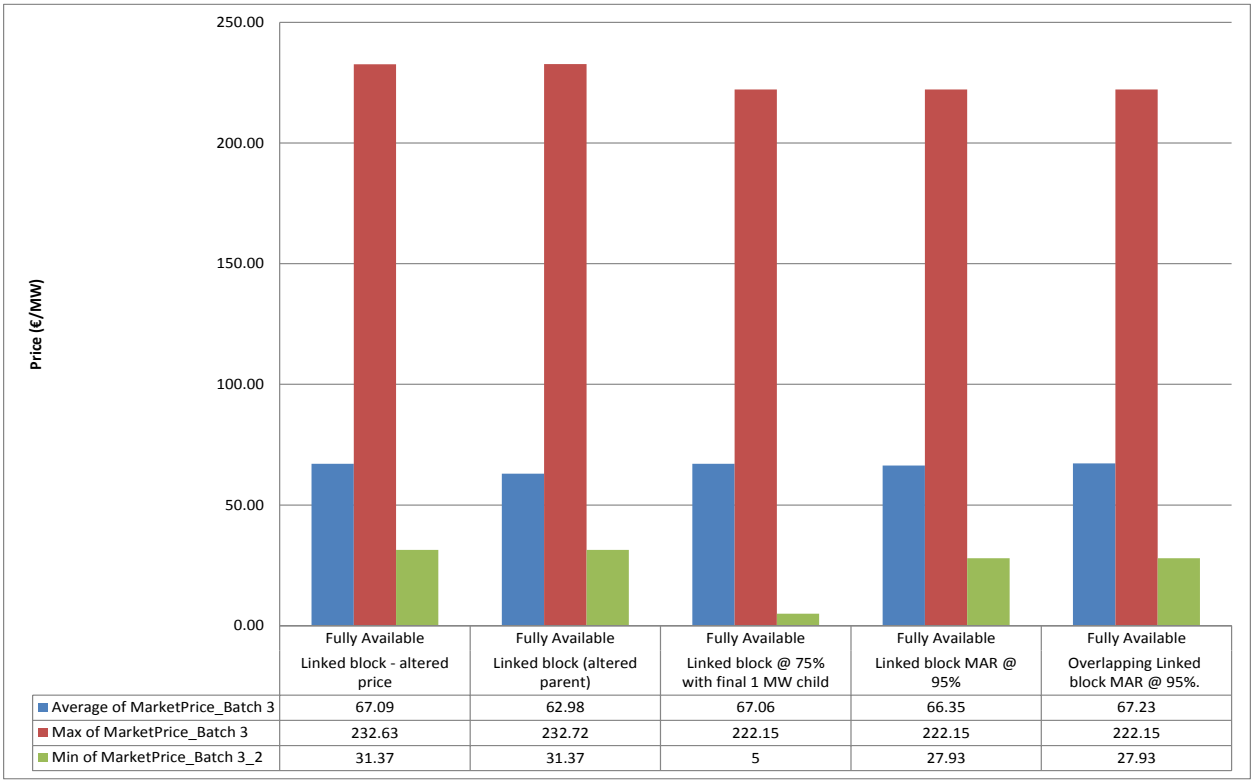


Figure 24: cleared demand by period for batch three results

This shows a change to the trend observed in batch two with a higher proportion of demand being uncleared overall and a high proportion of demand being uncleared in off-peak (in terms of load) hours than in batch two. This is consistent with the lower bid price of demand for batch three. While this had the effect of lowering the average clearing price in batch three, it should be noted that the total demand bid into the EUPHEMIA runs was the total of the load forecast; therefore, any uncleared demand would need to participate in later market timeframes in order to clear and any benefits to the DAM may have knock-on effects to these timeframes.

7.6.2 LINKED BLOCK ORDERS

For the majority of the changes to the method for implementing linked blocks, no significant effects on the overall pricing results were observed due to the respective approaches applied within batch three. The pricing information in relation to linked block sessions from batch three are presented in figure 25, below.



	Fully Available Linked block - altered price	Fully Available Linked block (altered parent)	Fully Available Linked block @ 75% with final 1 MW child	Fully Available Linked block MAR @ 95%	Fully Available Overlapping Linked block MAR @ 95%.
Average of MarketPrice_Batch 3	67.09	62.98	67.06	66.35	67.23
Max of MarketPrice_Batch 3	232.63	232.72	222.15	222.15	222.15
Min of MarketPrice_Batch 3_2	31.37	31.37	5	27.93	27.93

Figure 25: Pricing information for linked block sessions for batch three (four day sets)

There is some indication that the altered parent block (i.e. where the volume of the parent block is increased to 40% above minimum stable generation) reduced the average prices of sessions. While the sessions using a 75% MAR with a final 1MW child had a higher range, this was due to one day out of the four and was not indicative of an overall higher volatility. Hourly prices of this day are represented in figure 26 below.

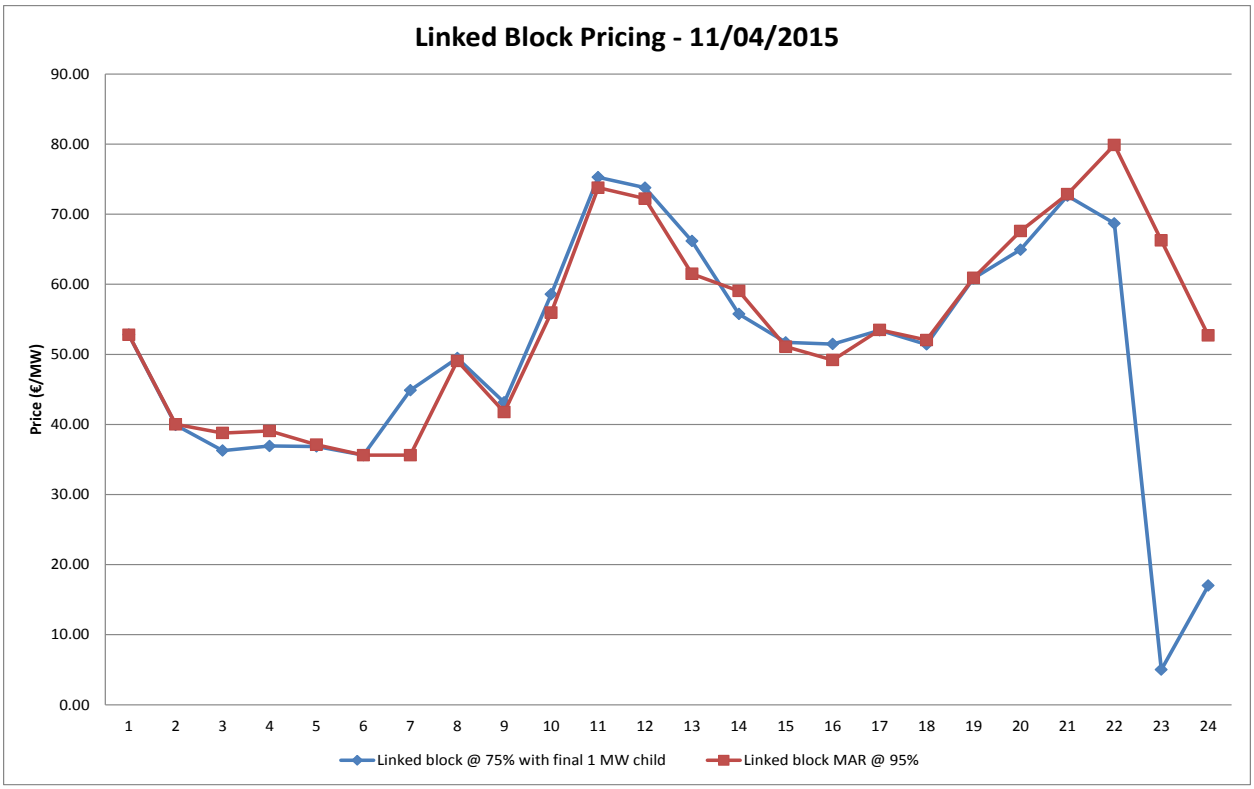
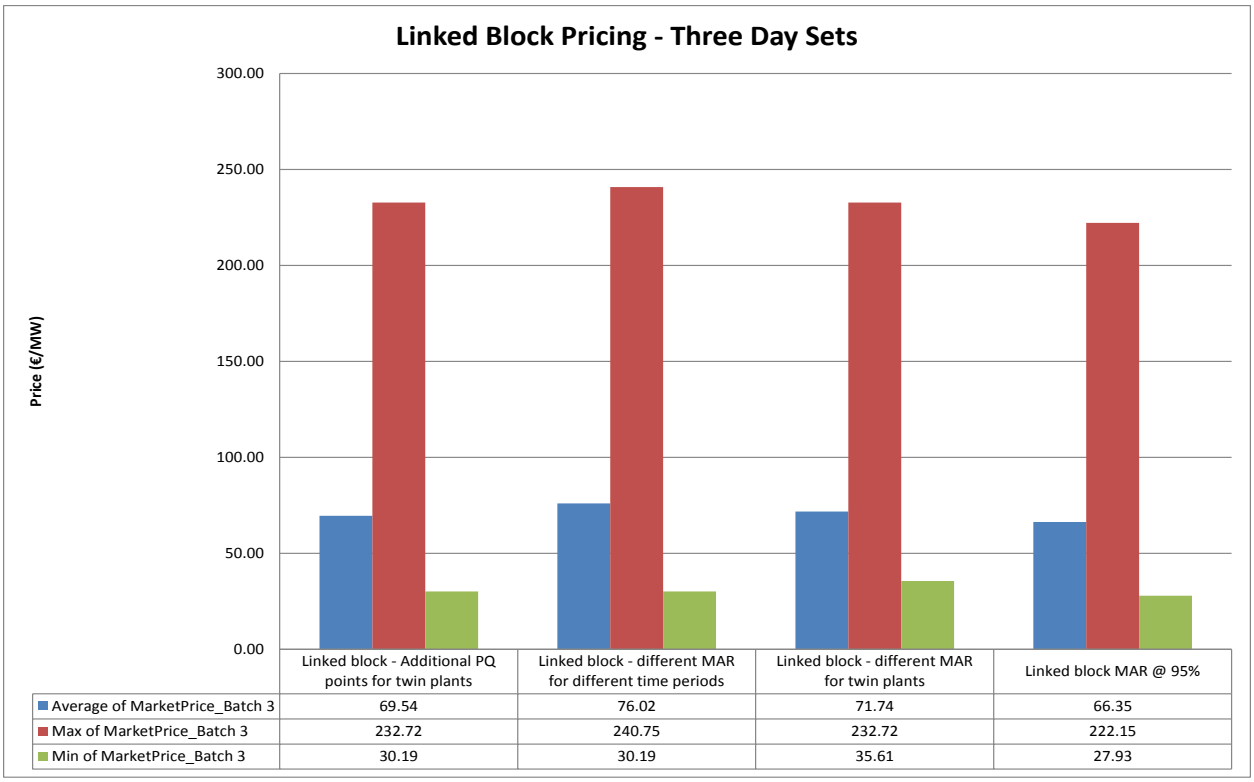


Figure 26: hourly prices for 11/04/2015 for linked block sessions in batch 3

As can be seen in figure 26, in the majority of hours the prices are very similar between the base case of 95% MAR and the case of 75% MAR with a 1 MW child. However, in hours 22 to 24 there is a more noticeable divergence between the two prices. The reason for this is constraint on the interconnector. In the base case, and other cases investigated for the same day, the interconnector is partially congested in hours 22 to 24 allowing for coupling with GB to affect the price. In the session with 75% MAR and a 1 MW child, the interconnector is fully congested in these hours and the price is derived from the order book in the I-SEM. Without indication of further improvement to the approach for linked blocks from the changes used in batch three, the use of 95% MAR was maintained as the base case for batch four.

As outlined in section 7.5.3, a number of additional trials using linked block orders were performed using three historical days rather than four. These sessions related to altering the method applied for twin plant[13] to assess if this would alter the scheduling for these units. For these sessions, the pricing results were altered by the changes made to the representations of twin plant the effects of this are outlined in figure 27 below.

[13] Twin plant are generator units in the SEM on the same trading site with the same commercial and technical data



	Linked block - Additional PQ points for twin plants	Linked block - different MAR for different time periods	Linked block - different MAR for twin plants	Linked block MAR @ 95%
Average of MarketPrice_Batch 3	69.54	76.02	71.74	66.35
Max of MarketPrice_Batch 3	232.72	240.75	232.72	222.15
Min of MarketPrice_Batch 3	30.19	30.19	35.61	27.93

Figure 27: linked block pricing for batch three (three day sets)

As detailed in figure 27, each of the alterations trialled caused an increase to the price over the base case (i.e. linked blocks using agreed assumptions with a 95% MAR). In addition to this, there were no significant changes to the scheduling of twin plants following the alterations to their representation outlined in section 7.5.3.

Across all sessions, there was one example of a change to twin plant scheduling which was observed in sessions using a different order type for each twin plant (i.e. one plant used complex orders and one used linked block orders). In this example, using the agreed assumptions, GU_500822 was input using a set of linked blocks while GU_500823 was entered using complex orders. Each represented the same costs but was scheduled to a different set of quantities within the same sessions. This example is outlined in figure 28 below.

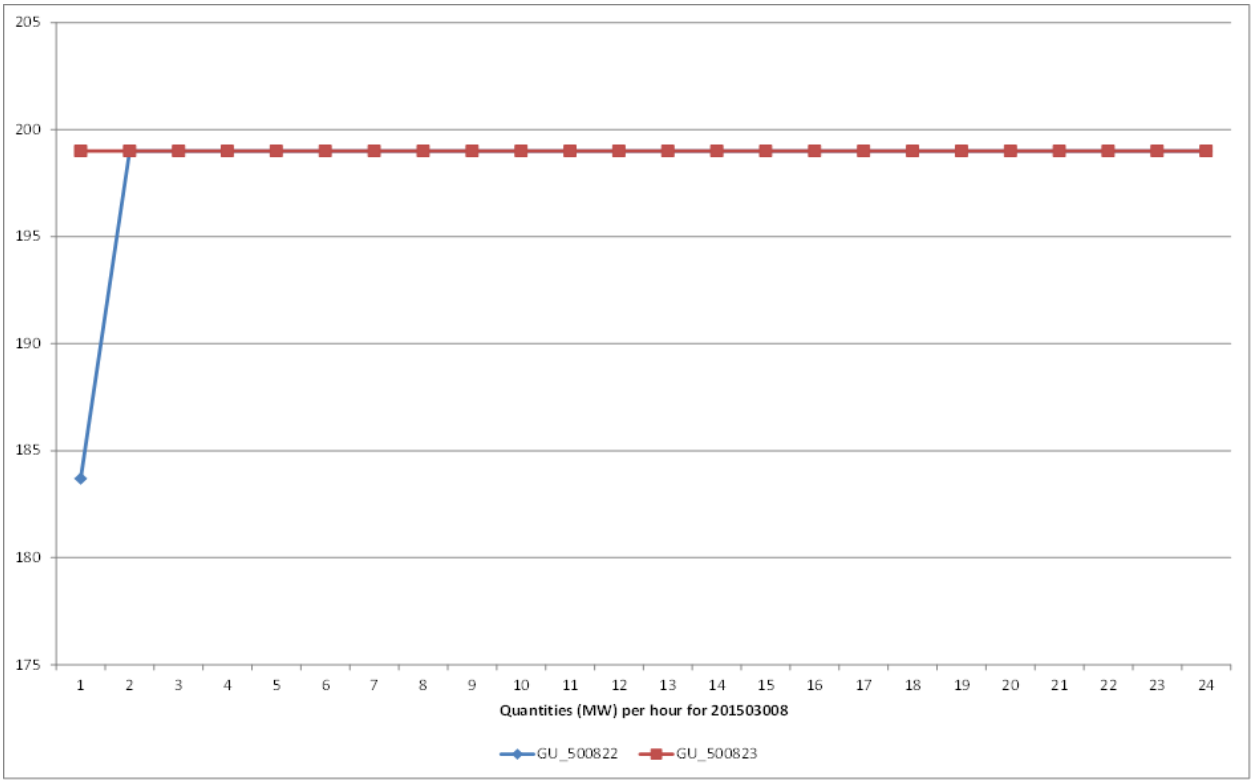


Figure 28: schedules of twin plan using different order types.

