MARKET PARTIES PLATFORM

Linking Energy Markets

Confidence issues regarding Day-Ahead Market Coupling

Discussion Paper

1 Introduction

The European Day-Ahead Power Markets have moved a long way forward in coupling individual Markets and providing Market Participants with new tools to submit orders. During this evolution, market participants have always considered that powerful modern solvers, such as the Euphemia algorithm, ensures them that published market results are not only accurate, but lead to optimal solutions. However, recent changes in the coupled mechanism have lead to questionable results. It appears that the optimization problems to be solved seem to have become too complex to handle within the current offered algorithm and calculation time frame. This has lead to a 'confidence' issue with regard to the results obtained. With this in mind and represented by way of this paper the Market Parties Platform would like to elaborate the issues and give a number of suggestions to improve transparency to regain the confidence.

2 Background

2.1 An inefficient, yet straight-forward beginning

Just a few years ago, European Day-Ahead Power Markets (DAPM) were quite simple and straightforward, albeit less efficient. Physical Transmission Rights were allocated explicitly, and national power markets typically, operated independently. Products were on the whole simple limit orders, which were submitted by market participants on an hourly basis, and limited amount of block orders which consequently had significant limitations[1]. Solving these Markets was a much simpler task; modern solvers could quickly produce the solution and guarantee an optimal outcome, thus establishing trust in the entire market operation.

This was exactly the basis upon which spot exchanges gained much of their popularity: they were the closest thing to the 'truth' with regard to correct pricing, the unquestionable benchmark concerning trading actions, and the basis against which other, longer term products could be compared with. Solutions were transparent, intuitive, and easy to analyze. Undeniably, the whole setup of the market contributed to this: low integration of intermittent production and a clear distinction of production units (base load, peaker etc.) facilitated clear, however rather expectable and intuitive solutions.

2.2 Increasing complexity and efficiency

However, it quickly became apparent that the Market setup was more or less limiting in two ways:

- Markets were de-coupled and resources could not be utilized efficiently amongst different Markets. It was quite often found that some cross border flows were wrong, e.g. flowing from high priced areas to low priced areas.

1 As examples, in 2005, APX used to limit the Block size to 50MWh/h (currently 400MWh/h), and Powernext to 100MWh/h (currently 400MWh/h) while also allowing only for a limited set of hour combinations in a block.

And/or,

- Simple limit orders and limited block orders, could not efficiently model the actual constraints of real production units (Minimum stable generation, ramping speeds, minimum up/down times etc.), thus leading to inefficient operation of production units or, as in some cases, to infeasible production patterns that had to be dealt with after the DA results were obtained.

The European Commission stepped up to help remedy the first of the above-mentioned shortcomings, by issuing Energy Packages, in which the EU actively promoted the integration of the European power markets. - The 3rd Energy Package (namely Dir. 2009/72/EC and Reg. 714/2009), went many steps further towards European integration and the creation of a target model, a coupled Pan-European Power Market. After much effort and encountering many drawbacks, ATC Market coupling managed to link a large number of local European Markets. Moreover, the long awaited Flow Based capacity allocation principle, which recently went 'live', promised to deliver even more efficient results.

The Power Exchanges have been very active in tackling the second of the aforementioned shortcomings. Initially, they gradually reduced the limitations on block orders, which assisted market participants in making decisions that had time coupling constraints (e.g. producers in determining the on/off status of their units). Later, they provided smart orders (link families/exclusive groups), which extended flexibility even further. All these advances were correctly made in order to model the actual constraints of real production units, although there remain some improvements to be made (e.g. with regard to hydro specifics).

3 Keeping confidence in the solution

As the Market coupling paradigm advanced and the available type of orders became more sophisticated, it became very difficult for a Market Participant to have an overview of the solution. Even with the established sophisticated tools, there are simply too many unknown variables in order to fully comprehend a published solution, let alone verify it. The market always considered this as a small price to pay for the increased market efficiency result and and ever interesting challenges for the MPs. Trusting that the resulting complex Mixed Integer Problem (MIP) was correctly modeled, and that an efficient modern solver was used, there was confidence that the optimal result within the given constraints could be assured.

However, the complexity of the Optimization Problem has exploded over time. More coupled areas have lead to more optimization variables and constraints. The introduction of smart orders obviously came with more integer variables and constraints. Special requirements (e.g. primal/dual constraints) also came up in order to incorporate different market philosophies (e.g. Italy's GME). Lately, the introduction of the Flow Based allocation principle, substituted a simple set of constraints required for the ATC approach with an extensive set of constraints based on the PTDF matrix. Throughout these steps of evolution, we assumed that, despite the complexity and the lack of overview, the solution would still remain optimal.

