I-SEM Trialing of EUPHEMIA: Initial Phase Results Overview

I-SEM EUPHEMIA Working Group
16th April 2015

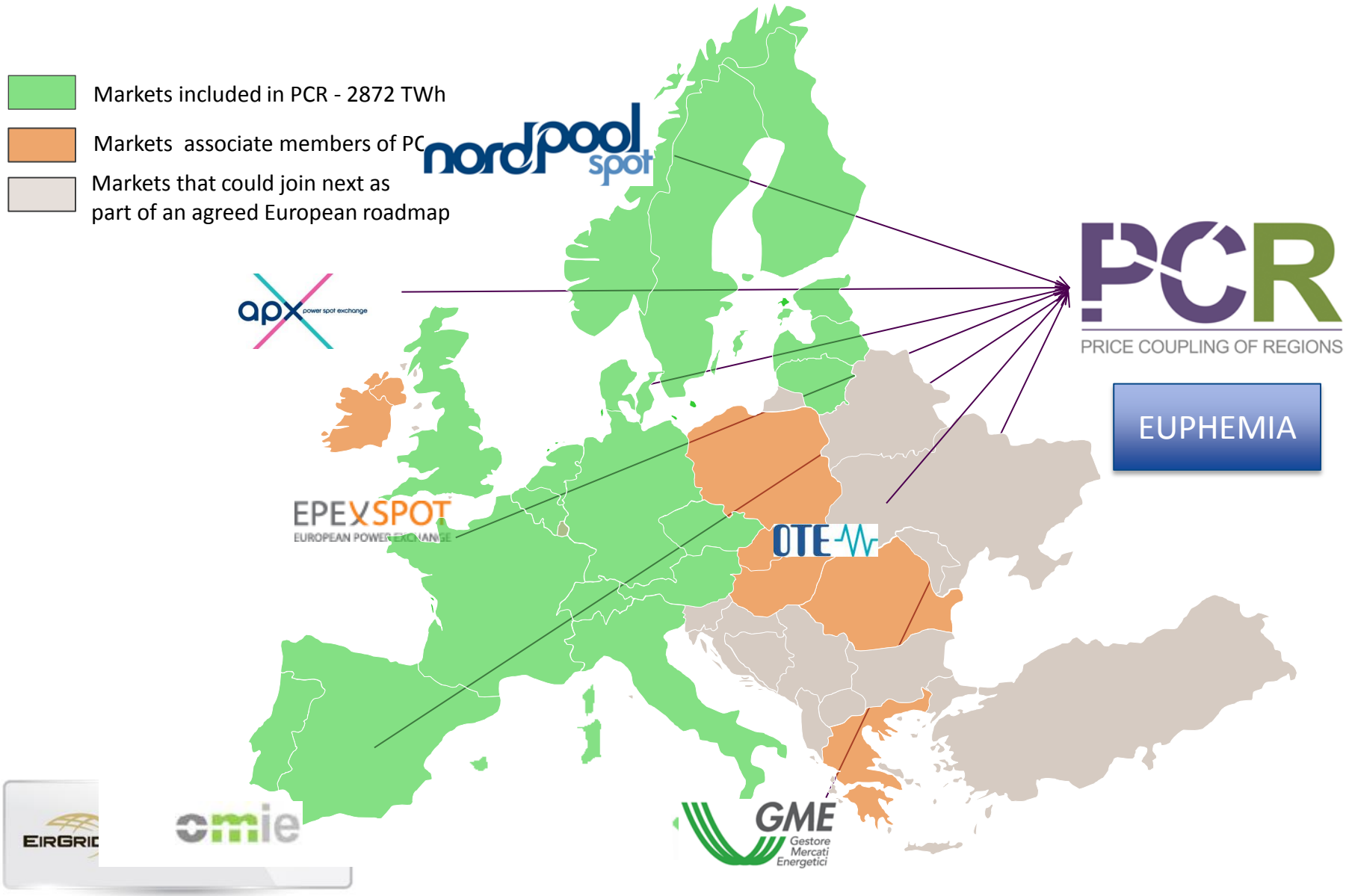
EUPHEMIA Workshop – Agenda

- Background of EUPHEMIA algorithm
- Overview of background and goal of EUPHEMIA trials
- Overview of Initial Phase goals and criteria
- Presentation of the assumptions used
- Presentation of early Initial Phase results
- Discussion of areas for further study
- Discussion of next steps

EUPHEMIA – Background

- EUPHEMIA is the algorithm used for day-ahead market coupling across Europe
- ***P***an ***Eu***ropean ***H***ybrid ***E***lectricity ***M***arket ***I***ntegration ***A***lgorithm
- Euphemia will be used to calculate electricity prices across Europe
- Euphemia optimises cross border capacity, increases transparency of prices and flows and optimises overall welfare

EUPHEMIA - Background



EUPHEMIA & SEM Algorithm Comparison

EUPHEMIA

- Portfolio/Unit based
- COD only
- Limited product offerings

SEM

- Unit based
- TOD & COD
- Technology specific rules

EUPHEMIA Trial Background & Goal

- Trial the implementation of EUPHEMIA for the I-SEM:
  - EUPHEMIA is functional and used throughout Europe
  - Goal here is to assess how best to use it in the I-SEM
- Assessment of order types available in EUPHEMIA:
  - A number of different order types available
  - Each has unique characteristics
  - Assessment is needed to determine the best ways to use order types
- Increase understanding of EUPHEMIA and order types:
  - Allow SEMO and industry the opportunity to trial the use of EUPHEMIA in advance of I-SEM go-live

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EUPHEMIA Trial – Context for today

- Assumptions:
  - Results dependent on the assumptions made by SEMO
  - Assumptions will be refined using working group feedback
- Results:
  - Early results of long analysis project
  - A lot of analysis is scheduled over the coming months
  - *"We don't expect to have got it right first time!"* – RLG 1.1
- Qualitative over Quantitative:
  - At this point, more focused on patterns and curve shapes
  - Not yet detailed on price or schedule comparison

EUPHEMIA Trials – Structure & Timeline

Initial Phase (SEMO only)
Jan 15 – Mar 15

RA & Industry Interaction
Apr/May 15

Commercial Phase (SEMO & Industry)
May 15 – Dec 15

EUPHEMIA Trial – Initial Phase Goal

- Perform initial trials of EUPHEMIA algorithm for I-SEM
  - Increase our understanding before industry engagement

- Trial a number of different order types
  - Assess the benefits and disbenefits of the order types available
  - Explore a number of different order types

- Assess the impact of coupling on prices and schedules

- Begin trialling of algorithm well in advance of I-SEM go live

EUPHEMIA Trial – Initial Phase Criteria

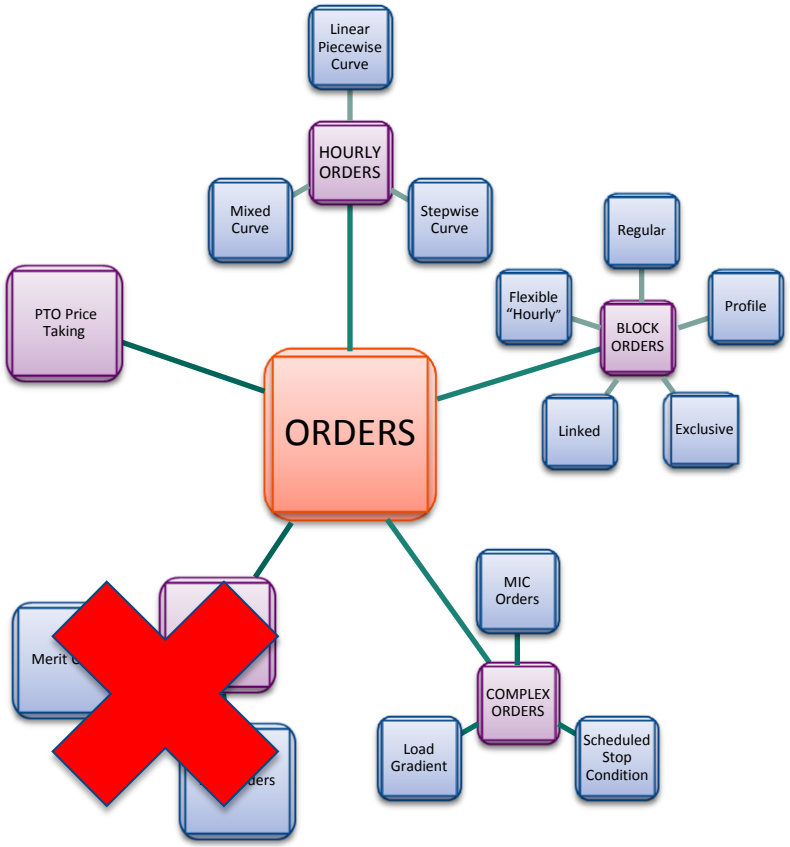
- Feasibility:
  - SEM principles are represented, e.g. generator costs are recovered, feasible schedule is produced
- Quality:
  - Prices produced are efficient, transparent and stable, e.g. prices follow similar patterns
- Algorithm Performance:
  - The impacts of our interaction with EUPHEMIA
- Suitability of Approach:
  - The combination of all other factors

EUPHEMIA Trial – SEMO's Initial Phase Assumptions

- Units represented as in the SEM:
  - Bid and offer data is based on the SEM input data
  - Price taker units (including suppliers) remain price taking
  - Attempts will be made to represent technical characteristics
- SEM principles applied in dataset creation:
  - Generators costs are recovered
  - All units participate fully in the market
  - Bidding code of practice is applied