It should be noted that this difference to the scheduling is a direct result of the assumptions used, rather than any fundamental difference between the order types. For block orders, values have been profiled to explicitly represent the technical limits and initial position of the unit (i.e. if a unit is at less than their max availability at the start of the day, it will need to ramp up in its first hour, as observed); however, the values entered for complex orders do not account for this and the load gradient (which represents the maximum change to output between hours) is not applied in hour one as there is no hour zero with which to compare. This resulted in the schedules produced in figure 28, despite both orders representing the same volume and cost. However, this indicates that, barring the explicit modelling of the generator profiling which was only included in the linked block order, EUPHEMIA made the same economic choice for each unit.

As the complex order schedule for GU_500823 outlined in figure 28 does not account for necessary ramping in hour 1, this schedule would result in an imbalance in later market timeframes which the linked block schedule for GU_500822 would not be exposed to. While the load gradient does not apply in hour 1 of EUPHEMIA scheduling, it would be possible to alter the values entered in a complex order in specific hours (i.e. offer less energy in hour 1 to represent production constraints) to account for profiling to avoid such an imbalance, if required.

7.6.3 COMPLEX ORDERS

As outlined in section 7.5.3, a number of different methodologies for deriving the inputs for complex orders were trialled in batch three. The goal of this was to assess the effects of the updated fuel cost calculation across a range of approaches and assess if this change indicates any change to inferences drawn from batch two in comparing these methodologies. The pricing information (maximum, minimum and average) for the different methodologies is presented below in figure 29.

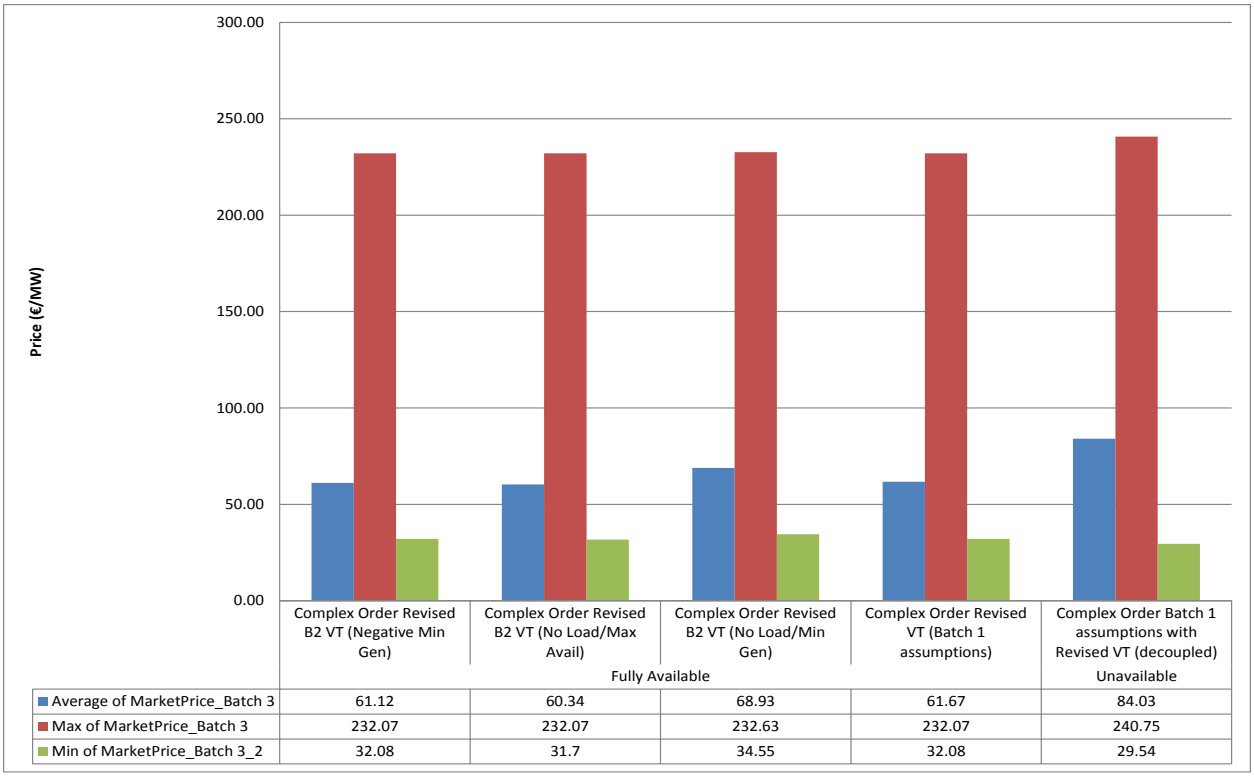
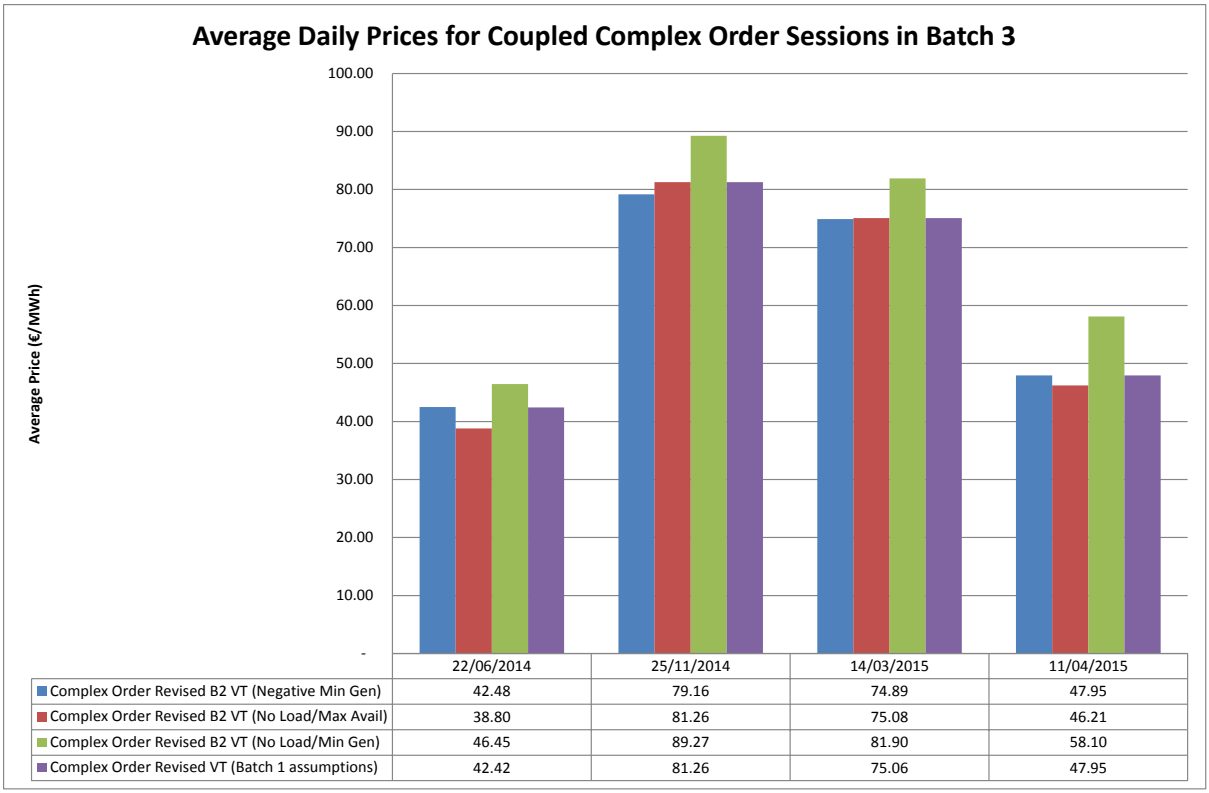


Figure 29: Pricing information for complex orders with interconnectors available or unavailable

The results show that the prices from dividing no-load costs by minimum stable generation (option 1) are higher than those dividing the no-load costs by maximum availability (option 2). This result, which includes the revised fuel cost calculation, is consistent with the findings of batch two and indicates that using option 2 for applying no-load costs to the VT will lead to better results for the same input than option 1.

Other than the higher prices from the use of option 1 of assigning no-load costs to the VT, the results are inconclusive as to which method for putting together complex orders led to the best results. Analysis of the daily average prices also does not point to a best approach; daily average prices are presented in figure 30 below.



	22/06/2014	25/11/2014	14/03/2015	11/04/2015
Complex Order Revised B2 VT (Negative Min Gen)	42.48	79.16	74.89	47.95
Complex Order Revised B2 VT (No Load/Max Avail)	38.80	81.26	75.08	46.21
Complex Order Revised B2 VT (No Load/Min Gen)	46.45	89.27	81.90	58.10
Complex Order Revised VT (Batch 1 assumptions)	42.42	81.26	75.06	47.95

Figure 30: Daily average prices for complex orders for batch 3

While there were changes to the pricing outcomes, due to the changes to variable cost representation, from using complex orders between batches two and three, the results of batch three do not indicate any issues with the interpretation of batches one and two.

As the prices never dropped as low as zero in the sessions, there was no observed difference between complex orders entered with a zero price in their first price quantity pair and a price of -€500 in their first price quantity pair.

7.7 BATCH FOUR – INPUTS

The purpose of batch four was to further the work of the previous batches with an aim to refining the approach taken to move closer to a representation of the I-SEM in practice based on revised assumptions as well as covering off any final areas of interest including:

- Revisions to assumptions about price making demand and wind;
- Alignment of the wind and load profile with that of GB; and
- Trialling of additional assumptions about complex order creation.

7.7.1 PRICE MAKING DEMAND

Following discussion with the I-SEM EUPHEMIA working group, the volumes which were entered as price making demand were altered for batch four. Previously, 10% of the demand profile was entered. For batch four, this was extended to 20% of the demand in every trading period. The price range entered remained unchanged. To allow for this, a greater number of increments were introduced to the demand curve. Each increment represented 1% of the volume and the prices of these incremental steps increased on a tiered scale. The price making cross section of the demand curve is illustrated in figure 31, below.

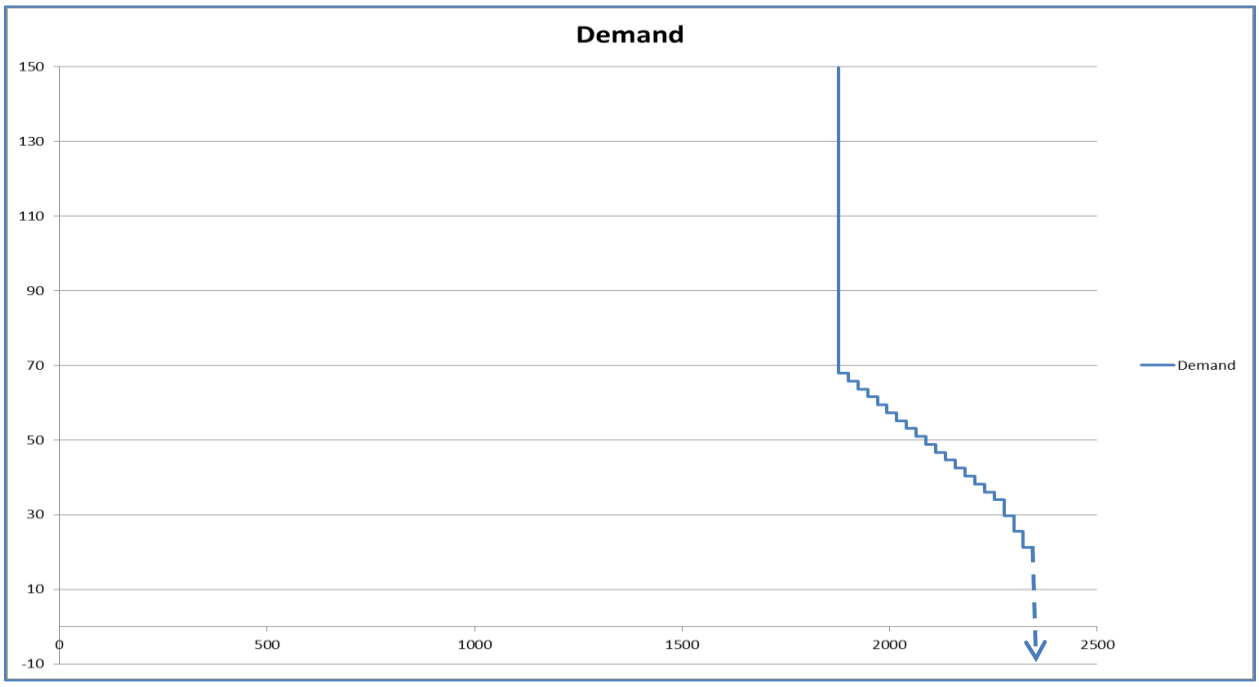


Figure 31: Price making cross section of the demand curve for batch four

It was felt that this may lead to a more accurate representation of the price range as the change in price was smaller allowing the demand clearing to be more reflective of the price. To allow for assessment of the effects of this price making demand in isolation, a session with price taking demand was entered for all sessions with price making demand.

7.7.2 ADJUSTED PRICE MAKING WIND

Following discussion with the working group, it was agreed that the values entered for price making wind orders would be adjusted. Following discussion with the Irish Wind Energy Association (IWEA), it was agreed to trial a representation of wind with lower prices than those seen in batch two. IWEA provided feedback on their view of the representation of wind. This contained proposed prices and MW values which would offer at these prices. To allow for the fact that different volumes of wind are present in each hour, these volumes were converted to percentage values which would be multiplied by the total wind proportion in each trading period, table 10 outlines these values.

Interval	Price	Suggested MW	% of Wind Portfolio
Offer at REFIT[14] price times -1	-€69.72[15]	1800	61%
Offer at ROC[16] price times -1	-€56.77[17]	650	22%
Offer at zero price	€0	500	17%

Table 10: Wind order data for batch 3 of the Scripted Trials

As outlined in table 9, the prices are linked to the prices of support scheme payments. The chosen volumes were based on estimate figures of the proportion of units in receipt of these payments. Units not in receipt of these payments would offer at a price of zero. The prices for support scheme payments were based on the most recent available figures for these schemes.