Recent developments, however, have undermined that confidence and it is now becoming essential to get back the buy-in of market parties if we want to go further with the process of market coupling in day-ahead and intraday. Therefore, we believe that there should be a cost-benefit analysis before any further coupling with other areas to ensure and prove that the enlarged coupling effectively increases the welfare.

On top of this, we understand that markets are characterized by significant differences between countries. In this context we plead for an alignment of existing market designs (convergence or simplification) prior to any additional geographical market coupling to avoid creating additional complexity. This is in line with what is foreseen in the CACM guidelines, which mentions that the coupling should be tackled as a step-by-step approach.

4 Evaluating optimality

The objective function of the optimization problem is typically social welfare, which has to be maximized. As with any optimization problem, a proven optimal solution would be ideal. Since this is not always possible within a reasonable amount of time for mixed integer problems of this magnitude, a suboptimal solution that guarantees some minimum quality that has been predetermined can be accepted[2]. A clear, quantitative and objective evaluation of the quality of the solution is therefore required. After all, how can confidence in the market operations be sustained when there are no minimum requirements for the quality of the solution? What if the calculated prices and quantities are significantly different than those of the optimum solution? How much value is lost due to a sub-optimal solution and who bears the cost?

The optimization theory provides for a quantitative and clear measure of a solution's minimum quality: the optimality gap. The optimality gap can be specified as absolute (in units of the objective function) or relative (a percentage). This gap guarantees that the solution already found is, at worst, of a certain quality (i.e. distance from the optimal solution). That is why optimality gaps are typical termination criteria for the execution of optimization problem solvers.

5 Indications of suboptimal solutions

5.1 Algorithm Execution terminated on a time limit

During the course of the last few months, the market has observed more and more situations when the optimization procedure stops after 10mins, without any proof that the (integer feasible) solution that has been found is close enough to the optimal one. We would expect

2 Even this compromise is quite rare for markets like e.g. the financial markets. In most markets, establishing prices and quantities is done through a very precise procedure that leaves little room for doubt.

an optimization procedure of this importance to terminate based on proof that it is sufficiently close to the optimum (i.e. on both an absolute and a relative optimality gap criteria) and not based on a time limit. In our view that has lead to solutions that are possibly not sufficiently close to the optimum, thus prohibiting valid trades and affecting the final DA prices.

If the given ten minutes is not enough to run the algorithm in an appropriate way we should investigate if it will be possible to extend the timeslot occasionally. This investigation should include all operational implications.

5.2 Information on solution optimality is not available

In the course of the last months, some market participants have communicated concerns to individual PXs. From the information that these PXs were in the position to disclose, we can derive that our concerns are indeed valid and that optimality is not guaranteed. Optimality cannot be guaranteed for a great number of solutions and many Market solutions are published at the 10 minute time limit without any solid evidence of optimality.

Despite efforts from our members in search for published reports and persistent questions to PXs about the actual optimality gaps reported by Euphemia algorithm used for the day-ahead coupling, market parties still do not know these values. They are not reported although they are the only objective and quantitative way of assessing the published solution's optimality. Instead, reference is being made to the achieved number of solutions. The last relevant report of APX, issued on 21/04/2015, contains the graph of Fig. 1, depicting the "Number of [OK] solutions".

We have to assume that "[OK] solutions" refer to feasible solutions. However, there is a big difference between a feasible solution and an acceptable (OK) solution. A feasible solution means that the solution makes sense (No constraints are violated, integer variables are indeed integer). In Euphemia's case, a feasible solution would guarantee that e.g. supply meets demand, blocks are either completely filled or not at all, interconnection capacity is not overloaded, etc. This does not say anything about the optimality of the solution and whether it is good enough (OK). It could be that supply and demand were not matched in an efficient way and that other orders could also have been filled or rejected, yielding considerably different hourly prices.

The number of achieved feasible solutions is only an indication of the algorithm progression and not a good measure of the optimality of the achieved solution. It is commonly used in other optimization approaches (e.g. Genetic Algorithms) where better measures of optimality, such as the optimization gap, are not readily available. In these cases, if a "sufficient" number of solutions is found and there is no further improvement of the objective solution after a "sufficient" amount of time/iterations/generations, it is presumed that the optimization has converged. Unfortunately, "sufficient" is very subjective and not suited for market operations, especially if it has not been previously explicitly agreed to what is considered to be "sufficient". In any case, even by this approach, we would consider the number of solutions presented in the graph to be “insufficient”, even if we examine the period before last February (pre-GME), after which the situation seems to have deteriorated even further.