Inputs

EUPHEMIA - Orders



EUPHEMIA – Simple Orders

- Simple price quantity pair with no conditions attached

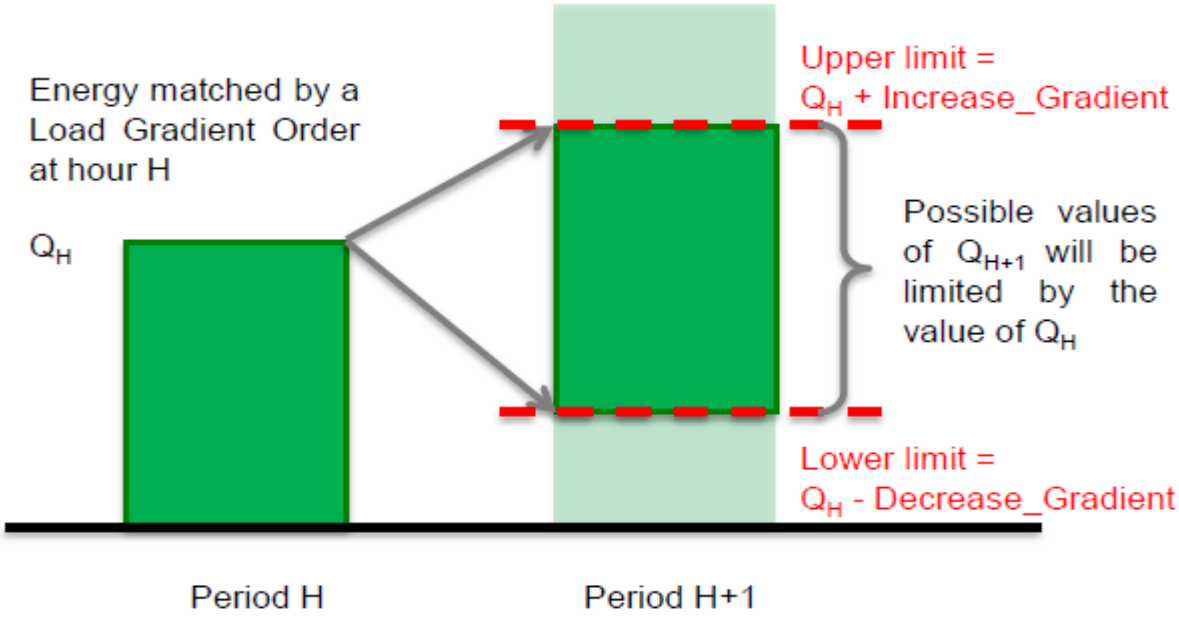
- Can be used for buy (supplier) or sell (generator) orders

- Used for price takers:
  - Generators bid -€500 to €3,000
  - Suppliers bid €3,000 to – €500
  - Explicit representation of implicit SEM characteristic

- Used for peakers:
  - Conditions not required due to unit capabilities
  - Prices entered based on SEM costs
  - Quantity based on profile of ramping on and off in one hour

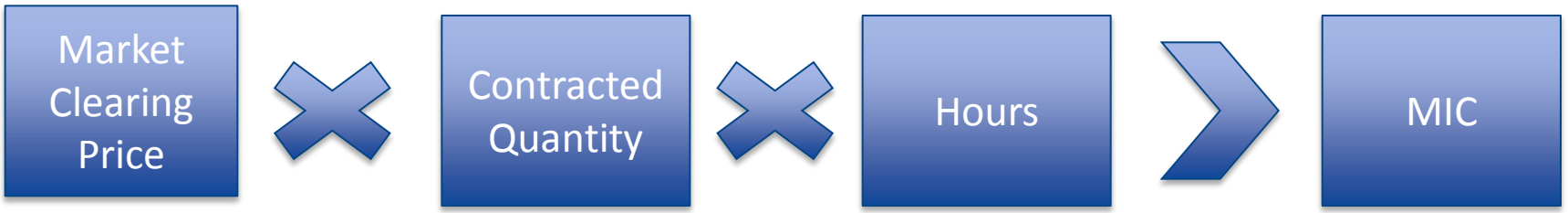
EUPHEMIA – Complex Orders

- Simple price quantity pair but with complex conditions
- Allow for a single hourly ramp up and ramp down rate (load gradient)



EUPHEMIA – Complex Orders

- Also allow minimum income condition (MIC)
- Fixed or variable cost which must be met for the order to be executed
- Will reject "In the Money" orders where the MIC is not met
- MIC allows generator units a way of representing their fixed costs in EUPHEMIA



EUPHEMIA – Block Orders v Complex Orders

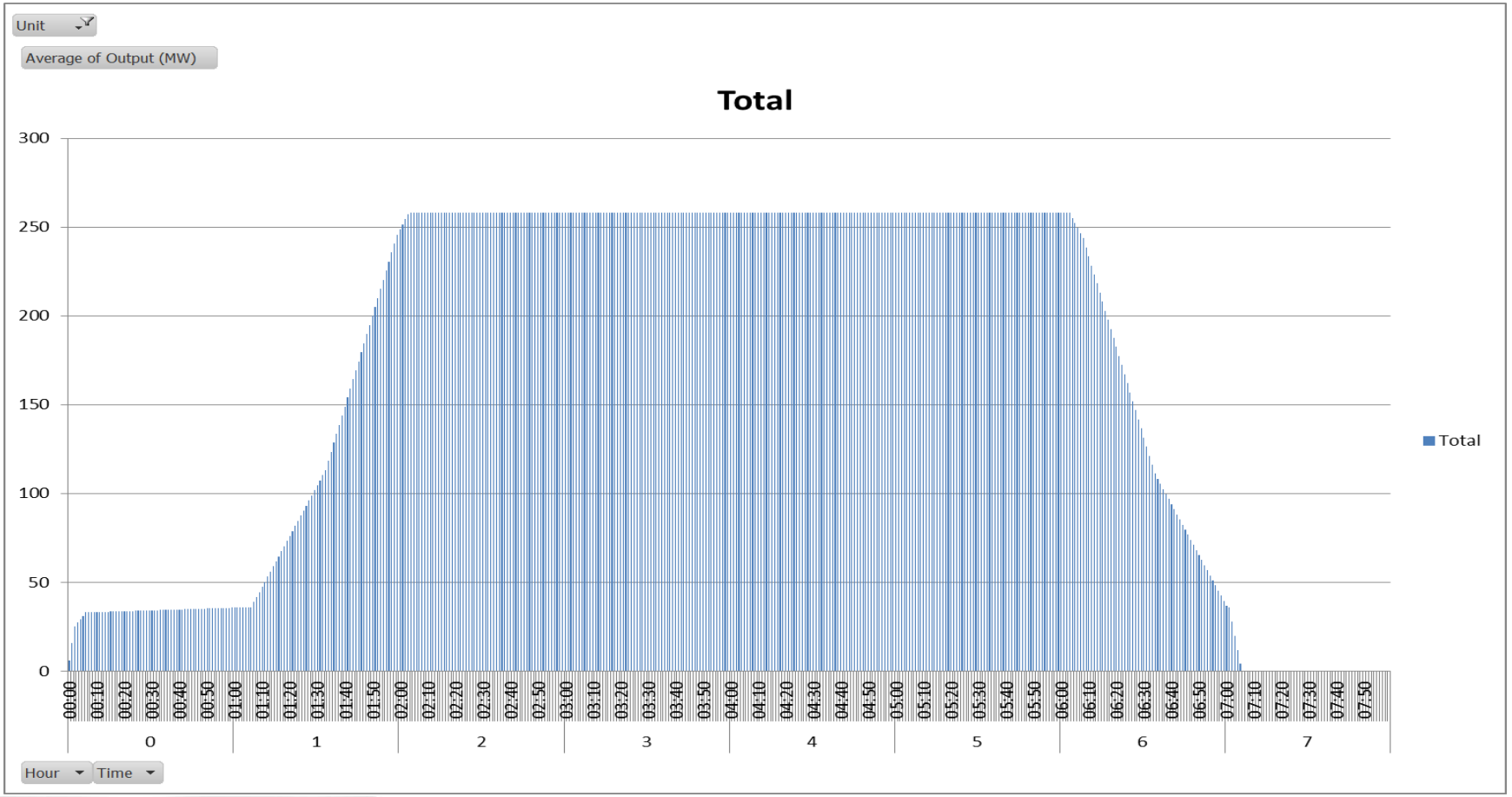
- Complex orders function similarly to SEM orders:
  - PQ pairs are submitted with conditions attached
  - The algorithm schedules the unit at a value in the PQ pairs
  - Any scheduling is subject to explicit conditions, e.g. fixed cost

- Linked blocks and exclusive groups do not function in this way:
  - Distinct blocks of energy (hourly MW values with single per MW price)
  - Requires profiling to determine the hourly volumes offered
  - Requires implicit application of technical characteristics and costs

- To allow for allocated fixed costs, entire block must be executed:
  - Referred to as kill-or-fill
  - Minimum acceptance ratio of 100%
  - If partially executed, only partial cost recovery is achieved