The main goal with this assumption was to allow for a situation where wind participants would not be at a risk of losing money on production (i.e. only exposed to negative price where this is compensated by other revenues outside of the DAM). Without clarity on the incentives which will be in place at I-SEM go-live, this may be one of many potential representations of wind in the DAM. The goal of entering these values in batch four was to assess the impact of wind units offering at very low prices.

7.7.3 ALIGNMENT OF LOAD AND WIND PROFILES

The baseline assumption for the I-SEM trialling of EUPHEMIA is that data is entered on a SEM trading day basis, i.e. 06:00 to 06:00. This is to allow for initial positions (i.e. whether a unit is on or off at the start of the day), technical offer data (TOD) and commercial offer data (COD) all to come from a single trading day. In line with this assumption, load and wind profiles were entered in previous batches based on the SEM trading day. However, when coupled, this causes a misalignment between the load and wind profiles of the I-SEM and that of GB where these will be correlated in the I-SEM in practice. The reason for this is that the EUPHEMIA orders are entered on a 23:00 to 23:00 GMT timeframe while SEM data is submitted on a 06:00 to 06:00 basis. This is illustrated in figure 32 below for the date 22/06/2014.

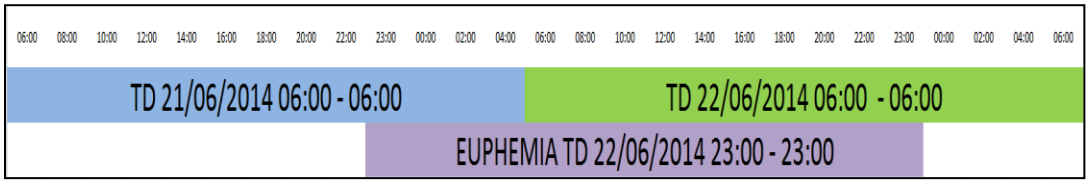


Figure 32: illustration of the SEM and EUPHEMIA days

This alignment means that the peak load are represented in different hours within the data in the I-SEM and GB, i.e. it is approximately hour 12 to 14 in the I-SEM and 18 to 21 in GB. This will have an effect on the relative scarcity in particular hours and, therefore, on the price spread between bidding zones. As the price spread, along with the configuration of the interconnectors, determines the flow between bidding zones, this may have a bearing on the results of these trials.

[14] Renewable energy feed-in tariff (REFIT) is a system of subsidies paid to eligible renewable generators in Ireland
[15] http://www.dcenr.gov.ie/energy/SiteCollectionDocuments/Renewable-Energy/Refit%20Reference%20Prices.pdf

[16] Renewable obligation certificates (ROC) are certificates issued to eligible renewable generators in the UK which can be used to offset renewable obligation payments
[17] https://www.ofgem.gov.uk/publications-and-updates/renewables-obligation-buy-out-price-and-mutualisation-ceiling-2014-15

It was agreed to trial sessions where the load and wind used to represent the I-SEM would be aligned with the hours used in GB, i.e. 23:00 to 23:00. To allow for a single source of SEM data, the TOD and COD would still come from the SEM trading day. This is illustrated in figure 33 below.

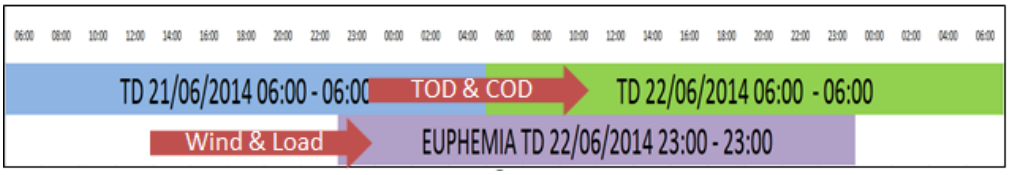


Figure 33: illustration of the sources of data used for batch four for trading day 22/06/2014

For clarity, not all sessions would be performed on this basis. Some sessions would continue with the baseline approach to allow for comparison. The details of the sessions are outlined in the trial script.

7.7.4 COMPLEX ORDERS WITH A ZERO VARIABLE TERM

Previous batches have investigated different methods of arriving at the VT MIC. While this has shown an effect on the results in terms of pricing and scheduling, and the understanding of the I-SEM EUPHEMIA working group has increased in this regard, the full impact of the VT MIC is not fully understood as it relates to I-SEM results. The VT MIC is used typically used to represent fuel costs as well as other variable costs. It will fall to the participant using the complex order to determine the relevant variable costs to include.

To allow for a better understanding of the implications of the VT MIC, the effects of trialling sessions which included price quantity pairs and a fixed term MIC as normal but which had a VT MIC of zero were investigated. Investigating sessions with a MIC of zero, and comparison of these results with other relevant sessions, would allow for the best assessment of the effects of the variable term itself and the risks facing participants who decide to alter the VT to a low level. To allow for comparison, only a subset of the sessions which were trialled as part of batch four included zero VT MIC. The full details of the sessions which were trialled are outlined in the trial script.

7.7.5 COMPLEX ORDERS WITH VARIABLE NO-LOAD COST AND ALTERED PRICE QUANTITY PAIRS

As the batch three results did not provide a conclusive answer on the best approach to take with complex orders, versions of complex orders combining the previously investigated measures were trialled in batch four. To investigate this, sessions were compiled which contained complex orders which had no-load costs included in the VT MIC using option 2 (i.e. by dividing the no-load cost by max availability) and which had a first price quantity pair with a price of -€500 and a quantity of minimum stable generation. This was investigated to assess if the elements of each methodology could be combined.

7.7.6 REFINEMENT OF VALUES INCLUDED

The following refinements to the approach taken were implemented:

- Units in Northern Ireland had their orders converted to euro from their pound sterling values;
- Peat units were entered on a price making basis;
- Price taking hydro units which had previously been omitted were included using standard procedure for hydro units; and
- Other price taking units which had previously been omitted (e.g. non-wind autonomous units) were included using simple orders.

These refinements allowed for the most accurate representation of the I-SEM in the final batch of the trials.

7.8 BATCH FOUR – RESULTS

7.8.1 PRICE MAKING DEMAND

Results of cleared and uncleared demand by period for batch four sessions with price making demand using the SEM trading day are presented in figure 34, below.

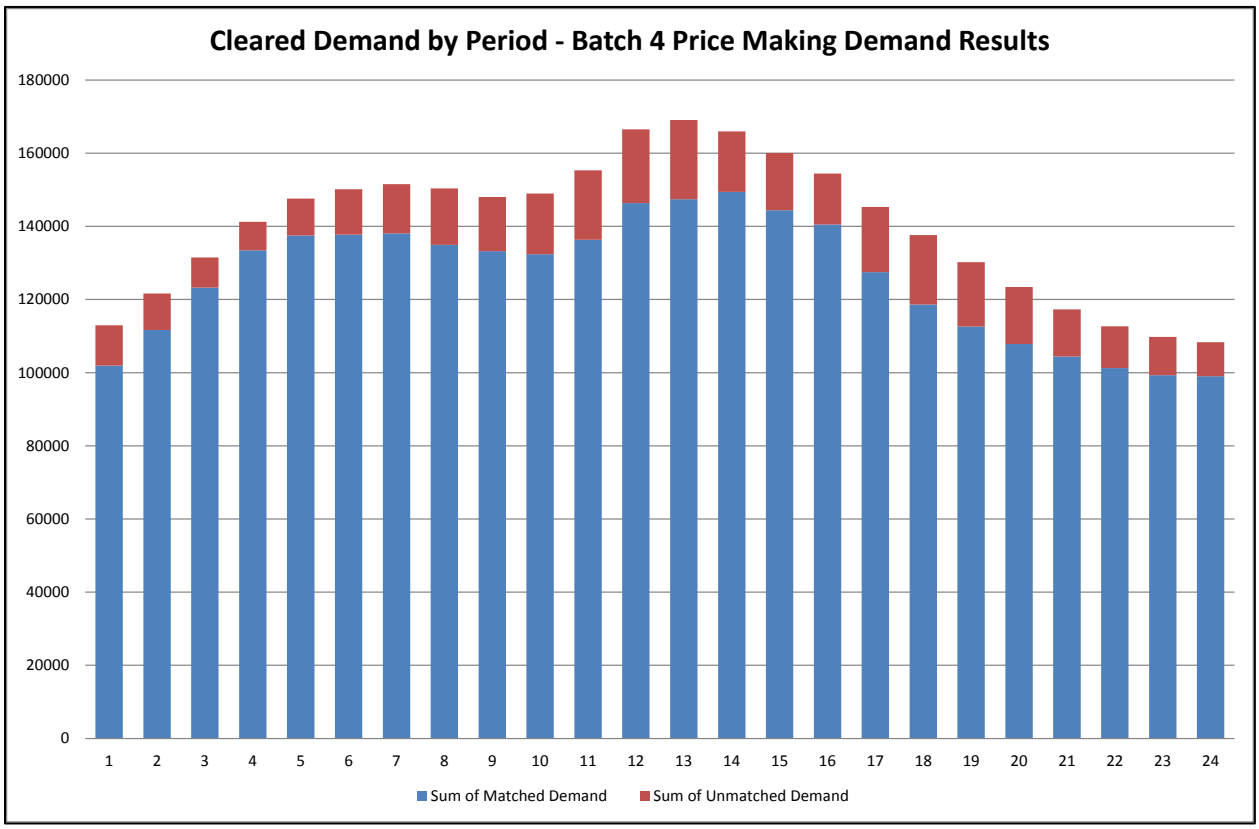


Figure 34: cleared and uncleared demand by period for batch four

These figures show that demand is partially cleared in all trading periods throughout the day, though there is a slightly higher proportion of demand which is partially cleared over the peak load hours. Similar results are seen in sessions using the EUPHEMIA load profile albeit with different hours in EUPHEMIA representing peak load (i.e. peak load is hour 19 rather than hour 12). These results are presented in figure 35, below.

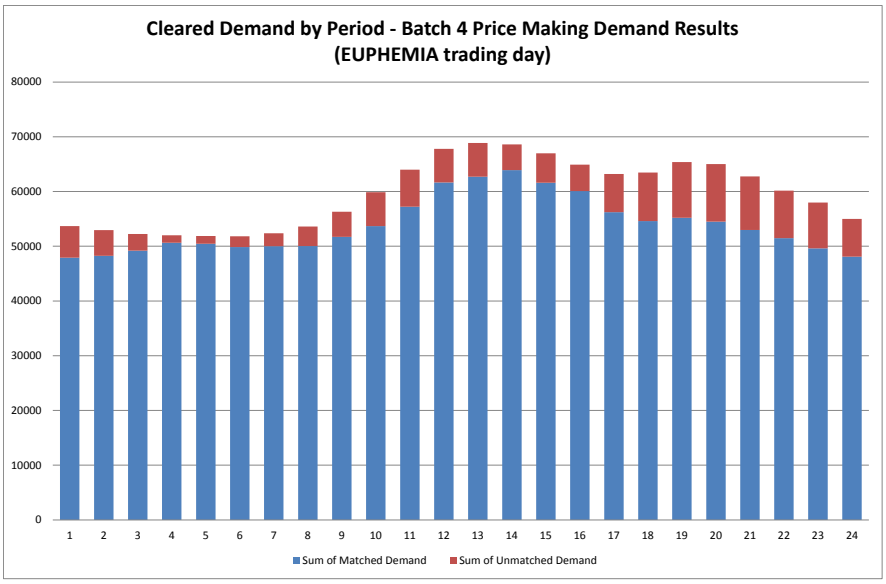


Figure 35: cleared and uncleared demand for batch four using the EUPHEMIA trading day

As the level of cleared demand and the clearing price are interlinked, these results are in line with the results in relation to the alignment of the load and wind profiles with the EUPHEMIA trading day outlined in section 7.8.2.

Analysis of the level of cleared demand by scenario type (i.e. order type used, trading day used and whether the session was coupled or de-coupled) does not show a consistent trend related to the effects of changing scenario of the level of uncleared demand. Results of cleared demand by scenario for price making demand sessions in batch four are presented in figure 36, below.

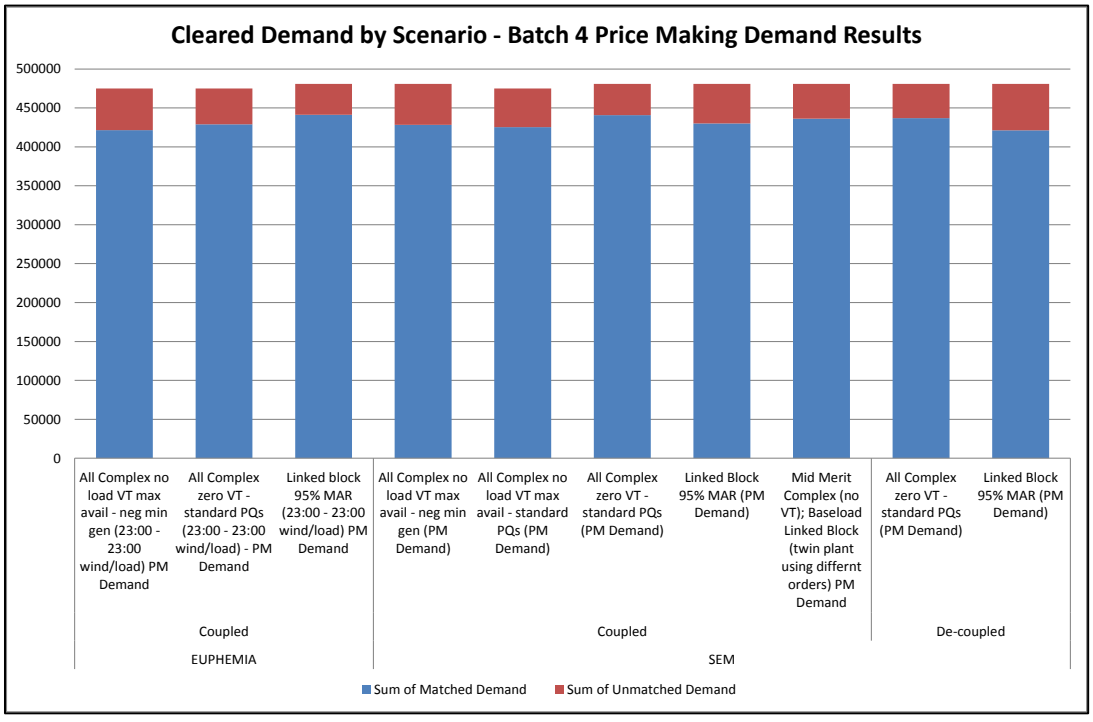


Figure 36: cleared demand by scenario type for batch four price making demand sessions

7.8.2 ALIGNMENT OF LOAD AND WIND PROFILES

The alignment of the wind and load profiles with that of GB had a noticeable effect on the prices in sessions when compared to those which were not aligned (i.e. used the SEM trading day wind and load). Price information of sessions using SEM and EUPHEMIA days for wind and load is presented in figure 37 below.