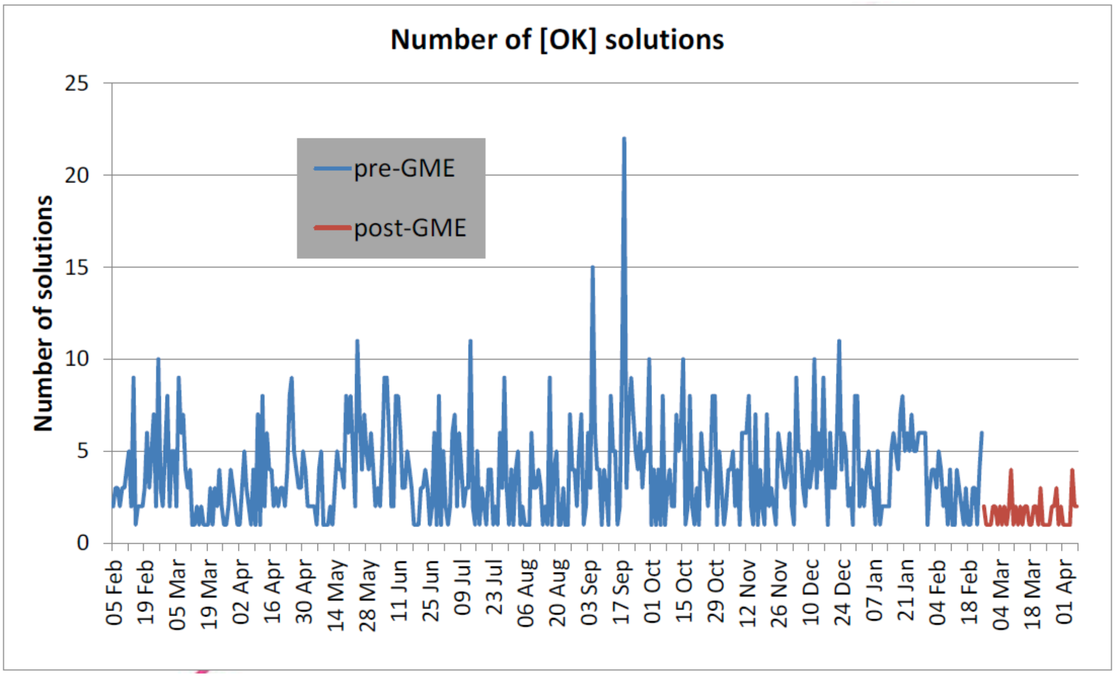

Fig.1: PCR algorithm performance update – Number of solutions (Source: APX)

6 Paradoxically Rejected Blocks (PRBs)

“Paradoxically Rejected” means that the rejection is correct although it might seem that it is not. This can indeed easily occur since there are finite (and usually limited) quantities of supply and demand for certain price levels[3]. It seems however that the notion of PRBs has been quietly expanded to cover every shortcoming of the solution procedure. Once again, some indication of optimality has to be provided in order for MPs to feel that their rejected blocks should actually have been rejected. Otherwise, any order can be rejected, irrespective of how deep in the money it is, and be regarded as a PRB without any further evidence.

7 Euphemia versions

Euphemia has been developed to solve the market coupling problem of the PCR (Price Coupling of Regions) project. As far as we know, it is an algorithm for which there is ongoing research and continuous improvements, for which version 9.2 is the last one that has been released in May 2015. There is, however, a lot of information missing about the versioning

3 As an example, it is easy to understand why a sell block of 400MWs@40€/MWh for a certain hour was rejected despite the fact that the price for that hour was 40.5€/MWh; there is just not enough buying interest (small quantities) at the respective price level.

process as this new version of Euphemia (including changes of features) has been released without any notification to market parties. Although we do understand the need for improvement – this paper addresses such a need – we feel that there should be a formal communication process before any new release to make sure that market participants are aware of the new features, the verification process and the go-live of new releases of the algorithm. Even more so when there are no optimality gap criteria during actual operation and it has become obvious that algorithm performance can significantly affect the market results.

8 Consequences

8.1 Market Participants

Market participants are currently exposed to an additional risk: the optimization risk. This is a new risk, not existent in other Markets. This risk cannot be easily modelled or hedged. Due to sub-optimality, market parties face potential loss of revenues, that can only be identified ex-post. At the moment, with the unexplainable PRB (Paradoxically Rejected Blocks) that market parties have experienced, the confidence in the products that are available in the day-ahead market (including smart bids), has decreased considerably.

