Market Operator Solver Policy

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1. Introduction

This Market Operator Solver Policy paper outlines the situations under which the Mixed Integer Programming (MIP) solver should be used to generate and publish the Market Schedules (Ex-Ante, Ex-Post Indicative and Ex-Post Initial) instead of the Lagrangian Relaxation (LR).

The Market Scheduling and Pricing (MSP) software used by SEMO is provided by ABB. As part of the delivery of market systems prior to the start of the SEM, ABB provided a software solution that could utilise two commercial standard market solvers. One of these is a proprietary piece of software developed by ABB which solves markets using LR methods. The other solver is CPLEX's implementation which uses Mixed Integer Programming (MIP).

Both MIP and LR are certified solvers and can be used for publication in accordance with the Trading & Settlement Code (the Code).

During the development of the SEM, it was considered that, as ABB's LR solution had already been implemented in other markets around the world while the CPLEX solution was not, SEMO would make use of the LR solution as its normal day to day solver, and retain the CPLEX solver for back up purposes only.

As a result, LR is used as the Primary Solver to generate and publish Market Schedules. MIP will be run if certain predefined events occur, and only published if certain predefined criteria are met. At present, it is neither practical nor feasible to run both solvers and compare results for each run given the current market deadlines and system and resource constraints.

2. Triggers for checking with MIP

The rationale for triggering the check of the LR result with MIP is to ensure the output of the LR method is the best available solution in the case of significant price events.

If one of the following events occur during the normal LR run:

1) ***System Margin Price (SMP) > €500/MWh and Shadow Price ≠ Price Cap (currently = €1,000/MWh)***
2) ***Shadow Price = Price Cap (currently = €1,000/MWh)***
3) ***Shadow Price = Price Floor (currently = -€100/MWh)***
4) ~~3)~~ ***LR MSP Failure***

then the Unconstrained Unit Commitment (UUC) should be run using the MIP solver.

Prior to this policy taking affect, publishing with MIP had only been triggered in the event of a price event and where a specific bid curve pattern led to a discontinuity in the search space which could in turn lead to LR providing local optimal solutions including price spikes. This new policy is inclusive of this old policy and MIP use will be triggered in this case under the new policy.

In the first instance, MIP should be run with a time constraint of 300 seconds. Only if this solution is found to be sub-optimal and sufficient time is still available prior to publishing deadlines should MIP 600 be tried.

This policy does not affect the publication timelines required under the Code. The operational activities set out in this policy document shall only be used where there is sufficient time available and the completion of the additional MSP software run and analysis of the results will not cause SEMO to be unable to meet the timelines required under the Code.

3. Criteria to publish Market Schedules with MIP with Price Cap/Price Floor

Where the Shadow Price is found to be set at Price Cap or Price Floor and no Participant has bid in at this level, this indicates that one of the constraints set out in paragraph N 17.4 of the Trading & Settlement Code has been breached. These are –

- Energy Imbalance with an Under-Generation event;
- Energy Imbalance with an Over-Generation event;
- Breach of Energy Limits for Energy Limited Generator Units;
- Breach of Interconnector Ramp Rates
- Breach of Interconnector Maximum Import/Export Available Transfer Capacity

Each of these events means that the solver could not find a ~~feasible~~ solution without resorting to a breach of one of the above constraints.~~to the market.~~

When the LR run produces ~~such a~~n ~~infeasible~~ solution~~,~~ that breaches one or more of the above constraints, but ~~if~~ the solution from the MIP run does not~~is seen to be feasible (as in not containing a breach of one of the above constraints)~~, then the MIP~~feasible~~ solution must be published over the ~~infeasible~~ LR solution. This is regardless of Production Costs or any other measure.

When both ~~the~~ LR and MIP run~~s~~ ~~produce~~s ~~an infeasible~~ solution~~s and the solution from the MIP is also~~ that have one or more of the above constraints breached~~infeasible~~, then the rules set out in section 4, General Criteria to publish Market Schedules with MIP will be applied.

4. General Criteria to publish Market Schedules with MIP

The criteria set out here are applied where the System Marginal Price is greater than €500 but the Shadow Price does not equal Price Cap, other than arising from the criteria set out in section 3 above.

Once the UUC has been run with MIP, the output from MIP needs to be assessed against the original LR run to determine which solution should be published.

The criteria and decision on which solution to publish are provided in the table below:

	Optimal	**Production Costs**	**Price Event**	**Publication**
Scenario 1	Yes	Lower	N/A	**MIP**

Scenario 2	No	Lower	Removed	**MIP**
Scenario 3	No	Lower	Not Removed	**LR**
Scenario 4	N/A	Higher or Equal	N/A	**LR**

Table 1: Solver Publishing Decision Criteria

The publication decisions defined in table 1 are based on consideration of the following:

1) "Optimal" refers to whether the MIP solution confirms, through application messages, that it has identified the lowest production cost solution.
2) LR is the Primary Solver for the market, and should be used in all circumstances except in circumstances as described in this policy.
3) The Trading and Settlement Code has as the primary objective of the Unit Commitment to minimise production costs over the given optimisation time horizon (section 4.67).

An explanation of each scenario is given below:

Scenario 1:
If MIP has found the optimal solution, and the production cost is lower with MIP, then the MIP run should be published regardless of whether the price event (SMP>€500/MWh or Shadow Price=PFLOOR) has been removed or not. This is because MIP has found the optimal solution and met the primary objective to minimise production cost.

Scenario 2:
If MIP has not found an optimal solution but the production cost is lower with MIP and the price event has been removed, then the MIP solution should be published. MIP has provided a solution which meets the primary objective of minimising the production costs and has also removed the significant price event, which had led to the questions over the LR solution found. This clearly demonstrates that the MIP solver has produced a better, though sub-optimal, solution than the LR solver.

Scenario 3:
If MIP has not found an optimal solution and the price event has not been removed, then the LR solution should be published. This would be the case even if the production cost is lower with MIP, as it would not be clearly demonstrated from these results that the MIP solution is better than the LR solution. Then the Primary Solver, LR, should be used in these circumstances.

Scenario 4: In any situation where the production cost is higher with MIP, then the LR solution should be published.

Once the policy as detailed above has been followed exactly and assessment has been carried out, Market Operations Manager approval is not required before publication.

5. Criteria to publish Market Schedules with MIP with LR MSP Failure

The criteria set out here are applied where MSP Failure has occurred using the LR Solver. i.e. LR has not provided a Valid MSP Solution.

The UUC will be run with MIP and if a Valid MSP Solution is obtained, then the MIP solution should be published.

If neither solver is able to find a Valid MSP solution, or there is insufficient time to complete the MIP run before the publishing deadline, then Administered Settlement shall be declared.

~~5.~~6. Notification of publication with MIP

Within one working day following publication of the Market Schedules, a market message will be issued on the SEMO website notifying all interested parties when a MIP solution has been published. Information on the publication of Market Schedules with the MIP solver will also be included in the Monthly Market Operator Report, published on the SEMO website.