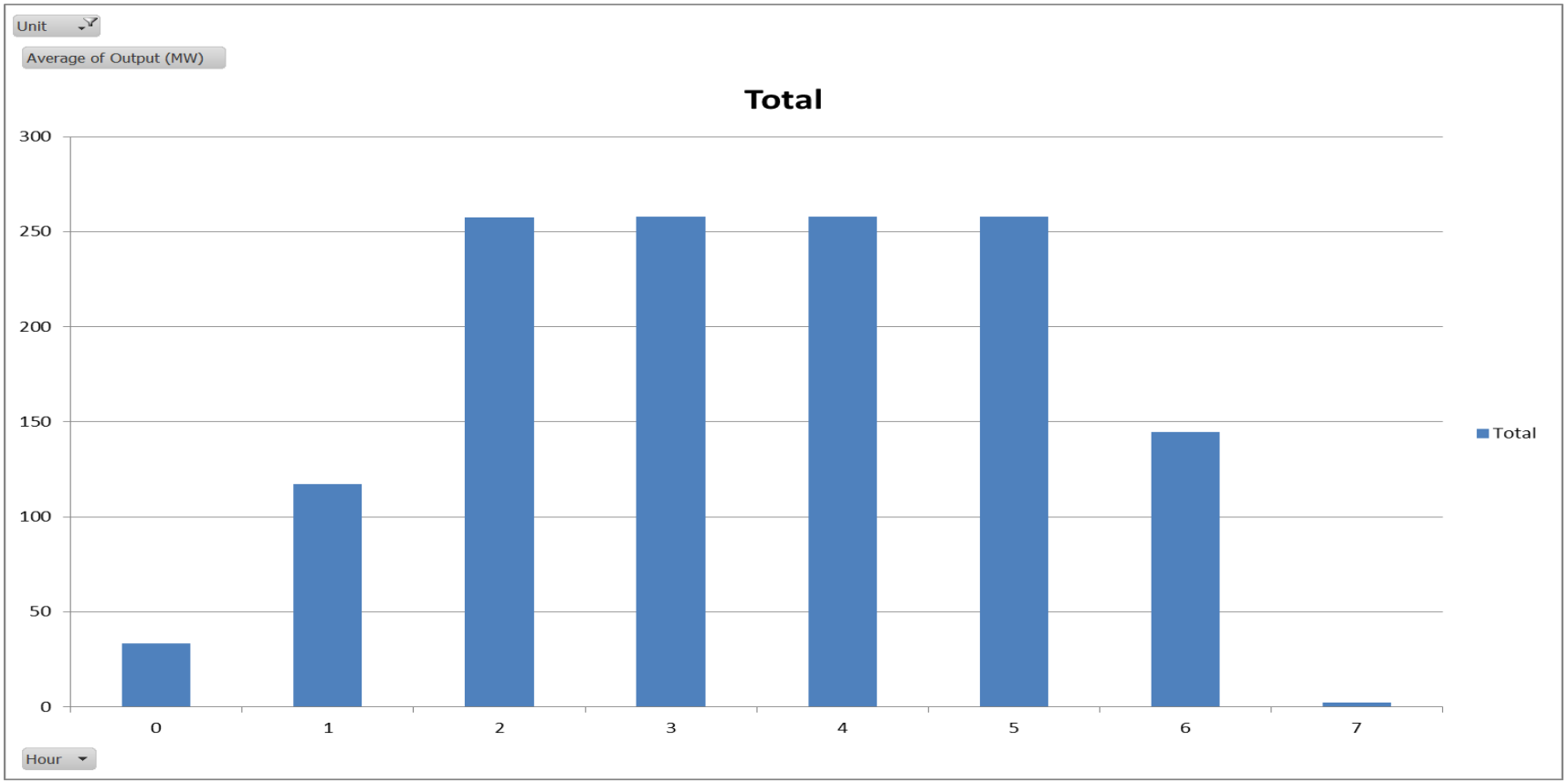
Block Orders - Profiling

- Used technical characteristics to create a minute by minute generator profile



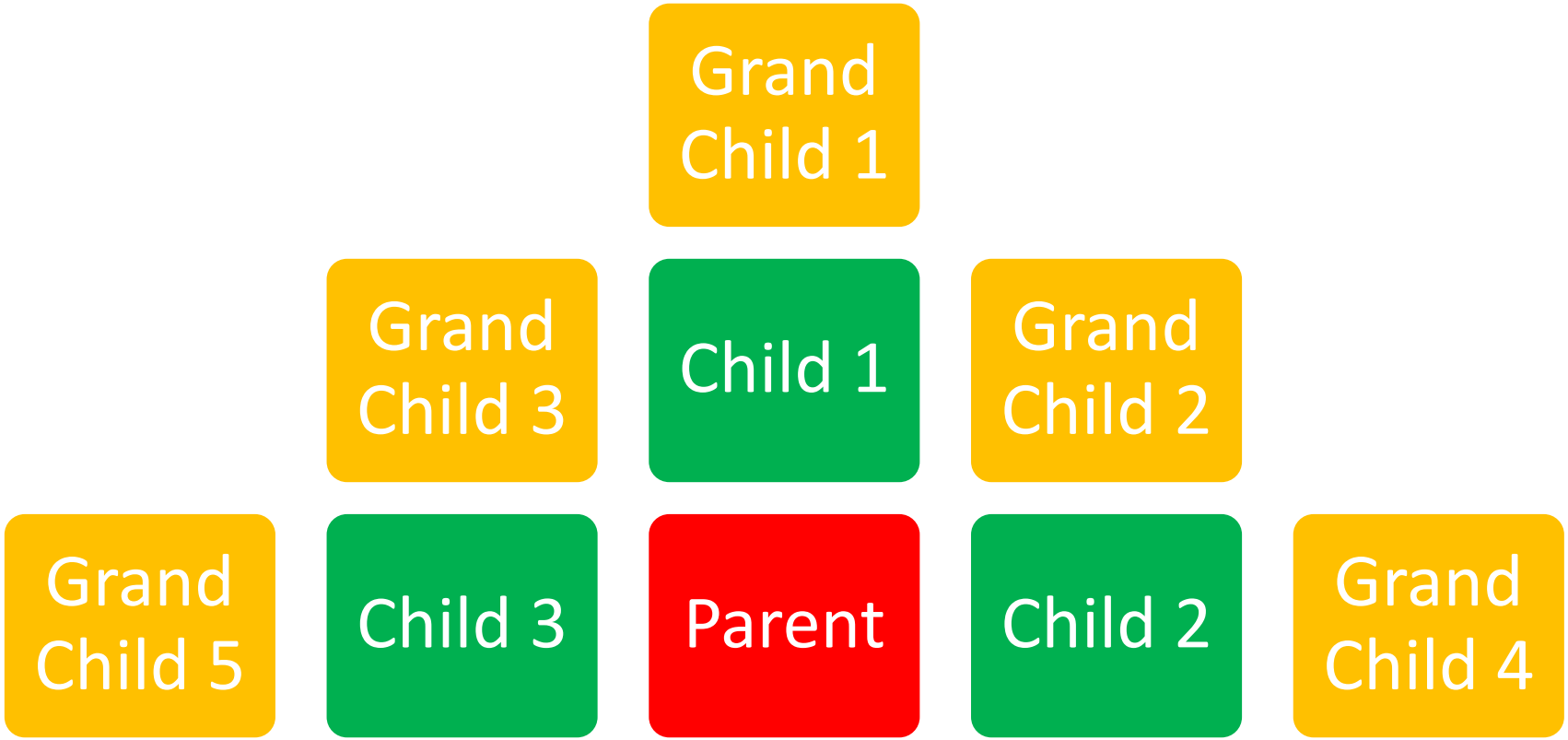
Block Orders - Profiling

- …and from this, create an hourly average output



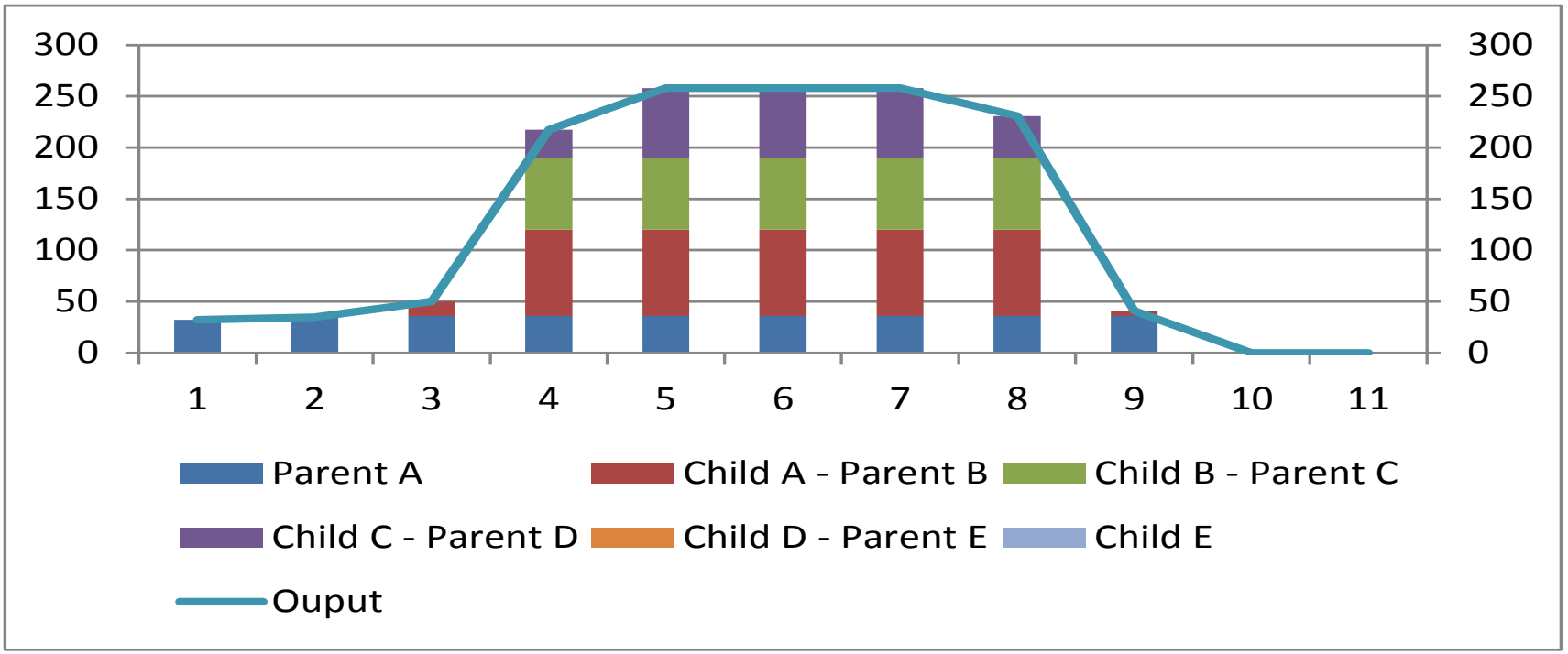
EUPHEMIA – Linked Block Orders

- …use linked block orders to separate the hourly blocks into interdependent "Parent" and "Child" blocks.