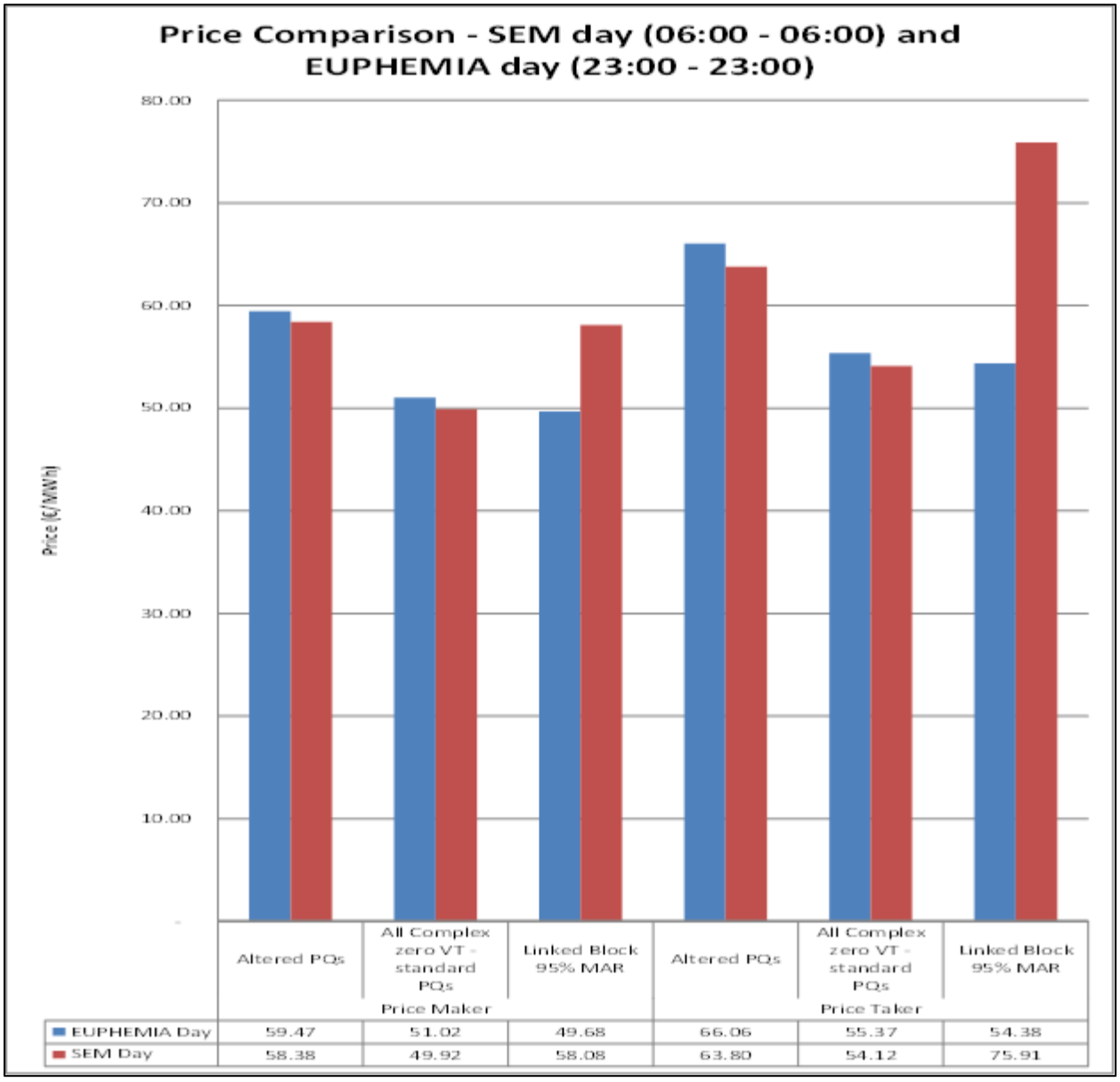


Figure 37: Average prices for sessions using SEM day and EUPHEMIA day

As can be seen in figure 37, alignment of the load and wind profiles had a small but noticeable effect on the prices for complex sessions while it had a larger effect on linked block sessions. However, the linked block data itself was not altered for these sessions. As linked blocks must be entered for explicit hours, parent blocks (which contain the start-up and other fixed costs) were entered into the peak hours of the trading day where the units were off at the start of the trading day. This ensures that the highest costs are considered against the periods in which the prices should be highest. The peak load chosen was from the SEM trading day and blocks were not adjusted for the new peak load along with the wind and load. Therefore, the blocks which are aligned with the peak hours in the SEM sessions are aligned with off-peak hours in the EUPHEMIA aligned runs (i.e. a block for hour 12 was for 18:00 in the SEM day but is for 11:00 in the EUPHEMIA day). This will affect the scheduling of these units and ultimate price outcomes. While there is a difference to the prices seen, this is more closely linked to the fact that linked block orders were not amended to follow the new peak than with the load and wind values themselves. The trend is evident with price making or price taking demand values.

While there are notable changes to the outturn results from aligning the wind and load with that of GB, the changes are to specific hours rather than to the overall average results. Results noticed were, except for the previously discussed linked block orders where block orders were set up at off peak times, on average similar to results using the same method with the SEM aligned wind and load data. This indicates that the results observed are more closely linked to the underlying wind and load, along with the orders representing SEM units, than they are to the conditions in GB outside of the positive effects of coupling on price.

This indicates that the inferences drawn from previous trial batches are not impacted by the original assumptions with respect to the load and wind forecast data.

7.8.3 COMPLEX ORDERS WITH A ZERO VARIABLE TERM

Sessions using zero variable term show the lowest price among complex order sessions. This is due to the fact that, as lower costs are represented, EUPHEMIA may schedule more mid-merit plant in these sessions than in others. The average prices from complex sessions are presented for comparison in figure 38 below.

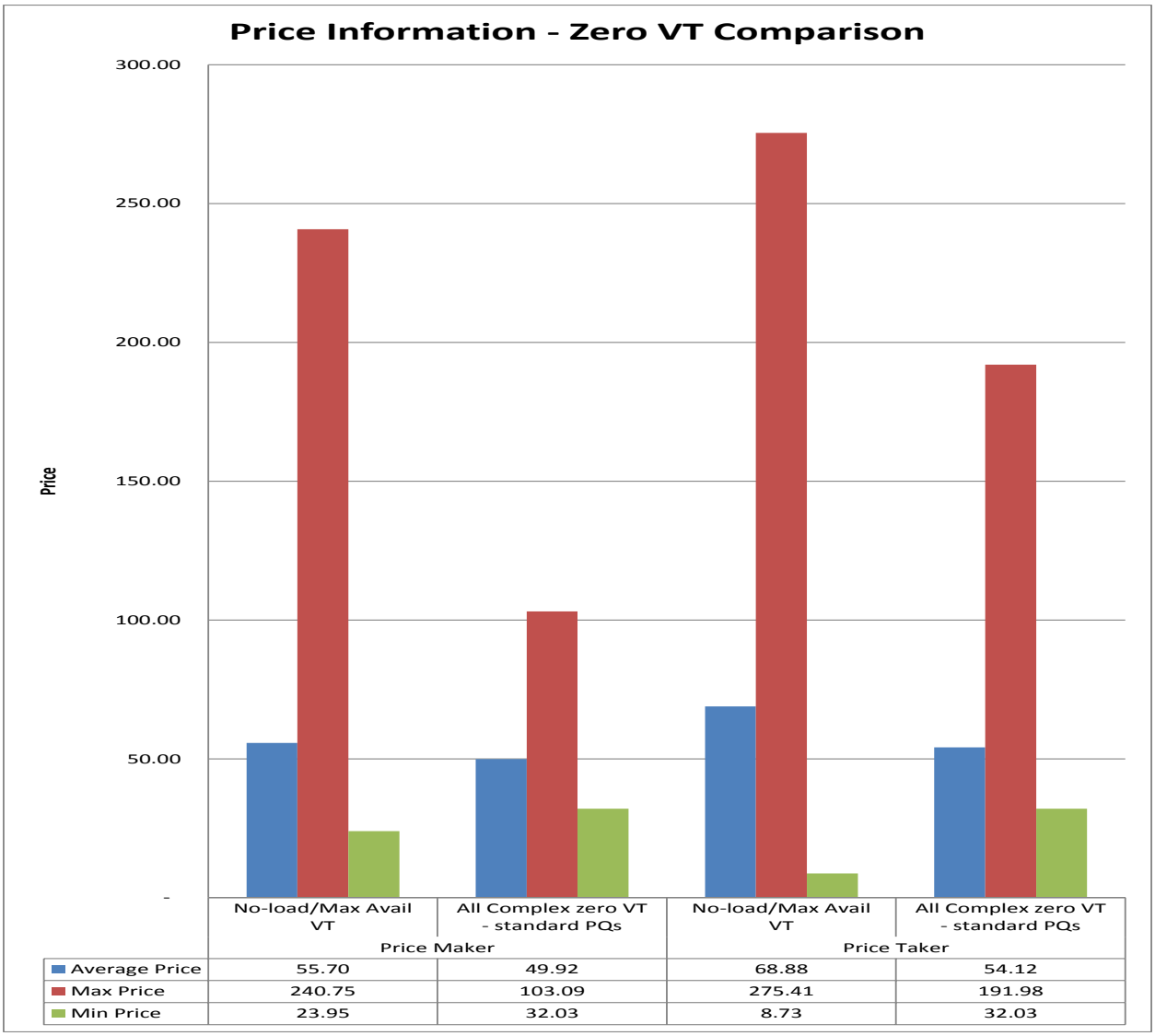


Figure 38: comparison of pricing information between zero VT and no-load/max availability VT

These low prices had a significant effect on the cost recovery of units with many instances of units, primarily mid-merit units, not recovering their costs. There were 152 instances of units not recovering their costs across 40 sessions using a zero VT MIC. An example of these instances for sessions using standard price quantity pairs and price taking demand are presented in table 11 below.

Session ID	Unit ID	Net Revenue
201504011	GU_400323	- 329,277.64
201504011	GU_400480	- 206,501.41
201504011	GU_400530	- 16,757.05
201504011	GU_400540	- 48,265.46
201504011	GU_400850	- 17,041.75
201504011	GU_400930	- 16,858.75
201504011	GU_500040	- 21,510.17
201504012	GU_400323	- 141,105.66
201504012	GU_400480	- 251,420.75
201504012	GU_400540	- 143,443.52
201504012	GU_500130	- 32,529.13
201504012	GU_500131	- 36,894.04
201504012	GU_500140	- 20,541.92
201504013	GU_400850	- 4,250.16
201504013	GU_500130	- 48,064.16
201504013	GU_500131	- 46,959.99
201504015	GU_500040	- 101,600.46
201504015	GU_500130	- 61,002.58
201504015	GU_500131	- 46,731.72

Table 11: list of instances of cost under recovery for session 201504011 to 201504015

As can be seen in table 11, the magnitude of the under recoveries encountered here are, in many cases, far greater than those seen in previous batches. For reference, the corresponding sessions using option 2 (i.e. no-load divided by max availability) for assigning no-load costs to the VT MIC had zero instances of under recovery across the same five days represented in table 10.

The primary cause of these under recoveries is that costs in the DAM are underrepresented where the fuel cost is not included. In order to assess the risk of under recovery, the fixed term was not altered and so only fixed costs are accounted for in the MIC though there is an implicit allocation through prices deemed by the price quantity pair. Without combining the VT and fixed term, or in accounting for the fuel cost in the fixed cost, the unit is only guaranteed by the MIC to recover their fixed costs.

The number of instances of units under recovering their costs, and in some cases the magnitude of the financial losses in the DAM, observed are greater than in previous trial batches indicating that, as trialled, such an implementation would create large risks for I-SEM participants. However, it should be noted that these results have looked at a zero variable term without adjusting the fixed term to account for an assumed variable cost and the level of under recovery seen would decrease where the fuel costs were accounted for in the fixed term.

As with all methods investigated for complex orders, the risks facing participants must be managed through informed use of these orders. These results show that units participating in the I-SEM using a zero VT MIC presents risks of losses where these units do not account for all their fuel costs in the fixed term.

7.8.4 COMPLEX ORDERS WITH VARIABLE NO-LOAD COST AND ALTERED PRICE QUANTITY PAIRS

For analysis of results relating to this condition, sessions using standard price quantity pairs and altered price quantity pairs were compared with each using option 2 for assigning no-load costs to the variable term. Pricing results are summarised in figure 39 below.

	All Complex no load VT max avail - neg min gen	All Complex no load VT max avail - standard PQs	All Complex no load VT max avail - neg min gen	All Complex no load VT max avail - standard PQs
	Price Maker		Price Taker	
Average Price	58.38	55.70	63.80	68.88
Max Price	207.75	240.75	240.75	275.41
Min Price	32.05	23.95	32.08	8.73

Figure 39: Pricing information for complex runs in batch four with differing price quantity pairs

Analysis of the prices show that while inconclusive on the effects on average price, due to different results from price taking and price making sessions, there is a trend that the total range of prices (i.e. maximum minus minimum price) is greater when standard SEM price quantity pairs are used. This is illustrated by the average hourly price for each complex order type in figure 40 below.

