Implementation Study

A report for the MoU signatories on the design of the market coupling solution in the Central West European (CWE) region, by the CWE MC Project

August 2008

Management summary

In the MoU, signed on the 6th of June 2007, the signatories have agreed on the design and implementation of the flow based market coupling in the CWE region. Since then, the eleven Project Parties have made important and significant progress on the design of the system, which is explained in this document. This document marks the culmination of a year's intensive work by the TSOs and PXs, including several consultations and interim reports to market participants, regulators and the Pentalateral Energy Forum (PLEF).

The Project Parties are fully committed to implement flow based market coupling, since that mechanism maximizes capacity for the region, while safeguarding grid security.

However, during the study the Project Parties have got a better understanding of the challenges and uncertainties associated to the flow based solution, and believe these can only be addressed through a sustained period of parallel running.

As a consequence, the Project Parties have taken the responsibility to propose to start market coupling with an ATC based solution, which will nonetheless still deliver significant benefits for the region, while continuing the development and assessment of the flow based solution.

Market coupling operation

During the daily operation of market coupling the available capacity will be published 11:15h at the latest. Market participants will have to submit their bids and offers to their local PX before 12:00h. The results will be published at 13:05h the latest. In the case results can not be calculated by that time, the fall back mechanism for capacity allocation will be applied and there is a decoupling of the PXs. As a fall back mechanism, the TSOs will implement an arrangement by which the available transmission capacity is allocated via a shadow explicit auction. For this purpose, a permanent database will be in place, allowing for capacity requests 24 hours a day, 7 days a week. In fall back, the PXs will decouple, meaning an isolated fixing of the PXs will be performed after having reopened their order books.

The underlying assumptions to this daily schedule are that gate closure times at the PXs is 12:00h, that the CWE MC algorithm takes a maximum of 10 minutes to compute the results, and that the calculation of flows to adjacent regions takes a maximum of 20 minutes.

The algorithm

The Project Parties have selected COSMOS as the algorithm to calculate daily market results. COSMOS is a branch-and-bound algorithm designed to solve the problem of coupling spot markets with block orders. It naturally treats all mandatory and nice-to-have technical requirements set by the CWE project, including step and interpolated orders, flow-based network under PTDF representation, ATC links ad DC cables (possible with ramping, tariffs and losses), profiles block orders, flexible blocks orders and linked block orders. COSMOS outputs net export and prices on each market and each hour, the set of accepted orders, and the congestion prices on each tight network element. These outputs satisfy all requirements of a feasible solution, including congestion price properties and the absence of Paradoxically Accepted Blocks. In addition, COSMOS is able to integrate new features such as those to be expected in a context of product and geographical extensions.

Network representation

It is proposed that the market coupling will start using ATC values for cross border capacity, representing the transmission grid. The methodology to calculate the ATCs is being developed. More explanation to this methodology will be given at the Pentalateral Energy Forum of 15 September 2008.

The main reason underlying to this proposal is that the Project Parties would like to have a better and unambiguous view on the consequences in terms of economic outcome of the mechanism. Extensive work has been done in the field of economic assessment, but it has to be acknowledged that the grid data used in the validation are only an approximation of the data which will be used when the process will be in real operation. The main cause of this is that the required grid data did not exist at the TSOs, for which the data had to be reconstructed in an automated way. The approximation has without doubt an impact on the number of pre congestions and on the results of the economic validation. In chapter 4 these impacts are further explained. Consequently, it is clear that at this stage the Project Parties are not fully convinced to start the market coupling with a flow based network representation.

In parallel to the ATC based market coupling operation, the Project Parties will test run the flow based mechanism during a period of for example 1 year. During this transition period, flow based parameters will be produced on a daily basis according to the standard operational procedures, and these parameters will be used to calculate the parallel market results. The period of test running the flow based mechanism will give the opportunity to closely monitor the behavior of the flow based market coupling and to compare the results with the results of the ATC based market coupling. It will also provide a realistic number of pre congestions and their causes. These results will be discussed with the signatories of the MoU.

Another advantage of such approach is that the market participants will have time to understand and prepare for the flow based mechanism and its behavior. This was a concern of market participants, expressed on several occasions.

After the switch to flow based the network will be represented by the flow based parameters (PTDF matrices, and maximal flows). We refer to the Orientation Study for the description of the methodology that is used to produce these parameters.

Economic validation

As already stated above, some reservations need to be made regarding the data used for the conducted simulations:

- For both simulations, in ATC and flow based mode, ATC based market data has been used and market learning effects under flow based market coupling are not included either in ATC nor in the flow based simulations.
- ATC and flow based models have been generated by TSOs in completely different contexts – operational conditions for ATC and ex post simulations for flow based.

    - Historical ATC data might be error prone because the ATC model gives a poor approximation of the security domain (sometimes overestimated, sometimes underestimated)
    - Flow based data may also be error prone because the FB parameters were reconstructed in an automated way and with many approximations for benchmark testing purpose. Since the FB methodology is still under study and will still be improved, no data from a full mature operational system exists at this stage.
- Finally, the explicit auction effects and the cross border arbitrages behaviour that are reflected in the current historical order books have not been removed from the order books for the simulations. Altering the order books will modify the results.

It is difficult to anticipate the effects on the results associated to the first two reservations mentioned, and different scenarios can be envisaged to correct the effects due to an overestimation of the German capacities.