Linked Block Orders – Dividing Profiles

- …and using price/quantity pairs, create parent child blocks based on costs



- Applying “uplift” costs into the parent block allows cheaper child blocks to be in merit

EUPHEMIA – Linked Block Pricing

- Linked blocks built in a series of layers:
  - Each layer accounts for relevant prices from PQ pairs
  - Lower layers are more expensive than higher layers
  - Cheap layers linked to expensive layers allow for activation of both

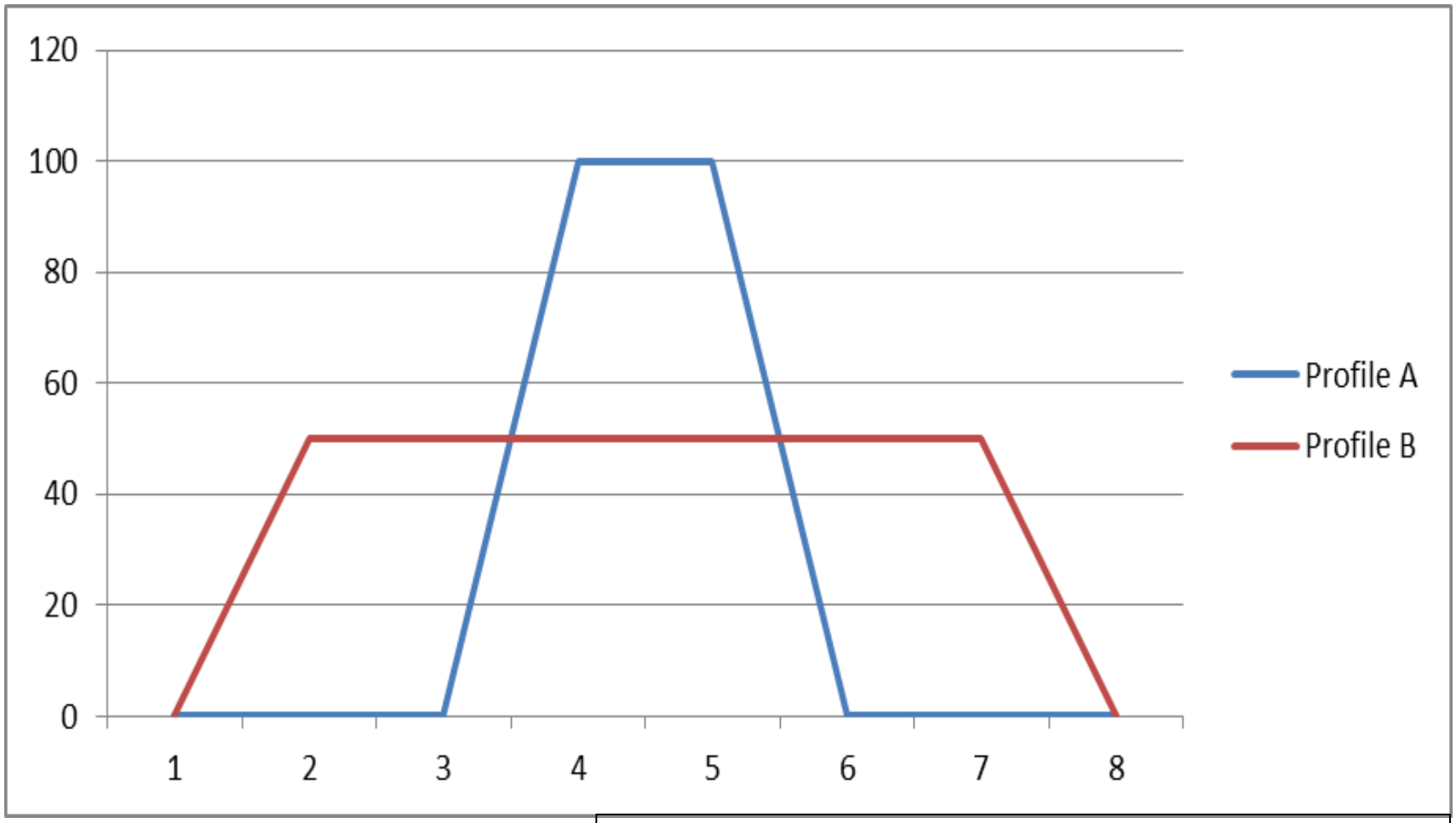
- First layer accounts for fixed costs at minimum stable generation:
  - All no load costs for the block & relevant start up costs
  - Volume weighted average of prices to meet MSG
  - Total cost divided by MSG to give MW cost for the layer

- Subsequent layers account for generators PQ pairs:
  - Layer two: MSG – Q1 @ P1
  - Layer three: Q2 – Q1 @ P2
  - Layer four: Q3 – Q2 @ P3
  - Process is continued out to max output quantity of the unit

EUPHEMIA Trials – Exclusive Group Orders

- Group of mutually exclusive profiles:
  - Each profile has a single (per MW) price and hourly quantities
  - Each profile is fill-or-kill
  - Only one profile may be chosen
- Each profile has costs apportioned based on fixed and variable costs incurred:
  - Lower volume/short duration profiles have higher per MW costs
  - Higher volume/long duration profiles have lower per MW costs
  - Price = costs incurred by profile/total volume of the profile
- EUPHEMIA determines which profile best meets the social welfare objective given the conditions of the day

EUPHEMIA Trials – Exclusive Groups



- Profile A and B each have a different price based on the costs incurred
- EUPHEMIA chooses A or B or None

EUPHEMIA – Cost Allocation/Bid Price Determination

Complex Orders

- Fixed and variable costs explicit with PQ pairs
- Will only be executed where costs are recovered
- Can be fulfilled for any value in PQ pairs

Linked Blocks

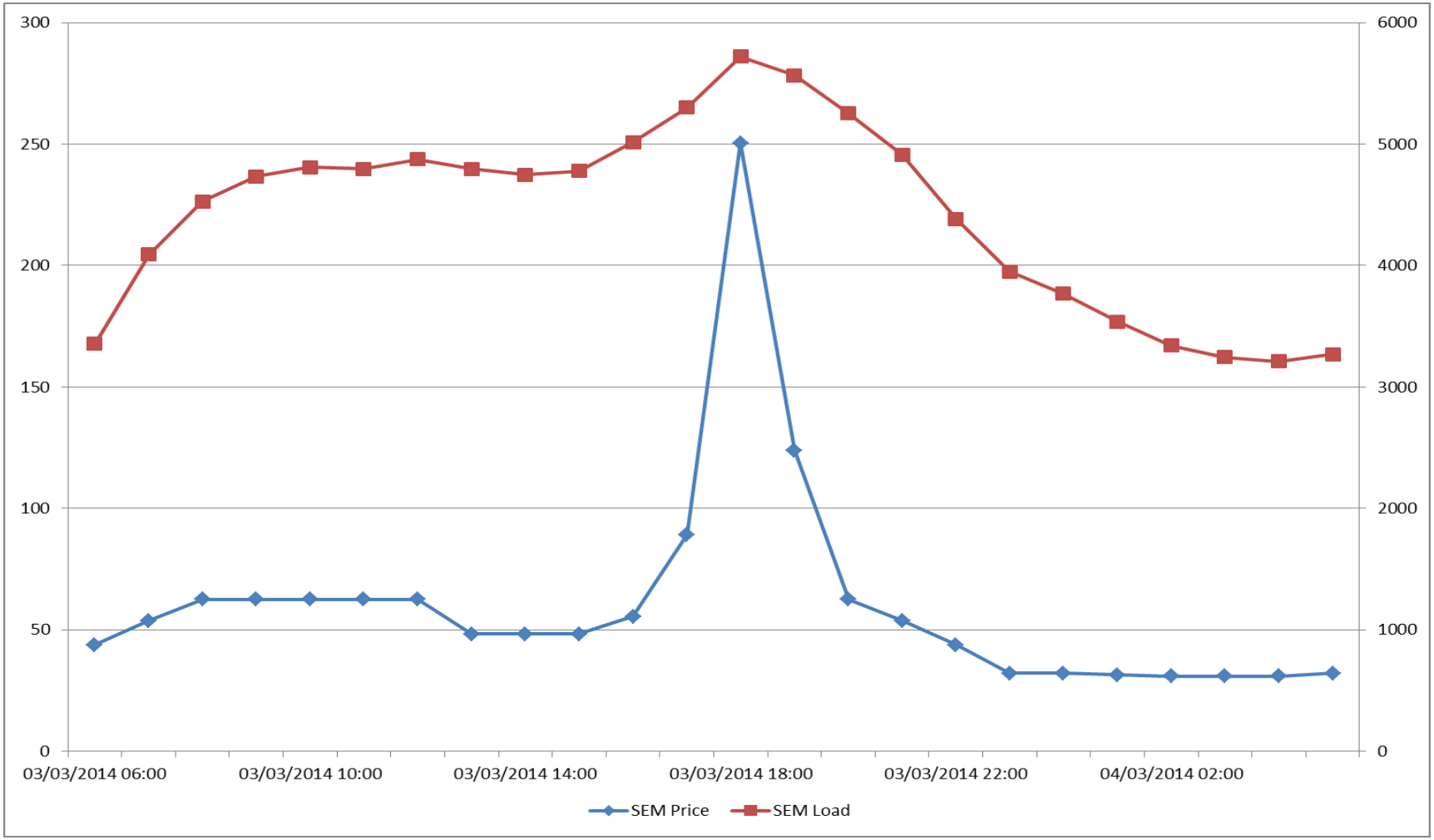
- Fixed and variable costs implicit in block pricing
- Expensive (low MW) linked to cheap (high MW)
- Must be 100% to recover apportioned costs