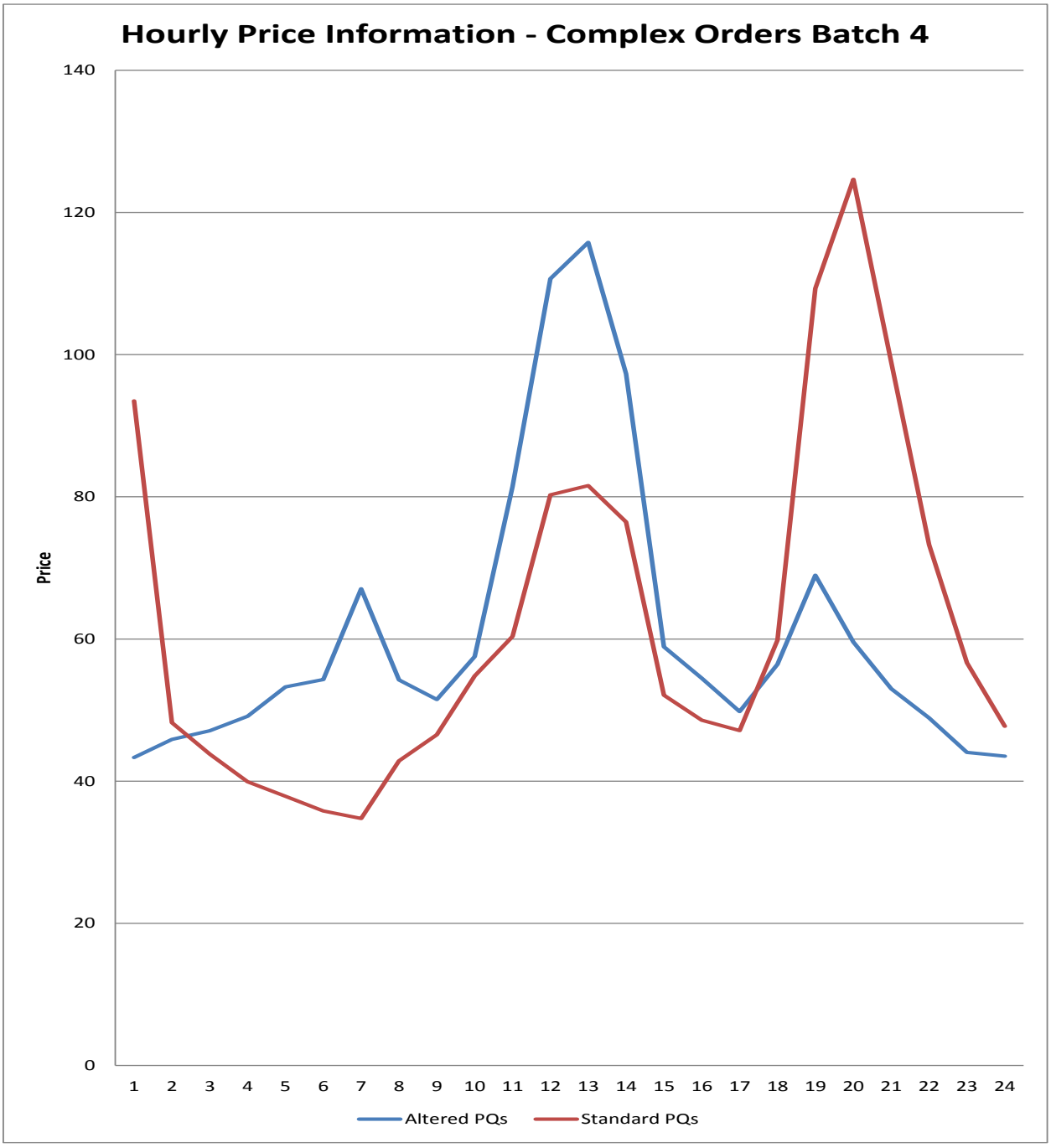


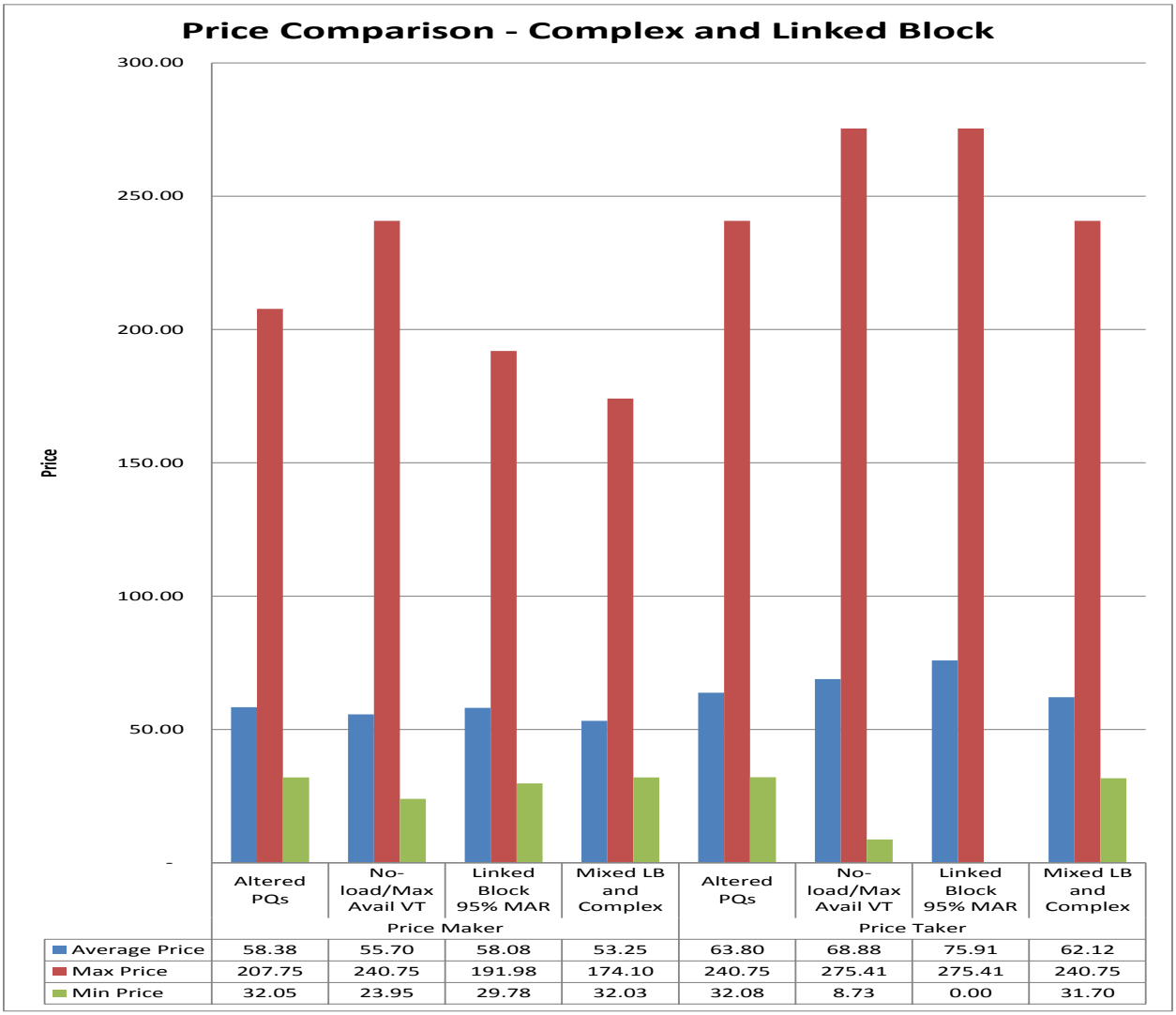
Figure 40: Average hourly prices for complex order sessions in batch 4

Comparison of the hourly values shows that while the price at peak load (hours 12 and 13) is higher on average with altered PQ pairs, prices are more stable throughout the day. This indicates that these runs are less affected by secondary peak prices at the start and end of the day which primarily occur due to interconnector congestion as the interconnectors move from import to export or vice versa.

It will ultimately fall to participants who choose to use complex orders to decide which method of implementing complex orders will best allow for implementation of risk mitigation and other strategies and these will change on a unit by unit basis. The results of batch four do not conclusively indicate a best method.

7.8.5 LINKED BLOCK ORDERS AND MIXES WITH COMPLEX ORDERS

It was agreed to investigate linked block orders to see if the refinements outlined in section 7.7.1 provided sufficient robustness to the pricing outcomes or if the issues previously encountered due to a lack of price makers in the market were still relevant. Figure 41, below, presents a comparison of pricing information from complex and linked block orders from batch four.

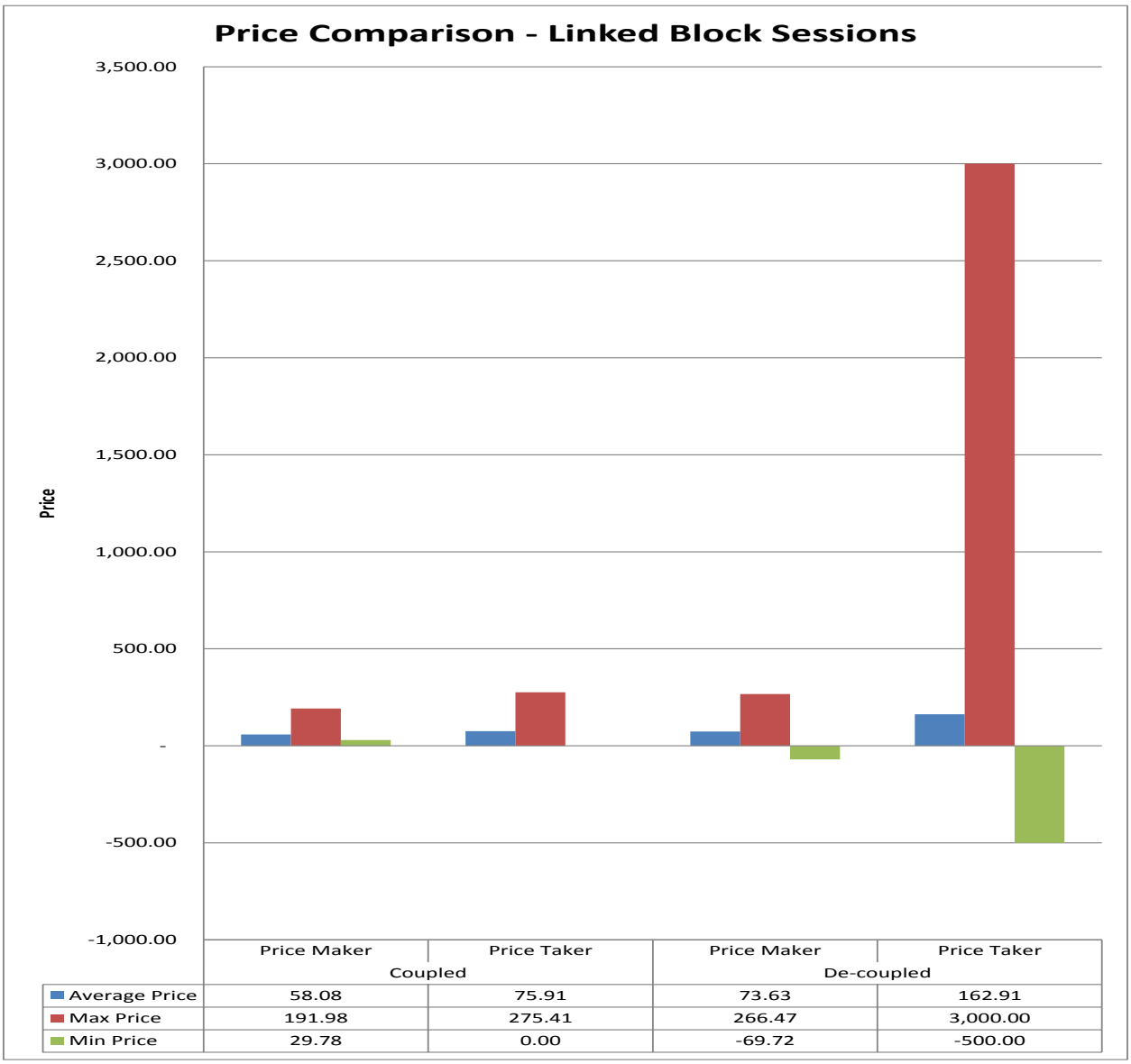


	Price Maker				Price Taker			
	Altered PQs	No-load/Max Avail VT	Linked Block 95% MAR	Mixed LB and Complex	Altered PQs	No-load/Max Avail VT	Linked Block 95% MAR	Mixed LB and Complex
Average Price	58.38	55.70	58.08	53.25	63.80	68.88	75.91	62.12
Max Price	207.75	240.75	191.98	174.10	240.75	275.41	275.41	240.75
Min Price	32.05	23.95	29.78	32.03	32.08	8.73	0.00	31.70

Figure 41: price information for linked block and complex orders from batch four

Figure 41 presents figures for coupled sessions which are aligned with the SEM day. Because of this, the outlying linked block prices detailed in section 7.8.1 (i.e. linked block sessions with higher prices stemming from altering the wind and load profiles) are not accounted for. As figure 41 shows, in the case of price making demand, prices from linked block only sessions are similar to those of complex order sessions and sessions using a mix of complex and linked block sessions. However, in the case of price taking demand, there is a greater increase to the linked block only session prices than is observed in the complex order sessions. This result is as expected as without price making demand, the number of price makers in the market is reduced.

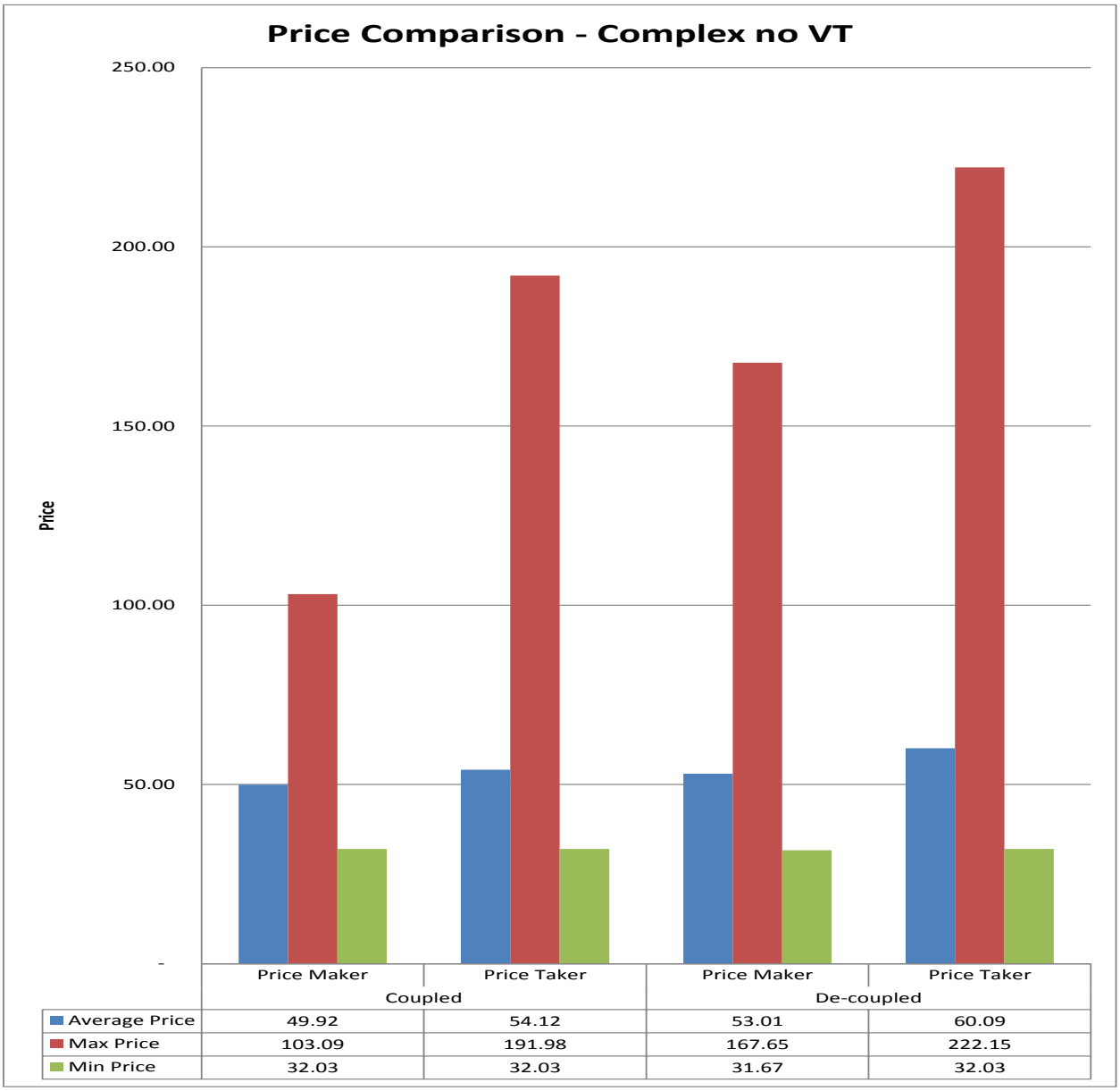
Further to this, linked block sessions were analysed on a de-coupled basis to assess if the assumptions about price making demand, along with other refinements outlined in section 7.7.1, would allow for sufficient price makers in the result of de-coupling. Results from coupled and de-coupled sessions are presented in figure 42 below.