We must also point out that any optimality gaps are not shared pro rata in the power market. By definition, they tend to affect the marginal production and supply, which is already struggling to achieve some positive margins. This means that certain market participants are affected more then others.

The risks are, of course, not limited to the spot market. Power markets with different time-frames influence each other. Moreover, the spot market is used, as previously stated, as an overall benchmark and a basis for other pricing schemes, most notable of which are the national subsidy mechanisms for renewable generation.

The biggest consequence however, is the loss of trust in the solution. Market participants need to know that some degree of optimality is guaranteed. Otherwise, efficiency and optimization give way to risk aversion and random chance results.

8.2 Welfare effects

Sub-optimality of an algorithm that maximizes social welfare means some social welfare is lost, because resources are not used optimally when matching supply with demand. Without an optimality gap, this cost cannot even be quantified. It could even be bigger than the expected gains of recent improvements. There is no way of knowing its magnitude without the relevant reports. Sub-optimal solutions prohibit valid trades from being executed, leading to erroneous prices and distorted price signals.

8.3 The need for more transparency under FB

We consider that the information currently available is not sufficient for market parties to predict and anticipate prices. Market parties should have access to data that enable them to understand the process and interpret results of the algorithm. The publication of technical parameters (PTDFs etcetera) for a set of standard scenarios and the update of such data in case of changes in the network topology (e.g. the installation of a new phase-shifter) would help market parties to increase their understanding of market prices. We also believe that the harmonization process within the FB domain should go further with a harmonization of the GSKs.

In addition we would like to have further clarity on the reason to limit the maximum exports under the flow-based approach. We understand the reasoning behind the limitation of the imports as a way to ensure (and give incentive) to have enough production within the country but we are not convinced on the limitation on export. If a country has exceeding production it should be authorized to contribute to the supply of its neighboring countries, hence reducing the spread in CWE.

9 Conclusions

Markets need certainty about the rules in order to operate efficiently. This includes the certainty that the Market results are based on algorithm executions with some pre-agreed specifications. Moving forward with the complexity of the coupled European Day-Ahead Power Markets, we are not convinced at all that this consideration assuming that all these technical issues are covered is still given. Despite the lack of information, we have identified and proven some cases of sub-optimality

We believe we need to stand on solid ground in order to move forward. We need to assess the cost of sub-optimality and agree on a quantitative threshold of acceptable accuracy based on the optimality gap. Otherwise, the expected benefits of further coupling expansion and better cross border capacity allocation techniques, such as Flow Based, are in danger of being outstripped due to loss of MPs confidence and sub-optimal Market solutions.

10 Suggestions

In this last paragraph we would like to make a list of suggestions that would increase the confidence in the market. The list is not exhaustive and should be used as the first input for the dialogue with the coupling project.

- Publish all appropriate metrics for each run (i.e. relaxed solution outcome, MIP gap, number of feasible solutions found, number of PRBs), if perhaps also make available by country.
- Make an informal second run for each auction in which the model is given the same input, but allowed to run for 12 to 24 hours or until a small MIP Gap is reached, and make these results available. In this way they could also publish information about how many of the paradoxically rejected bids are in fact incorrectly rejected bids (due to the short algorithm calculation time/chosen algorithm structure).
- Publish details (i.e. full mathematical model description and/or source code) of Euphemia.
- Publish grid topology information used under Flow Based market coupling to provide market parties with means to better assess the impact of change in technical parameters on prices.
- Assess the gained welfare of potential further geographic expansion and prevent expansion without first convergence of products offered.
- Publish the calculation time of runs when lower than 10 minutes to have a view on the share of runs limited by the time constraint.
- Investigate the possibility of extending calculation time
- Encourage convergence of market designs in the regions involved in the market coupling to relieve regional complex constraints that hamper the efficiency of the algorithm. We propose to do this in an investigation of all PXs and market participants to define what products are relevant for the market.

Market Parties Platform

The Market Parties Platform is a cooperation of energy industry associations in the Central West European electricity market (including the Benelux, France, Austrian, Swiss and German market). Main goal of this cooperation is to actively promote the forming of an integrated CWE electricity market and efficient coupling with the surrounding regions. This will increase efficiency of the market and will therefore bring benefits to the electricity consumers in this region. The work is strongly linked with Eurelectric.

Current secretariat:
Energie-Nederland
Lange Houtstraat 2
NL-2511 CW Den Haag
info@marketpartiesplatform.eu
www.marketpartiesplatform.eu

For more information about this publication, please contact:

Ruud Otter
rotter@energie-nederland.nl

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