Exclusive Groups

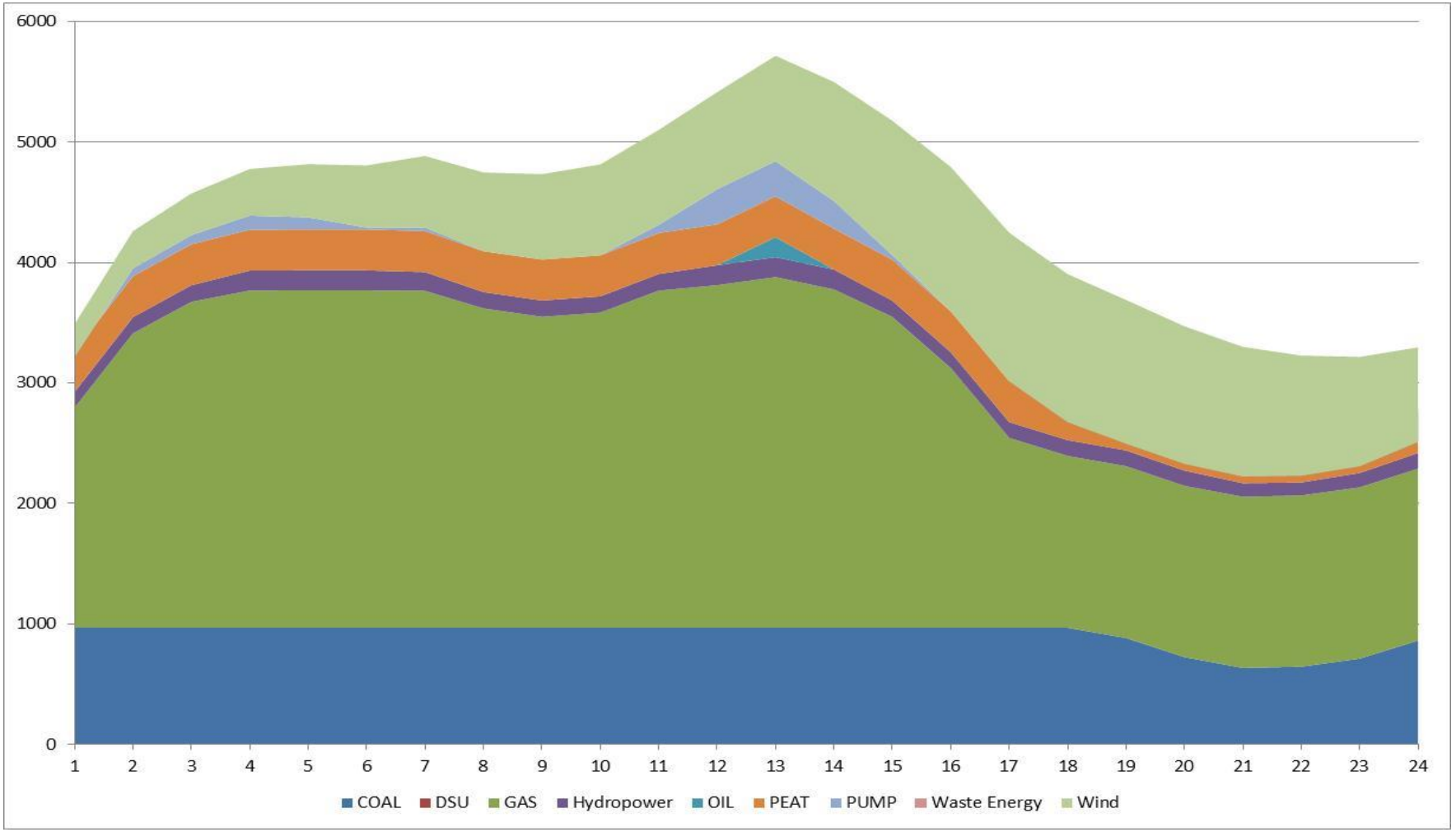
- Fixed and variable implicit in block pricing
- Mutually exclusive blocks with individual prices
- Must be 100% to recover apportioned costs

Results

Results – SEM Schedule



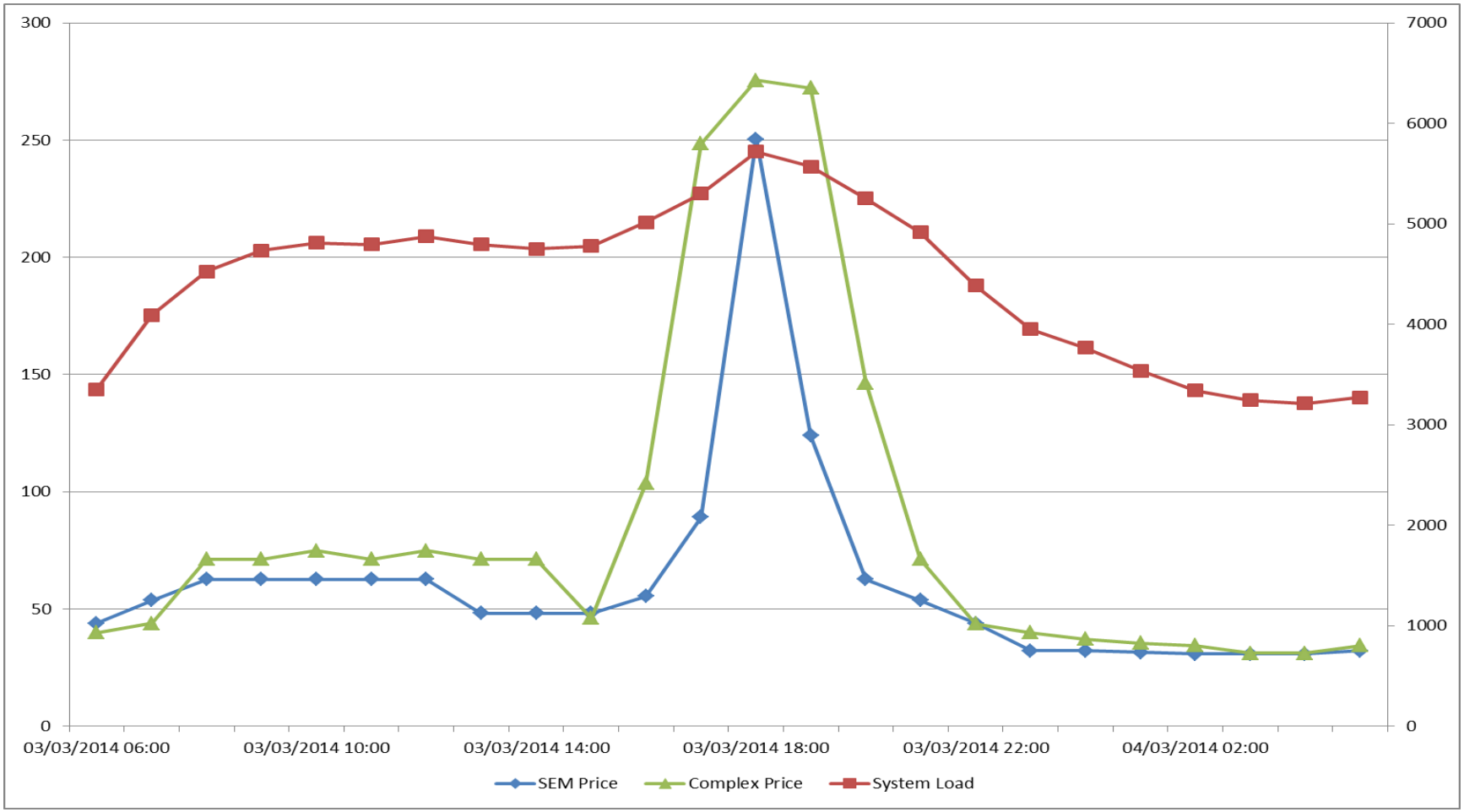
Results – SEM Schedule



Complex Orders – Review of assumptions

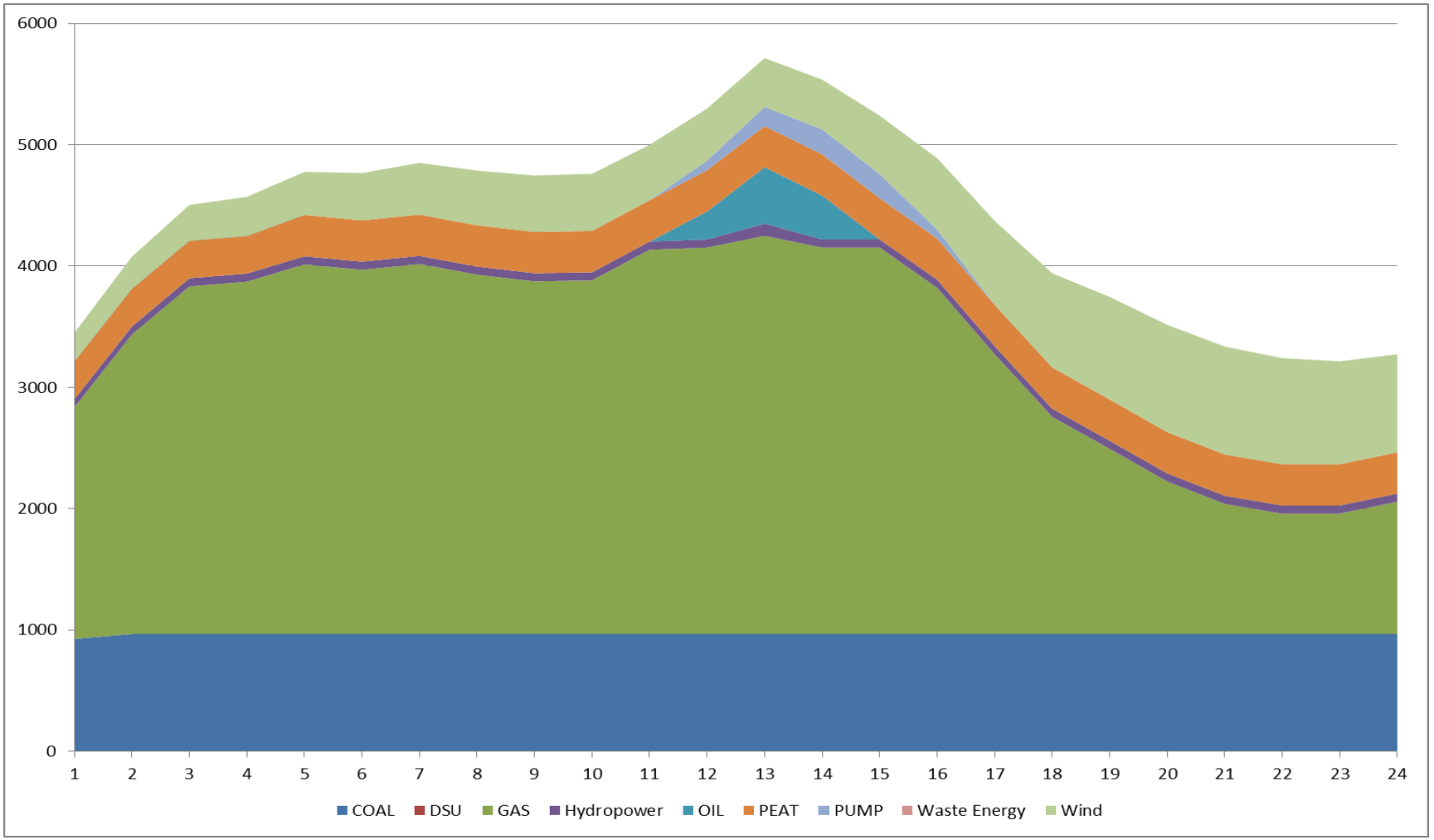
- PQ pairs with explicit fixed and variable costs
  - Costs must be recovered for the unit to be scheduled
  - This is applied by EUPHEMIA to all complex orders
- Cost data is based on SEM bids
  - Variable costs based on volume weighted average price
  - Fixed costs based on relevant no load and start up costs
- Technical data based on SEM bids
  - Single ramp up and ramp down rate only
  - Ramp rates are weighted average of all ramp rates
  - Explicit bidding of SEM algorithm behaviour