	Coupled		De-coupled	
	Price Maker	Price Taker	Price Maker	Price Taker
Average Price	58.08	75.91	73.63	162.91
Max Price	191.98	275.41	266.47	3,000.00
Min Price	29.78	0.00	-69.72	-500.00

Figure 42: coupled and de-coupled results of linked block sessions from batch 4

As can be seen in figure 42, there is a large increase to the range of prices for linked block sessions where these are de-coupled. This effect is larger where demand is price taking with a number of instances of price floor and price cap occurring. It should be noted that these values are representative of the assumptions used in batch four and may not be reflective of actual I-SEM activity. For comparison, batch four also had de-coupled sessions for complex orders using no VT, results from the relevant no VT sessions are presented in figure 43 below.



	Coupled		De-coupled	
	Price Maker	Price Taker	Price Maker	Price Taker
Average Price	49.92	54.12	53.01	60.09
Max Price	103.09	191.98	167.65	222.15
Min Price	32.03	32.03	31.67	32.03

Figure 43: comparison of coupled and de-coupled results from zero VT complex order sessions

While comparison here should be tempered by the results outlined in section 7.8.2 (i.e. that sessions with zero VT had very low prices which caused issues with cost recovery), the effect of de-coupling on the price range is much lower with these complex order sessions. While these results show that the risk associated with linked block orders are still present with the refined inputs, the main concern was in sessions which were de-coupled and had price taking demand.

7.9 ADDITIONAL ANALYSIS

7.9.1 PARADOXICALLY REJECTED ORDERS

Paradoxically rejected orders[18] are orders which appear to have their economic conditions (e.g. block price or MIC value) satisfied at the market clearing price but which have been rejected (e.g. a generator block order which is rejected though its block price is below the clearing price). For clarity, an order being paradoxically rejected does not mean that the order should have been accepted. Typically, this occurs where inclusion of the order impact on the clearing price to such an extent that the rules relating to the relevant order type are no longer satisfied (e.g. including the order would decrease the price such that the cost condition could no longer be satisfied). It is possible for a block order or a complex order to be paradoxically rejected. Paradoxically rejected orders are a common part of EUPHEMIA solutions and are a necessary side effect of not allowing paradoxically accepted orders, i.e. orders which are accepted even though their required costs are not met. However, as such a concept does not exist within the SEM, due to the uplift function adjusting the clearing price to account for costs not covered by the shadow price, SEMO agreed to investigate the levels of paradoxically rejected orders in the Scripted Trials.

Paradoxically rejected blocks (PRBs) and complex orders (paradoxically rejected minimum income conditions, PRMICs) are flagged within the EUPHEMIA results. However, linked block orders with the configuration used in these trials are not easily flagged by this process. Linked blocks are processed as individual parent and child blocks. While in the optimisation a transfer of welfare from child to parent exists, which can cause expensive parent blocks to be accepted due to cheaper child blocks, the welfare of each block is considered individually when assessing if the block is a PRB. In the trials, linked blocks have an expensive parent block (representing fixed costs) and cheaper child blocks (representing incremental costs). Accordingly, where the expensive parent block is too expensive to be accepted individually, it is, therefore, flagged as being out of merit. The child block orders are then flagged as being rejected as the parent block was rejected. While this accurately reflects the blocks on an individual basis, a combination of these blocks may have been paradoxically rejected. Neither the parent block nor the child block are individually a PRB, as they would not individually be accepted due to their constraints, and are not flagged as such. However, when looking at the results of the trial it is necessary to look at parent and child blocks together as a generator unit submits a number of these collectively to represent their costs and profile. This makes quantifying the number of paradoxical rejections for generator orders difficult and detailed analysis to attempt to quantify this by analysis of inputs and results was outside of the scope of the I-SEM trialling of EUPHEMIA. However, as each complex order represents the orders of a single unit, no such limitation applies to the assessment of PRMICs. Therefore, the below analysis relates to complex orders only.

[18] Further information on paradoxically rejected orders is available at: https://www.apxgroup.com/wp-content/uploads/Euphemia-Stakeholder-Forum-11-Jan-2016.pdf

Table 12 shows the number of instances of paradoxically rejected complex orders per batch in the Scripted Trials.

Unit ID	Batch One	Batch Two	Batch Three	Batch Four	Total
GU_400120	0	4	0	0	4
GU_400121	0	5	0	0	5
GU_400140	0	0	0	3	3
GU_400180	0	10	7	2	19
GU_400271	0	0	2	0	2
GU_400272	0	0	1	0	1
GU_400323	2	8	6	8	24
GU_400480	0	6	3	3	12
GU_400530	4	0	2	1	7
GU_400540	0	9	3	5	17
GU_400850	0	1	2	1	4
GU_400930	0	6	13	5	24
GU_500040	0	2	1	2	5
GU_500130	0	3	1	2	6
GU_500131	4	2	3	4	13
GU_500140	2	7	3	1	13
GU_500280	4	9	13	1	27
GU_500281	0	11	19	1	31
GU_500282	4	8	19	1	32
GU_500822	0	0	0	0	0
GU_500823	0	0	1	0	1
Batch total	20	91	99	40	250

Table 12: Information on paradoxically rejected MIC (PRMIC) orders across all batches

Review of these results across batches should be considered against the number of complex orders which were present in each batch as defined in the trial script, e.g. batch one only contained complex orders for half of the units and had 50 sessions rather than 100.

Table X shows two trends in the units which most commonly have paradoxically rejected orders:

- Units which have a weighted average offer price close to the average clearing price (e.g. GU_400323); and
- Units which have another similarly costed plant on a single trading site (e.g. GU_500280 – GU_500282).

It should be noted each unit would have to satisfy their MIC to be activated. For units on a single trading site, if only one of these units can satisfy their MIC over a trading day, only one unit would be scheduled. As the other units have similar costs, and therefore similar complex orders, the orders of the other units are likely to also be in-the-money but are rejected as their MIC cannot be met because their inclusions would impact to final clearing price and thus the overall revenues. Therefore, these orders are paradoxically rejected.

While there is no consistent trend in the change to the number of PRMICs per unit across batches, there is a notable decrease in the total number of PRMIC orders in batch four as compared to batches two and three. It should be noted here that batch four had a number of runs using a variable term MIC of €0 reducing MIC values overall and making the constraint easier to satisfy.

While there is no similar analysis available for linked block or exclusive group orders, a particular example was highlighted in the analysis shared in working group meetings of a paradoxically rejected block order.

For session 201502081 in batch two of the Scripted Trials, there was a noted case of paradoxically rejected linked block orders. In this case, two units (GU_500280 and GU_500282) submitted orders which were identical in terms of volume (i.e. same volumes in the same hours) and structure (i.e. same number of blocks with the same volume in each corresponding block) due to the units having the same initial condition and technical data. For this session, the price of each block for GU_500282 was cheaper than that of GU_500280; however, GU_500280 was accepted despite its higher costs. Details of the orders are outlined in table 13 below.

Unit ID	Average price of blocks[19]	Accepted or rejected
GU_500280	€99.67	Accepted
GU_500282	€95.98	Rejected

Table 13: details of block prices for GU_500280 and GU_500282 for session 201502081

The example was shared with APX who reverted with a response following analysis by the algorithm vendor. It was confirmed that this solution was sub-optimal and though undesirable, it was explainable following analysis. This is a possibility in sub-optimal solutions where a block may be a PRB in one solution but be accepted in another solution which could not be found due to the time limit imposed. While this is an example of a sub optimal solution, and its potential effects on scheduling, the following should be noted:

- PRBs are a necessary part of EUPHEMIA and not a direct indication of the quality of a solution;
- PRBs may still be present in optimal solutions; and
- Sub optimal solutions occur in mixed integer programming (MIP) runs of the current SEM as a time limit is also imposed in the SEM and this may have similar effects on scheduling of units.

7.9.2 COMPARISON WITH RELEVANT SEM STUDY RUNS

There are many differences between the SEM Market Scheduling and Pricing (MSP) software and EUPHEMIA. These cover a range of differences both in functionality and the objective function of the algorithms. Some of the key differences are as follows:

[19] In the case of linked block orders, the overall transfer of welfare from child blocks to parent blocks is what is actually considered. Average prices are included here as a simplification for illustrative purposes

- The SEM MSP uses Lagrangian relaxation as a primary solver, with mixed integer programming (MIP) as a secondary solver, while EUPHEMIA uses MIP only;
- The SEM MSP seeks to lower production costs in the SEM while EUPHEMIA seeks to maximise social welfare over all bidding zones;
- The SEM MSP has a number of features to optimally represent units with specific characteristics (e.g. pumped storage) while EUPHEMIA has products which must be adapted, for the purpose of producing commitment starting point for dispatch, for a range of technologies;
- The SEM MSP allocates volumes to interconnectors based on the bids of interconnector units while EUPHEMIA bases interconnector allocations on the price spread between bidding zones;
- Participants in coupled markets are not subject to any Bidding Code of Practice while this is implicitly maintained in the SEM participant data used in the trials;
- The SEM MSP has access to significantly more information for units than EUPHEMIA and this may alter how the units are scheduled, ultimately affecting the price; and
- The SEM MSP has an uplift function which allows a lower merit unit to serve peak load and recover fixed cost while EUPHEMIA only has access to units order information.

Given the above points, it is not possible to directly compare prices or schedules produced by EUPHEMIA to the outturn SEM prices and schedules. Moreover, these trials are at an early stage and the results thus far are not necessarily reflective of the results of EUPHEMIA once the I-SEM goes live. Any comparisons between SEM and EUPHEMIA outputs are included for reference only; results are not reflective of expected outturn results and therefore conclusions should not be drawn of final I-SEM prices.

During the Commercial Phase, there were requests for SEMO to provide SEM market data which could form a basis for comparison with the results of the Scripted Trials and Unscripted Trials. This was requested as the actual historical SEM data differed from the data used in the EUPHEMIA trial runs. This is due to the fact that ex-ante 1 (EA1) data was the basis of the EUPHEMIA trial orders but only the within day 1 (WD1) wind profile was available. To account for this, and the difference in solvers between SEM MSP software and EUPHEMIA, study runs of the SEM historical days from the Scripted Trials and Unscripted Trials were completed. Two runs were completed for each day, one using the full availability of the interconnectors and one using zero availability of the interconnectors. The conditions were as follows:

- EA1 data would be used for everything other than wind forecast (e.g. bids, load forecast etc.);
- WD1 data would be used for the wind forecast only;
- Interconnector flows would be taken as interconnector unit nominations (IUNs) as calculated during unit commitment;
- For runs including the interconnectors, interconnector user bids would remain unchanged and the flows would be calculated as normal given the new wind forecast included in the run;
- For runs which did not include the interconnectors, capacity holdings (and therefore IUNs) would be set to zero; and
- All runs would be complete using MIP with a 600 second time limit.

The average price information of these study runs for runs including and not including interconnector values are presented in table 14 for the Scripted Trials and table 15 for the Unscripted Trials.

Date	Average Price - Zero ATC	Average Price - Full ATC
22/06/2014	59.34	43.75
25/11/2014	75.44	76.61
24/01/2015	63.52	44.76
14/03/2015	77.14	61.3
11/04/2015	55.92	43.64

Table 14: average price information for SEM study runs for Scripted Trial dates

Date	Average price - Zero ATC	Average Price - Full ATC
11/03/2015	64.55	70.26
01/06/2015	43.96	42.34
09/06/2015	55.81	49.05
04/08/2015	51.68	49.72
17/11/2015	43.44	41.31
02/12/2015	59.96	51.64
27/12/2015	30.51	29.55

Table 15: average price information for SEM study runs for Unscripted Trial dates

It should be noted that, for the reasons stated above, this data is provided for reference only. The results contained within this report should be viewed in line with the goals and assumptions of the project and are not intended to be reflective of the I-SEM price nor of a replication of the SEM conditions in EUPHEMIA.

8 UNSCRIPTED TRIALS

The Unscripted Trials represent those trials which were performed without a trial script. Furthermore, in the Unscripted Trials, the input data was created by the members of the I-SEM EUPHEMIA working group rather than by SEMO; SEMO continued to create data to represent units which were not covered by the orders submitted by working group members (e.g. small wind units, supplier units which have not participated in the I-SEM EUPHEMIA working group etc.).

While there were no direct rules applied or monitored during the Unscripted Trials, working arrangements were agreed by the working group and SEMO. The primary arrangements were as follows:

- Working group members were expected to provide orders for all relevant supplier and generator units;
- SEMO provided foreign exchange (FX) rates for the SEM trading days to be used for any currency calculations;
- Data was entered on a SEM trading day (06:00 – 06:00) basis for an agreed set of trading days;
- Working group members were expected to accurately reflect their costs (e.g. orders will attempt to recover starts, where required);
- The entire load and wind forecast will be entered for each hour with SEMO creating orders for any units not covered by a working group member; and
- Suppliers will be assigned a proportion of the load forecast in each hour based on market share data supplied by SEMO. This market share data will be a proxy based on the retail market reports for Ireland[20] and Northern Ireland[21].

As part of these working arrangements, a set of historical SEM trading days to be used for the Unscripted Trials were agreed. The programme for the I-SEM Trialling of EUPHEMIA assigned 28 datasets split over two 14 dataset batches to the Unscripted Trials. Following discussion with the working group, it was agreed that only 7 historical days would be investigated meaning that each day would be looked at twice per batch. This is illustrated in figure 44, below.

Figure 44: Illustration of the batches involved in the Unscripted Trials

[20] http://www.cer.ie/document-detail/Retail-Market-Reports/646
[21] http://www.uregni.gov.uk/publications/quarterly_transparency_report_qtr_on_retail_energy_market_nov_2015

For clarity, there is no requirement for the strategies or order types used for a particular unit, or group of units, in one of the batches of the Unscripted Trials to be used in another (e.g. inputs to 1A do not need to be linked in any way to inputs in 2A etc.).

Following discussion with the I-SEM EUPHEMIA working group, it was agreed that the 7 historical days investigated should cover a range of time periods throughout the year. Feedback from the working group also asked for the inclusion of specific trading days which had load and wind conditions which were of interest to the working group. The final list of trading days investigated is presented in table 16 below.

Date	Condition
27/12/15	Winter Day
02/12/15	Winter Day
09/06/15	Summer Day
01/06/15	Summer Day
04/08/15	Desired Wind Level
11/03/15	Desired Wind Level
17/11/15	Desired Wind Level

Table 16: Historical SEM Trading Days investigated as part of the Unscripted Trials

8.1 BATCH ONE – INPUTS

Inputs for batch one of the Unscripted Trials were received from 13 organisations, listed below:

- AES;
- Aughinish Alumina;
- BGE;
- Bord na Mona;
- Electric Ireland;
- Energia;
- ESB GWM;
- Gaelectric;
- Power NI PPB;
- Power NI Supply;
- PrePay Power[22];
- SSE; and
- TEL.

[22] Though not a member of the working group, PrePay Power requested to participate in the Unscripted Trials

All participants in the Unscripted Trials provided a separate submission for batches 1A and 1B though some units were treated the same in each batch. SEMO created orders to account for any units which were not covered by submissions to the Unscripted Trials, e.g. small wind units, supplier units not represented on the working group etc.

8.1.1 BATCH 1A

Orders were received for a range of units including thermal units, wind units, hydro units, storage units and supplier units. Orders used a range of strategies, as decided by the participants creating the orders; while input data was shared with all participants, the methodologies applied to create inputs was not shared and so full details of these orders are not outlined in this report.

For wind units, orders were received from 5 participants all of which were price taking orders. This is outlined in table 17, below.

Company	Price Taker	Price Maker
BGE	X	
Energia	X	
Gaelectric	X	
Power NI	X	
SSE	X	

Table 17: breakdown of wind unit participation type

This is moves away from the assumption used in batch four that wind units would offer at prices reflective of support scheme payments or zero; however, as the prices do not typically go as low as zero, outside of the de-coupled linked block sessions, there was little practical difference between the wind orders used in batch four and those submitted for the Unscripted Trials batch 1A.

For supplier orders, there were a mix of price taking and price making orders submitted. For batch 1A, four of six suppliers entered fully price taking orders. The remaining two provided price making orders[23]. Table 18, below, outlines the breakdown of these orders by supplier for batch 1A.

Company	Price making order	Price taking order
BGE	X	
Electric Ireland	X	
Energia		X
Power NI		X
PrePay Power		X
SSE		X

Table 18: breakdown of supplier unit orders for unscripted phase batch 1A

These inputs show that suppliers may choose different methods of participation in the Unscripted Trials which is in line with the goal of this phase of the I-SEM Trialling of EUPHEMIA.

[23] For these purposes, a price making order is any order with a price making element even where there is also a price taking element to the order

For thermal and storage units, a mix of linked block and complex orders were used by participants. In some cases, participants chose to use both linked block and complex orders while in others, only one order type was used. The breakdown of the orders used is outlined in table 19 below.

Company	Linked block only	Complex only	Mix
AES			X
Aughinish Alumina		X	
BGE		X	
Bord na Mona			X
ESB GWM		X	
Energia			X
Gaelectric	X		
Power NI PPB			X
SSE	X		
TEL			X

Table 19: breakdown of order types used for batch 1A of the Unscripted Trials

These inputs show a slight preference for a mix of linked block and complex orders; however, while there was an overall preference for a mix, there were as many instances of a single order type being used as there was a mix. This mix of inputs provides further evidence that participants are able to participate as they desire in the Unscripted Trials.

8.1.2 BATCH 1B

There were no differences between the inputs for wind in batch 1A and batch 1B of the unscripted trials with all participants continuing to participate on a price taking basis.

For supplier units, there were some changes to participant inputs in batch 1B from the inputs in batch 1A. Some suppliers switched between price making and price taking orders in batch 1B. The breakdown of supplier participation is outlined in table 20, below.

Company	Price making order	Price taking order
BGE		X
Electric Ireland	X	
Energia	X	
Power NI	X	
PrePay Power		X
SSE		X

Table 20: breakdown of supplier order types in batch 1B of the Unscripted Trials

Furthermore, as suppliers, as with other participants, could enter orders with more or less volume than their forecast, there were some changes to bid volumes between batch 1A and 1B. This change between batches further shows that suppliers are able to implement the strategies they wish to trial in the Unscripted Trials.

For thermal and storage units, a mix of linked block and complex orders were used by participants. In some cases, participants chose to use both linked block and complex orders while in others, only one order type was used. The breakdown of the orders used is outlined in table 21 below.

Company	Linked block only	Complex only	Mix
AES			X
Aughinish Alumina		X	
BGE		X	
Bord na Mona			X
ESB GWM		X	
Energia			X
Gaelectric	X		
Power NI PPB			X
SSE	X		
TEL			X

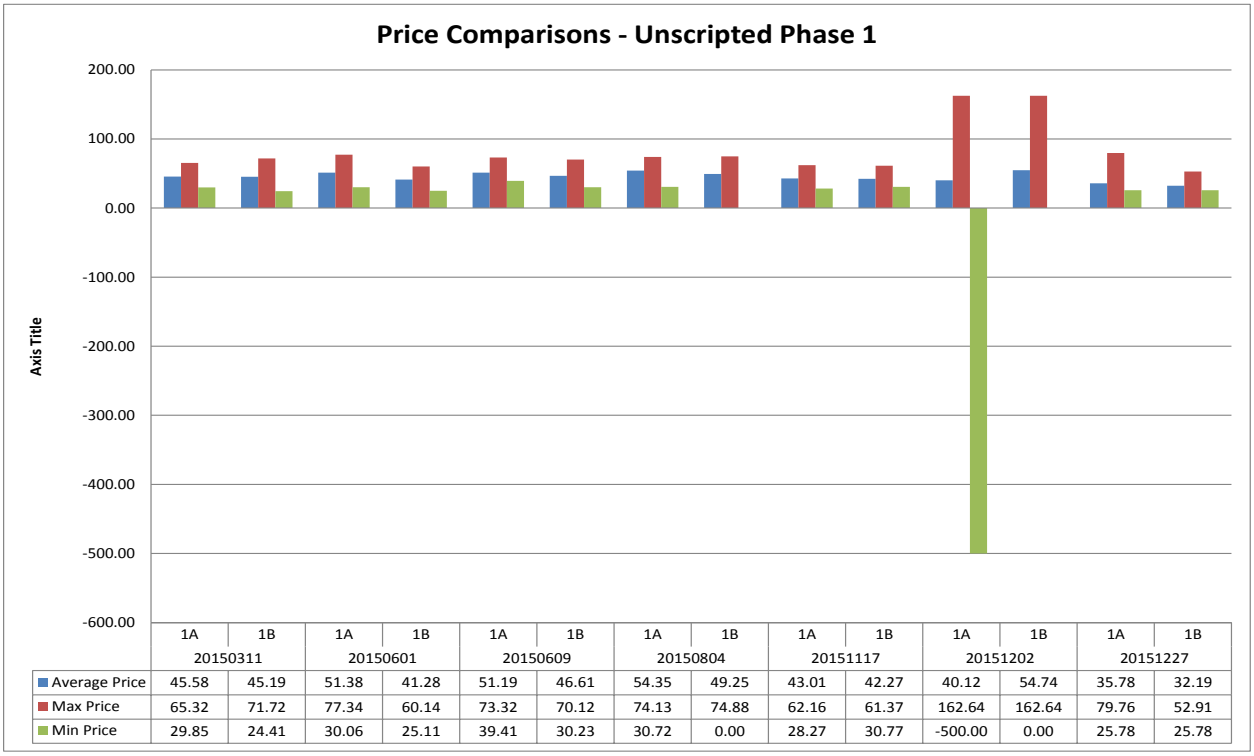
Table 21: breakdown of order types used in batch 1B of the Unscripted Trials

While the breakdown of orders used remains the same as those input for batch 1A, the order type used by individual units was, in some cases, changed.

8.2 BATCH ONE – RESULTS

Due to the lack of a defined trial script for the Unscripted Trials, and the divergent methods used in arriving at orders, market results cannot be compared with expected results on an overall basis. However, market results, along with relevant analysis, are presented below.

Figure 44 shows the pricing information for session in batch 1A and 1B of the unscripted trials showing average, maximum and minimum pricing information for these sessions.



	1A 20150311	1B 20150311	1A 20150601	1B 20150601	1A 20150609	1B 20150609	1A 20150804	1B 20150804	1A 20151117	1B 20151117	1A 20151202	1B 20151202	1A 20151227	1B 20151227
Average Price	45.58	45.19	51.38	41.28	51.19	46.61	54.35	49.25	43.01	42.27	40.12	54.74	35.78	32.19
Max Price	65.32	71.72	77.34	60.14	73.32	70.12	74.13	74.88	62.16	61.37	162.64	162.64	79.76	52.91
Min Price	29.85	24.41	30.06	25.11	39.41	30.23	30.72	0.00	28.27	30.77	-500.00	0.00	25.78	25.78

Figure 44: pricing information for batches 1A and 1B of the Unscripted Trials

As can be seen, the different order type implementations used led to different market outcomes when looking at the same day in batches 1A and 1B. In certain cases, results are quite similar with more divergent prices in other cases.

Apart from sessions relating to 02/12/2015 (a day chosen for its low margin (the difference between load and wind) value), all prices remain within a range of approximately €25 to €80. This indicates that, given the assumptions made by participants to arrive at inputs for batches 1A and 1B, the market has arrived at a sufficiently robust solution to allow for the block orders. While this may or may not be indicative of actual market behaviour, it provides further evidence that given the presence of coupling and a reasonable estimate of market behaviour that a mix of block, complex and simple orders provides for an efficient market solution.

The sessions relating to 02/12/2015 represent an outlier for these results with the highest range of prices. The lowest of these prices (€0 in batch 1A and -€500 in batch 1B) are each set in hours 1 and 2 of the relevant days. These are hours of very high wind and low load. While the wind is a key contributing factor, a number of units in each batch entered complex orders which included price quantity pairs at -€500 and €0. This allowed a number of units to be scheduled for a low quantity in hours 1 and 2 and recover costs (as defined in their MIC) in later hours. An example of such scheduling, based on GU_400270, is presented in figure 45 below.

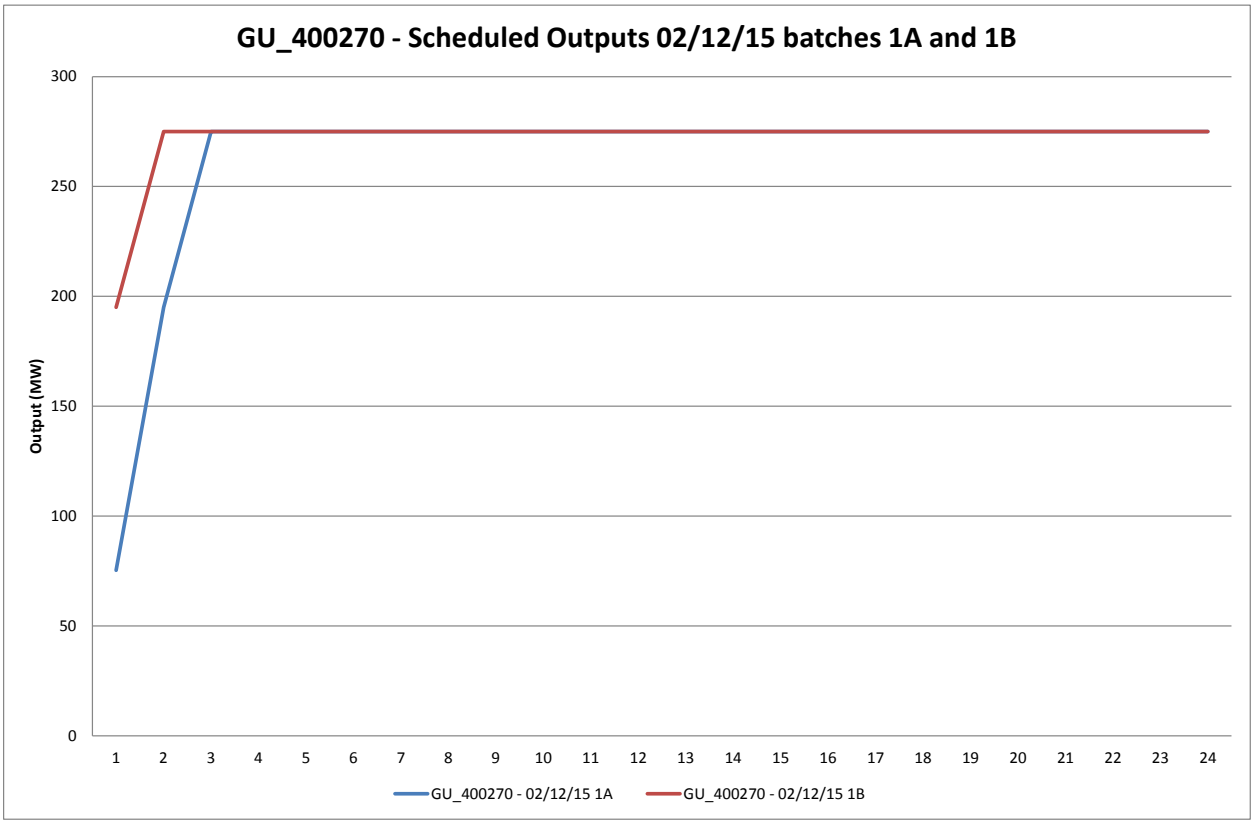


Figure 45: Scheduled outputs for GU_400270 for 02/12/15 batches 1A and 1B

This was also the cause of the €0 price seen in hour one of 04/08/15 in batch 1B of the Unscripted Trials with a number of thermal units being scheduled for a minimum quantity to allow for a very high wind (and correspondingly low margin) value in the underlying market conditions.

8.3 BATCH TWO – INPUTS

Inputs for batch one of the Unscripted Trials were received from 13 organisations, listed below:

- AES;
- Aughinish Alumina;
- BGE;
- Bord na Mona;
- Electric Ireland;
- Energia;
- ESB GWM;
- Gaelectric;
- Power NI PPB;
- Power NI Supply;
- PrePay Power[24];
- SSE; and
- TEL.

These were the same organisations which took part in batch one of the Unscripted Trials. As with batch one, there were some differences between the inputs received for batch 2A and 2B. These inputs are outlined in section 8.3.1 and 8.3.2.

8.3.1 BATCH 2A

The inputs for batch 2A for wind units are outlined in table 22, below.

Company	Price Taker	Price Maker
BGE	X	
Energia		X
Gaelectric	X	
Power NI	X	
SSE	X	

Table 22: summary of wind orders for batch 2A of the Unscripted Trials

This marks a change from the 1A and 1B inputs as in those runs there were no price making wind orders. It should be noted that a wind order is marked as price making even where only a portion of the order is price making (i.e. a unit with only 1% volume as a price maker would still be marked as a price maker). A summary of the demand orders received for batch 2A is presented in table 23, below.

[24] Though not a member of the working group, PrePay Power expressed an interest in participating in the Unscripted Trials

Company	Price Taker	Price Maker
BGE		X
Electric Ireland	X	
Energia	X	
Power NI	X	
PrePay Power	X	
SSE	X	

Table 23: Summary of demand orders for batch 2A of the Unscripted Trials

This is similar to 1A of the Unscripted Trials with the majority of orders submitted as price taking orders though there were some changes to prices entered.

For thermal and storage units, the breakdown of orders submitted for batch 2A is outlined in table 24 below.