Results – Complex Orders (SEM Only)



- **Stable prices - follow load and generator availability**
- **Transparent prices – match to bids**
- **Good performance – algorithm solved quickly in all cases**

Results – Complex Orders Schedule



Complex Orders – Potential Refinements

- Complex orders function in a manner similar to the SEM – understanding of functioning is stronger than blocks

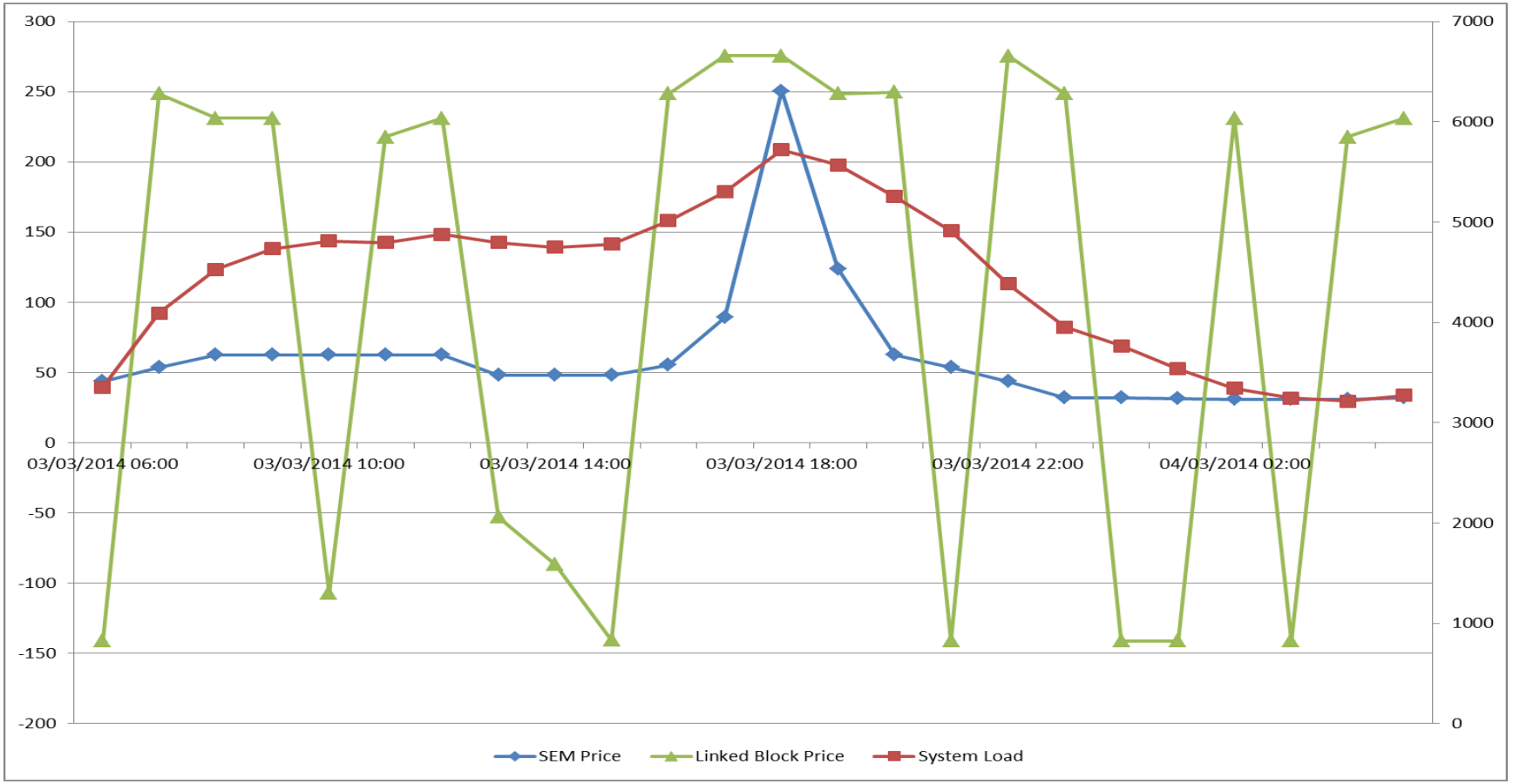
- Use of special units:
  - Pumped storage hydro
  - Energy limited hydro

- Review of assumptions and inputs:
  - Are the inputs reflective of participant behaviour?
  - Can the inputs be made more efficient?

Linked Blocks – Review of assumptions

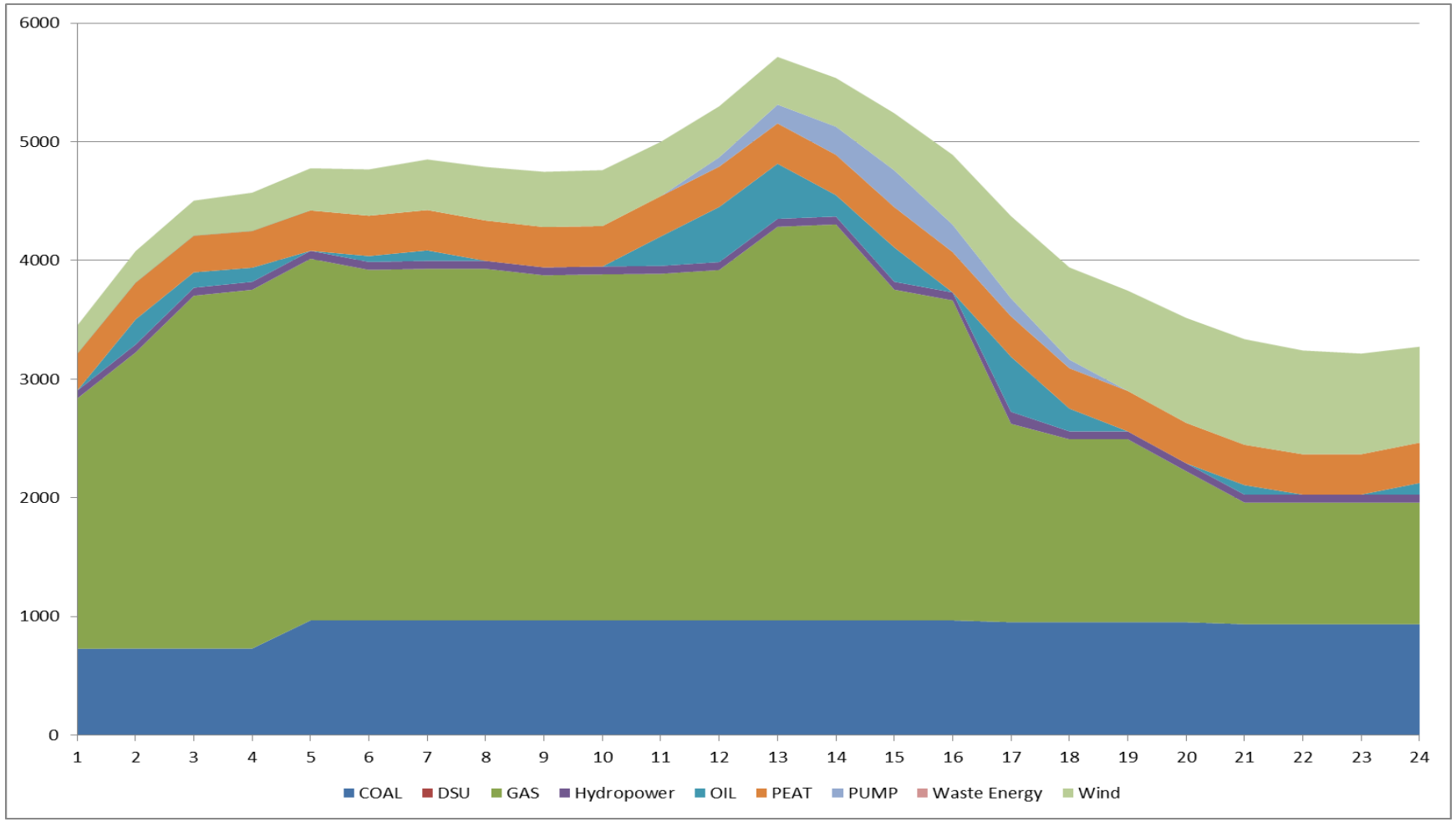
- Series of interlinked blocks
  - Expensive low MW block linked to cheap high MW block
  - Must schedule lower MW blocks to access high MW blocks
- Cost data is based on SEM bids
  - Fixed and variable cost and bid implicit in block prices
  - Must calculate the cost of each linked block based on cost incurred
  - Each must be 100% executed to recover fixed costs
- Technical data based on SEM bids
  - Technical data implicit in the blocks
  - Profiling based on technical data required to build blocks

Results – Linked Block Orders (SEM Only)



- **Unstable prices – prices not linked to load/gen availability**
- **Poor performance – order complexity meant algorithm reached time limit in many cases**
- **Potential mitigations – methods to mitigate available (see later slide)**