Company	Linked block only	Complex only	Mix
AES			X
Aughinish Alumina		X	
BGE		X	
Bord na Mona		X	
ESB GWM			X
Energia		X	
Gaelectric	X		
Power NI PPB			X
SSE			X
TEL			X

Table 24: breakdown of thermal and storage order submitted for batch 2A

While there were some changes to the breakdown of orders entered as compared to batches 1A and 1B, the trend was largely similar with a slight preference towards using a mix of orders over only using a single order type.

8.3.2 BATCH 2B

There were no changes to the breakdown of orders submitted for wind units between batches 2A and 2B. The breakdown of orders demand orders submitted for batch 2B is presented in table 25 below.

Company	Price Taker	Price Maker
BGE	X	
Electric Ireland		X
Energia		X
Power NI		X
PrePay Power	X	
SSE	X	

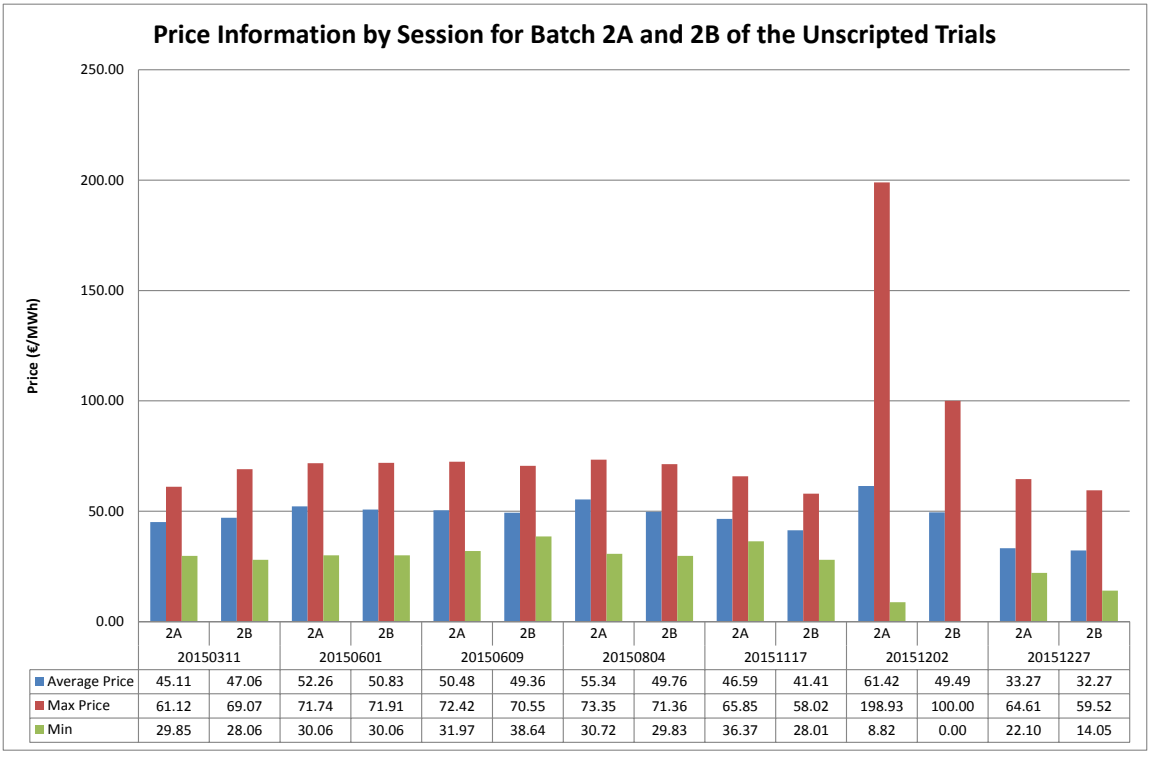
Table 25: breakdown of the demand orders submitted for batch 2B of the Unscripted Trials

This shows a change in the order types used between batch 2A and 2B. Furthermore, as with batch 1A and 1B, there were in some cases changes to total volume represented by the orders. This was in line with the goals of the Unscripted Trials but should be considered when interpreting results.

There were no changes to the overall mix of order types used for thermal and storage units on a per participant basis; however, on a unit basis there were some changes as in batches 1A and 1B. There were also changes to the values of orders showing that participants were able to adjust their strategy to trial further implementations of the orders.

8.4 BATCH TWO – RESULTS

Results from batches 2A and 2B of the Unscripted Trials were similar in most cases to those of batches 1A and 1B. While changes are present, in the absence of common assumptions in the creation of order types, it is difficult to isolate the cause of these changes. Average, maximum and minimum price information for each trading day of batches 2A and 2B are included in figure 45 below.



	2A	2B	2A	2B	2A	2B	2A	2B	2A	2B	2A	2B	2A	2B
	20150311		20150601		20150609		20150804		20151117		20151202		20151227	
Average Price	45.11	47.06	52.26	50.83	50.48	49.36	55.34	49.76	46.59	41.41	61.42	49.49	33.27	32.27
Max Price	61.12	69.07	71.74	71.91	72.42	70.55	73.35	71.36	65.85	58.02	198.93	100.00	64.61	59.52
Min	29.85	28.06	30.06	30.06	31.97	38.64	30.72	29.83	36.37	28.01	8.82	0.00	22.10	14.05

Figure 45: Price information by session for batches 2A and 2B of the Unscripted Trials

As was seen in batches 1A and 1B, the prices are most volatile for the trading day 02/12/2015. This was a result of the low margin (i.e. high wind and low demand) in the early hours which decreased over the day leading to low prices in the early hours of the trading day and higher prices over the hours of peak load. While the maximum prices are higher for 02/12/2015 than for other trading days, these are in line with the prices seen in batches 1A and 1B.

The similar results to batches 1A and 1B suggest that, while there were changes to individual behaviours in batches 2A and 2B, there was no significant change to overall behaviour of the market. This is consistent with the inputs received as outlined in section 8.3.1.

9 CONCLUSIONS

9.1 GOALS OF TRIALS

The Scripted Trials have addressed all areas for further study of the Initial Phase including:

- Investigation of the effects of price making demand;
- Investigation of the addition of more simple order based price making units;
- Further investigation of complex orders; and
- Investigation of orders which are not bound by the bidding code of practice.

The Scripted Trials have also expanded on these to review other elements of the order types. The knowledge gained from review of the Scripted Trials has contributed to a better understanding of the order types among working group members. The Scripted Trials provided working group members with sufficient knowledge to allow for active participation in the Unscripted Trials. For these reasons, the Scripted Trials have achieved the stated goals.

The goal of the Unscripted Trials was to allow members of the I-SEM EUPHEMIA working group to actively participate in the process of creating order types and to assess how they choose to interact with EUPHEMIA. This report has presented analysis of the inputs received for the Unscripted Trials. Broadly, these are similarly structured to the Scripted Trial inputs; however, the specific implementations used have varied from the more structured assumptions of the Scripted Trials by participant or in some cases by unit. This shows that working group members have developed sufficient understanding of EUPHEMIA in order to be able to practically take part in the trials (i.e. create their own orders) and to implement strategies as they see fit. For these reasons, the Unscripted Trials have achieved the stated goals.

9.2 SIMPLE ORDERS

Throughout the I-SEM Trialling of EUPHEMIA, simple orders have proven to be an order type which can be used for a wide range of unit types effectively. Simple orders have been used effectively for the following unit types:

- Supplier units;
- Wind units;
- Storage units;
- Peaker thermal units; and
- Energy limited hydro units.

Simple orders have been shown to, through informed manipulation of the prices and quantities input by the user, allow for the needs of these units. Simple orders are likely to be used by a large number of units in the I-SEM due to providing a simple method of participation for units which do not require complex conditions. For those requiring more sophisticated representation, typically baseload and mid-merit thermal plants and storage plant requiring cost and technical considerations with their orders, simple orders alone would not provide a sufficient solution for the I-SEM DAM.

Given that the units which would most likely not use simple orders (baseload and mid-merit thermals) are important to price formation in the I-SEM, and that many of the units which will use simple orders will be price takers (e.g. wind units), there is likely to be insufficient liquidity of price making simple orders to provide stable prices without other measures. This has further implications into the viability of block order and complex order based implementations for the I-SEM, which are outlined in sections 9.3 and 9.4.

A point to consider for simple orders is that it is currently unclear how certain participants (e.g. supplier units, wind units, peakers etc.) will be incentivized in the I-SEM and what market timeframe will provide them the best route to market. Due to the lack of clarity on these incentives, and the unclear role of aggregation and assetless trading in the DAM, the level of liquidity of simple orders in the I-SEM DAM cannot be fully predicted at this point.

9.3 COMPLEX ORDERS

The Commercial Phase analysis has led to an increased understanding of the implications of using complex orders for the I-SEM DAM. The main findings have been in the area of the risk profile faced by generator units in the I-SEM. It is likely that, for a sufficiently robust strategy, participants will need to implement active strategies in how they prepare the minimum income condition (MIC) and PQ pair values. Adjusting these variables directly affects the risks facing participants and many strategies may be viable depending on the business model and risk profile of individual participants. Participants will be able to evolve these strategies through market trial and other activities subsequent to the I-SEM Trialling of EUPHEMIA.

The results from complex orders have been better in terms of transparency, price formation and price stability. Additionally, the Scripted Trials have highlighted ways in which participants can use these orders to mitigate risks. Through altering the volume offered in each hour, participants can also affect a level of control over their profile in the DAM. Complex orders can provide a sufficiently robust solution for the I-SEM allowing for the needs of I-SEM participants and producing appropriate pricing and scheduling outcomes with risk mitigation measures.

9.4 BLOCK ORDERS

The Commercial Phase has explored various ways in which the use of block orders may be supported by additional price making orders. This has included using linked blocks in combination with simple orders (both buy and sell orders) and in combination with complex orders and through coupling with other markets through interconnection.

These trials have shown the positive effects on the pricing of including these additional price makers with block orders (both in terms of stability and in lowering the average price for the same inputs); however, differing volumes of these orders in the trial have had differing effects in this regard. It is currently unclear to what level of liquidity these orders (apart from the largely known level of interconnection) would be available in the I-SEM DAM. Additionally, as evidenced in de-coupled runs, coupling is only a solution to the pricing issues encountered during the Initial Phase up to the point of interconnector constraint (e.g. ATC congestion or ramping) and would not provide a solution at times of outages of interconnectors or de-coupling.

It will fall to I-SEM market participants (i.e. generators, suppliers and traders) to arrive at a mix of orders which allow for an efficient market solution. While in the majority of cases it is likely that sufficient price makers would be available (if assumptions of the later trial batches are in line with I-SEM behaviour) through simple orders and interconnection, the results of study have shown a risk of volatility to the overall results associated with use of block orders with only simple orders. Therefore, a solution using block orders, simple orders and complex orders may provide for better results.

While sufficient price makers would need to be in place to support the use of block orders, block orders have properties in relation to representation of costs and profiles which can be used to the benefit of participants in the I-SEM. To allow for the flexibility desired by participants, linked block orders have been the primary area of study, for block orders, during the trials. This was prioritised over exclusive group orders (which were also explored in the Initial Phase and batch one of the Scripted Trials) due to the time and resource constraints of the I-SEM Trialling of EUPHEMIA and feedback of the I-SEM EUPHEMIA working group. It should also be noted that exclusive group orders are still a form of block order and the issues observed in relation to pricing with linked block orders were observed with exclusive group orders; thus the concerns expressed above would equally be applicable. As with complex orders, participants would be able to further develop strategies for implementing block orders to derive their benefits through activities subsequent to this study such as market trial.

As regards a solution using a combination of block and other order types, the principle issue is liquidity of orders that can set an appropriate price. A combination of linked blocks with simple orders and / or complex orders can deliver this. Given that a large section of the SEM generation portfolio has similar characteristics and costs, and these units are typically the price makers, it will need to be determined how participation using linked blocks could be managed to avoid the risk of discrimination either against one set of generators over others. Restrictions on the order types available to certain participants would, in effect, reduce the risk mitigation methods available to those participants compared to others. As such, it would not be appropriate to limit access to a particular order type to a certain class of units. Therefore, any solution of the I-SEM using multiple order types should allow for equal access to these to all market participants.

Given the assumptions of this study (primarily that the key price makers in the I-SEM would use block or complex orders over simple orders), block orders may best account for the risks facing I-SEM participants when in combination with complex orders and simple orders; however, this is contingent on sufficient liquidity of appropriate price makers (either buy or sell orders) being available in each run of the DAM.. Results from batch four of the Scripted Trials show that with sufficient price making demand orders, results from sessions using block orders only may be similar to those using complex orders only or using a mix of orders. Inputs to and results from the Unscripted Trials, which did not require a specific mix of orders, showed that when given access to multiple order types participants arrived at a balance of order types providing for sufficient liquidity of price making orders in these trials.

9.5 IMPLEMENTATION FOR THE I-SEM

It should be noted that any implementation of EUPHEMIA for the I-SEM will be subject to testing and approval by the PCR. As the purpose of this study has not been to assess whether the investigated implementation would be acceptable to the PCR, this report makes no assertion as to whether the outlined implementation would be accepted by the PCR.

Many elements of the implementation of the I-SEM DAM have been decided, explicitly or implicitly, by the I-SEM HLD; these would include:

- Each interconnector will have separately modelled losses;
- The order book will use stepwise curves;
- Orders will be entered on a dual currency basis; and
- Orders will be generally submitted on a unit basis (with some exceptions permitted according to market rules and licences, as per the HLD draft decision).

Given the number of design elements which have been decided upon, the findings of this report are limited to the order types which will be available in the I-SEM DAM. It is the view of SEMO and the I-SEM EUPHEMIA working group that, the I-SEM DAM should allow for sufficient order types to allow for the needs of I-SEM participants. While any implementation will be subject to the testing and approval of the PCR, it is the view of the members of the I-SEM Euphemia Working Group that the following orders should be implemented in the I-SEM DAM:

- Simple orders;
- Complex orders (including all conditions of complex orders);
- Block orders;
- Linked block orders; and
- Exclusive group orders.

This is subject to the caveat outlined in section 9.4 that, all implementations using block orders will require sufficient liquidity of appropriate price makers. While acknowledging this point, there is evidence from this study that a solution using both complex and block orders will allow the maximum flexibility to I-SEM participants while still providing appropriate pricing and scheduling outcomes.

10 APPENDIX A: GLOSSARY OF TERMS

Term	Meaning	Explanation
COD	Commercial Offer Data	Data submitted by participants to the SEM covering the commercial components of their offer (e.g. fixed and variable costs)
MAR	Minimum Acceptance Ratio	A value between 0 and 100% denoting the minimum percentage of the total volume of the block order which must be accepted for the block to be activated
MIC	Minimum Income Condition	A set of values (fixed term and variable term) which denote the minimum income which must be received for a complex order to be activated
MSP software	Market Scheduling and Pricing software	The software used to calculate prices and schedules in the SEM
REFIT	Renewable Energy Feed-in Tariff	Subsidy scheme available for qualifying renewable energy producing units in Ireland
ROC	Renewable Obligation Certificates	Certificates issued to qualifying renewable generators which can be used to offset payments of the renewable obligation in the UK
SMP	System Marginal Price	The half hourly clearing price of the SEM
TOD	Technical Offer Data	Data submitted by participants to the SEM covering the technical components of their offer (e.g. ramp rates, capacities etc.)