Results – Linked Block Orders Schedule



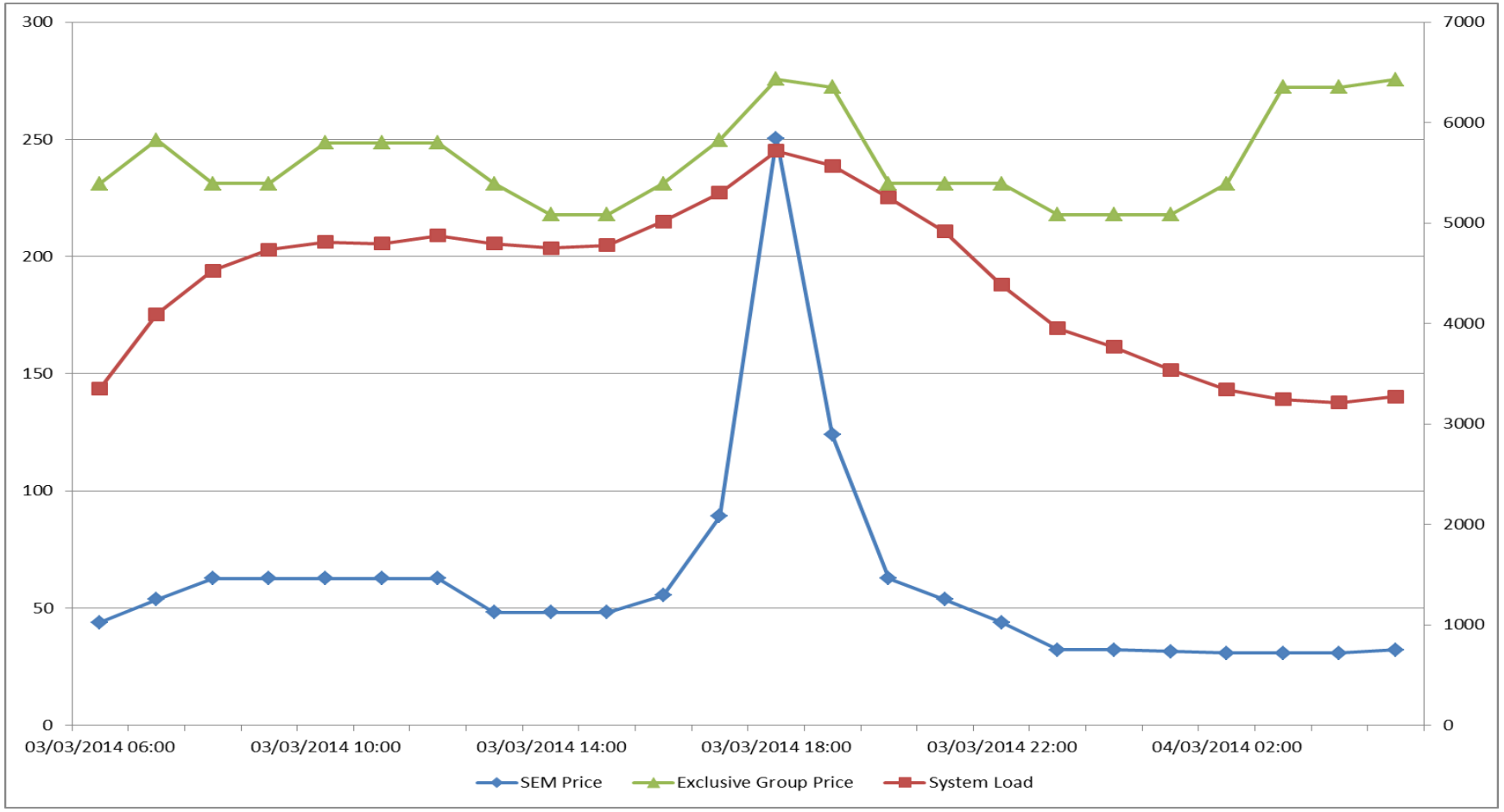
Linked Block – Potential Refinements

- Blocks, as entered, can only be 100% on or off – “fill-or-kill”
- Meaning blocks cannot set the price – same principle as when a gen unit is at max/min output
- Potential changes to this approach would be to introduce more price makers:
  - Price making demand – suppliers bid a maximum price
  - Price making wind – wind units bid in a minimum price
  - Interconnection – access price makers in other bidding zones
- Limitations in production of partial execution of linked blocks – could explore non-linked blocks which are not fill-or-kill
- Potential changes to approach will be further explored during the commercial trial phase

Exclusive Groups– Review of assumptions

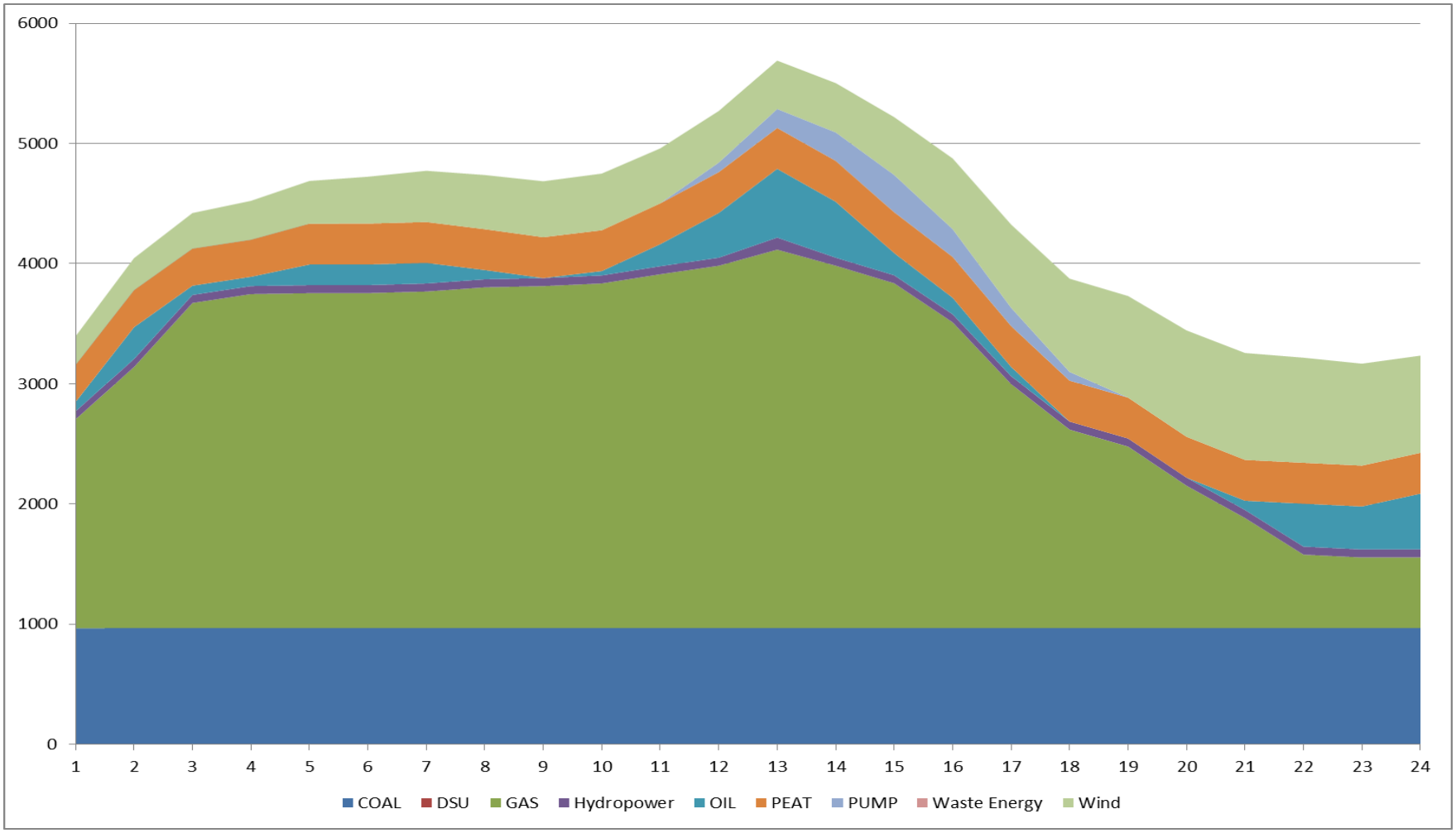
- Series of mutually exclusive profiles
  - Each profile represents different prices and volumes
  - EUPHEMIA can only accept one profile from the group
  - Profiles entered representing range of possibilities
- Cost data is based on SEM bids
  - Fixed and variable cost and bid implicit in block prices
  - Must calculate the cost of each block in the group based on costs
  - Each must be 100% executed to recover fixed costs
- Technical data based on SEM bids
  - Technical data implicit in the blocks
  - Profiling based on technical data required to build blocks

Results – Exclusive Group Orders (SEM Only)



- **Unstable prices – prices not linked to load, many price cap events**
- **Poor performance – order complexity meant algorithm reached time limit in many cases**
- **Potential mitigations – methods to mitigate available (see later slide)**

Results – Exclusive Group Schedule



Exclusive Group – Potential Refinements

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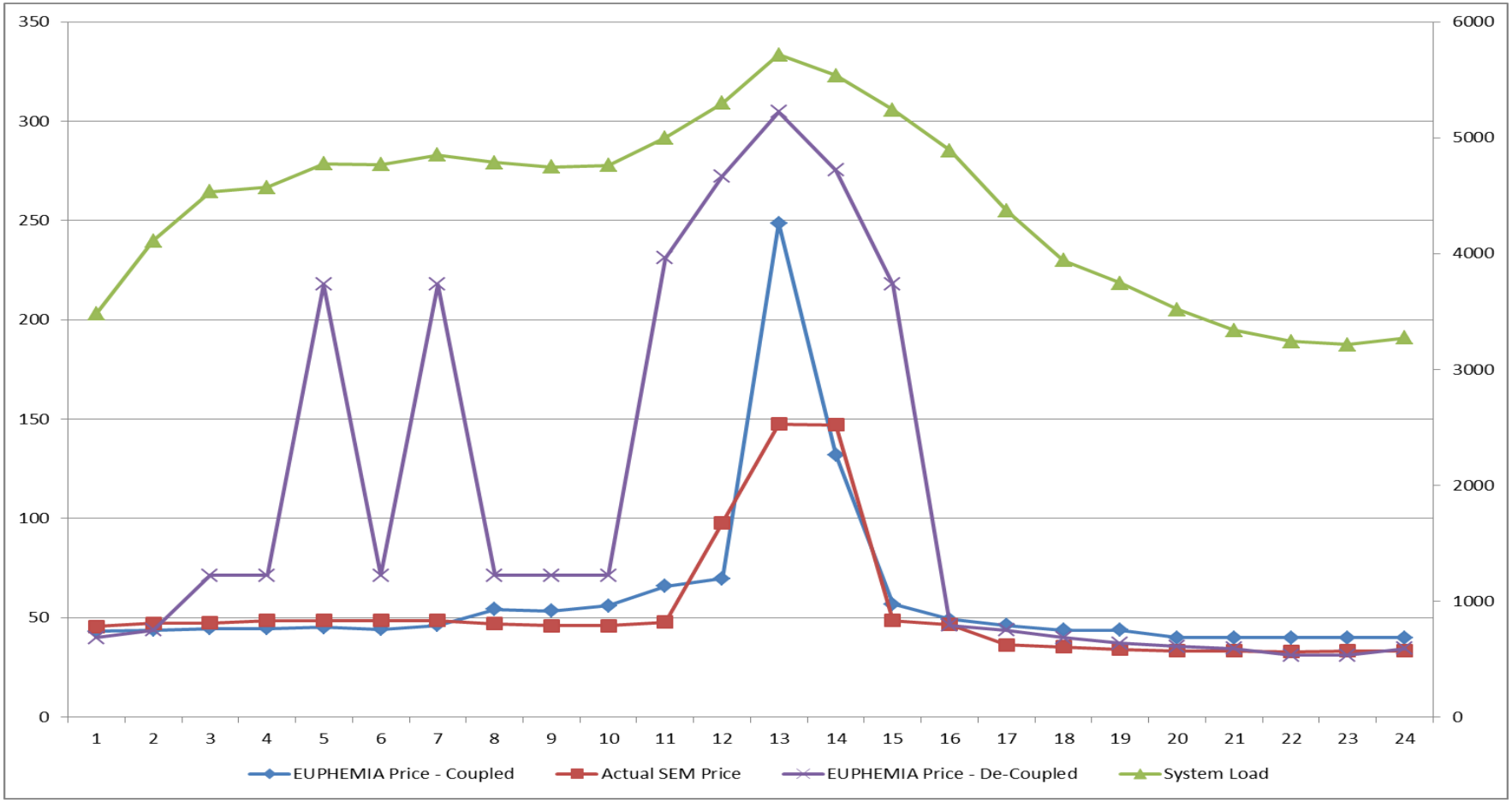
- Potential changes to this approach would be to introduce more price makers:
  - Price making demand – suppliers bid a maximum price
  - Price making wind – wind units bid in a minimum price
  - Interconnection – access price makers in other bidding zones
- Could explore non kill-or-fill – would need to discuss risk of cost recovery and potential for partial acceptance of two blocks
- Potential changes to approach will be further explored during the commercial trial phase

EUPHEMIA Trials – Coupling with other zones

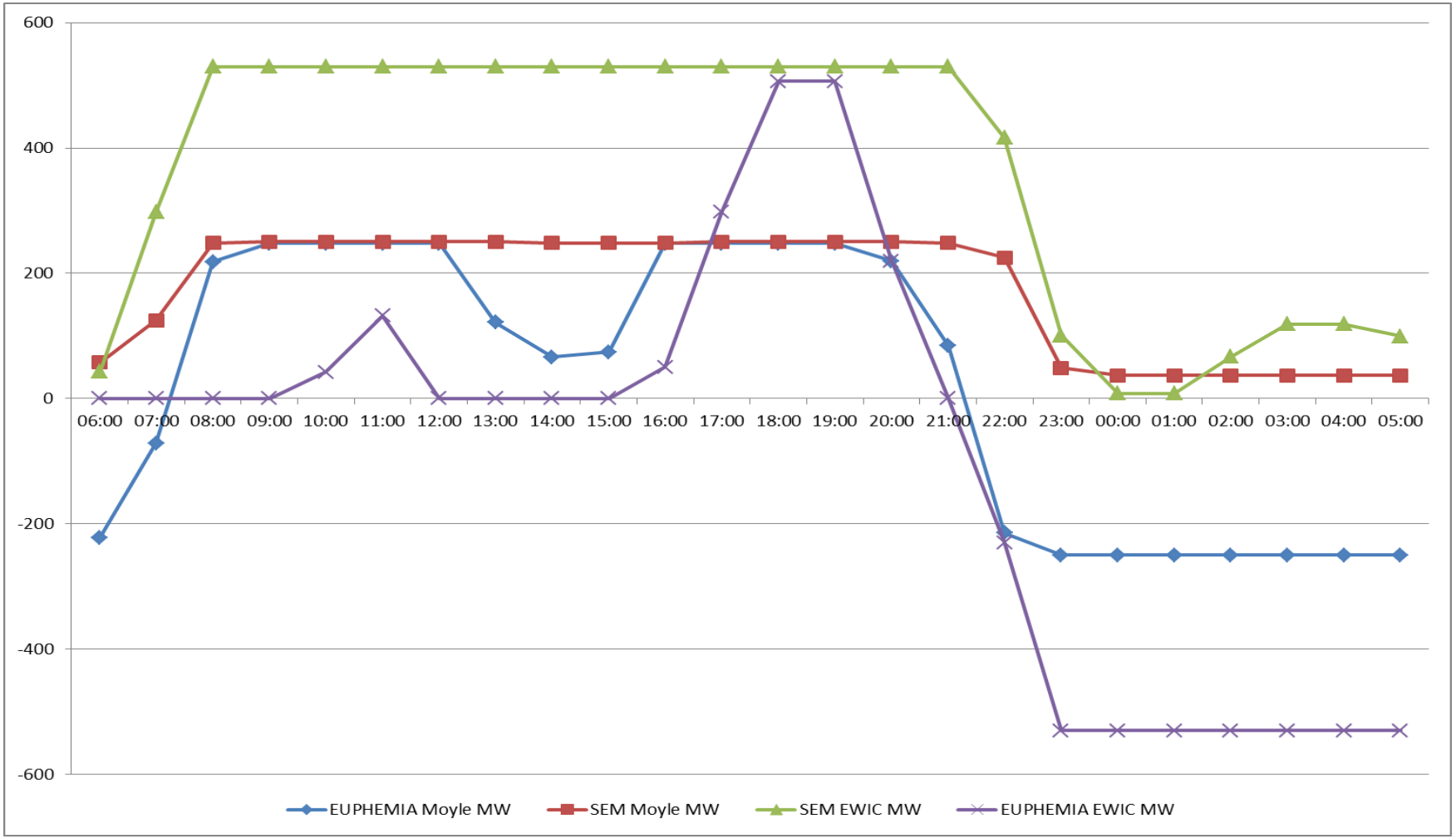
- Trial batches performed with interconnectors
  - Assess the effects of interconnection on prices and schedules
  - Assess the impact of the I-SEM coupling on algorithm performance
- Interconnectors represented as in the SEM
  - Moyle and EWIC represented
  - Values based on the values used for the SEM trading day
- Datasets based on complex orders
  - Assess the impact against known values
  - Understanding of block orders not fully developed

Results – Coupled Prices v SEM only Prices



- **Use of Complex Orders – to show effect of coupling**
- **Expected Effect on Price – spikes reduced and average price reduced**
- **Algorithm Comparison – SEM only focus (ABB algorithm) versus European focus (Euphemia)**

Results – Coupled Interconnector Schedules



- **<u>Interconnectors move with price</u> – higher variation**
- **<u>Capacity Usage</u> – better use of capacity than SEM i.e. exports after 21:00 when prices low**

EUPHEMIA Trials – Initial Results

Complex Orders	• Price formation comparable to SEM • Stable prices in all cases – prices linked to load/wind profile • Positive scheduling results
Linked Blocks	• Issues with price formation • Reduced complexity likely needed– inconsistent performance • Potential ways to improve prices – discuss with WG
Exclusive Groups	• Large issues with prices • Reduced complexity needed – poor algorithm performance • Consistent performance issues – would not be acceptable
Coupling	• Expected effect on prices – given high prices, price dropped • Confirms coupling is operable with trial order books

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EUPHEMIA Trials – Areas for further study

Wind

- Effect of increased wind, e.g. 2020 volumes
- Potential for price making wind bids

Emerging Technologies

- Compressed air storage
- Battery storage
- Backup Power

Demand Participation

- Price Taking v Price Making Volumes
- Formation of bid prices

Next Steps

EUPHEMIA Trials – Next Steps

- I-SEM EUPHEMIA Working Group
  - Working Group has been formed
  - Representatives from 17 different organisations and the RAs
  - Regular meetings between SEMO and working group
  - Provide feedback and insight on trial assumptions/results

- Commercial Phase Trials
  - Will take place between May and December 2015
  - Will involve industry participation through working group
  - Will trial over one year of data
  - Open to exploring areas not explored in initial phase trials

EUPHEMIA Trials – Next Steps

- SEMO will finalise the additional trials agreed with industry
  - Trials agreed with industry representatives in March 2015
  - Data being finalised for execution in EUPHEMIA
  - Will cover agreed scenarios and provide an additional month of data
- Working group will provide feedback on assumptions
  - What are the opinions of the working group members on the assumptions used by SEMO?
- Working group will provide feedback on commercial phase
  - What scenarios should be trialled
  - Should different criteria be applied than those in the initial phase
  - What dates/conditions should be trialled

EUPHEMIA Trials – Feedback & Further Queries

- There are a number of different forums available for further details or to provide feedback:
  - Discuss any interaction with a member of the I-SEM EUPHEMIA working group – members can provide feedback to SEMO at meetings
  - Send any mails to euphemia@sem-o.com – feedback is welcome on the process (including results and assumptions), workshops or interactions by SEMO
  - Attend future public workshops – over the course of the project (scheduled to last until 31/12/15) SEMO will hold further workshops; details of workshops are currently TBC
  - Request bilateral meetings – the industry working group is the primary means of industry interaction but SEMO may be able to facilitate bilateral meetings where working group interactions are insufficient

Questions?

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