First conclusion of the assessment is, by comparing the results under a flow based and an ATC market coupling, that the benefits of a market coupling under a flow based model did not appear clearly on the different market indicators.

However, from a theoretical point of view, flow based remains the best way to have the market and the security domain coexist. Firstly, the flow based domain represents more accurately the network security area, whereas the ATC domain does not, and may even violate it. In other words, the ATC and flow based methodologies and their respective level of security are different.

Secondly, with flow based, contrary to ATCs, no assumption on the contractual paths are made (for instance ATC FR-DE at the expense of ATC FR-BE). In this view, an important point which has not been specified nor quantified in this analysis, but which would be interesting to investigate, is the difference in network security between the flow based and the ATC modes.

The market validation analysis also showed that non intuitive effects do happen under flow based model whereas they do not under an ATC Model. Preventing these effects to occur does not provide satisfactory solutions because of the combined effects resulting from the existence of pre-congestions arising in the current flow based test cases prior to the market coupling and from a lack of liquidity on the Belgium market on particular hours. A remaining open question concerns the general acceptability of adverse flows and thus of non-intuitive solutions.

Another conclusion that could be drawn from the analysis is that the fear that under FB price may be out of bound was unjustified, since such cases did not occur in the simulations. However, there is no proof that this will be the case in the future, and special rule should be implemented with this respect.

The phenomenon of curtailment being exported (i.e. rejection of part of the price taking orders) happens to be relatively limited, even when negative prices are introduced on EEX (especially under ATC). As announced, EEX will implement negative prices in the German hub, while negative prices are not available at the other PXs. The introduction of negative prices in Germany is necessary because in certain market situations (e.g. high wind power generation in hours with low demand), supply exceeds demand at a price of 0.00 EUR (old lower price boundary at EEX). This may result in pro rata curtailment, meaning that relevant block bids will not be accepted and sellers with single hour bids can only sell part of their order volume. Pro rata curtailment does not only affect those participants who intend to sell short term excess power but also those who secured their physical portfolios in the past through derivatives transactions with futures that they now intend to settle physically through the spot market.

The exchange has to guarantee fulfillment to the highest degree possible. Part of this is that orders are fulfilled in the way intended by the participants and that the interplay of the different exchange instruments (e.g. physical fulfillment of futures via the spot market) is working properly.

For the reasons stated above, the Exchange Council of EEX decided on 23 March 2007 to introduce a negative lower price boundary in the German hub. This decision is also backed by a scientific report on power market design ("Strommarktdesign") of Prof. Ockenfels, University of Cologne. The English translation of this report will be available for all stakeholders in due time.

There is no consensus yet on introducing similar price boundaries in other markets. As a consequence the market coupling is likely to start with non harmonized price boundaries.

Finally comparing the results of the simulations under CWE-MC and the historical situations shows an improvement of all market indicators, but these results must be taken with caution, and considered as a best case, taking into account the overestimation of the volume in the order books due to explicit auction effects that were not removed.

A general conclusion is that a refinement of the order books is needed to remove the volume due to explicit auctions and the cross border arbitrages behaviour from the historical order books. Different scenarios for this can be envisaged. Depending on the assumption that is taken, results on all indicators are expected to vary from the results presented here, which should be considered as a best case.

Fallback arrangement

In the CWE MC procedures, a fallback situation occurs when the market coupling system operator declares that, for any reason, correct market coupling results (i.e. MC results fulfilling the check conditions) cannot be published before the critical deadline.

The principle of the proposed fallback arrangement is to allocate the ATCs via a “shadow explicit auction” and a full decoupling of the PXs. This means an isolated fixing by the 4 PXs, performed after having reopened their order books

Cost recovery

The Parties involved in the CWE Market Coupling have developed a model for the treatment and ultimate recovery of the costs associated with the provision of the CWE market coupling, related to both the setup and the ongoing operations. This cost recovery model was developed on the basis of two main assumptions.

The first assumption is that the CWE community is the main beneficiary of the CWE Market Coupling and will pay all reasonable costs related to the setup and operation of the CWE Market Coupling.

The second assumption is the acknowledgement of the regulators competence under local law. This assumption implies the setup of a cost recovery model in such a way that local discussions with the local regulator can happen. We should however acknowledge the fact that an interdependency is existing between local regulator approval processes through the cost sharing mechanisms.

Taking into account those two main assumptions, the cost recovery model was developed. The model comes down to outlaying the principles of cascading down to the level of individual TSOs of all CWE Market Coupling related cost.

Implementation plan

After finalization of the design phase, the pre-implementation phase will start. During this phase, the Project Parties will set up the project organization for the implementation phase, procure the system, and complete the market validation with the improve data. They will await the regulators endorsement of the cost recovery mechanism, as well as endorsement of the coupling mechanism designed. After endorsement is given, the implementation phase will start in December 2008 and will continue until the launch of market coupling, which is foreseen towards the end of 2009.

A detailed bottom up plan will be presented for the end of October 2008 which will also address the potential for bringing forward the delivery date.

The forecast costs, 26million euros, remain within the range previously indicated to the PLEF. A detailed bottom up budget will be presented in October 2008.

As a consequence of this planning, the market coupling will start with price coupling. In the Progress Report it was explained that the EEX trading system and the German Exchange Act do not allow for a price coupling. However, some steps of the announced merger of EEX and Powernext that tackle those issues will be finalized before the start of market coupling. This enables the Project Parties to start with price coupling. The new common trading system of EEX and Powernext will allow for price coupling. The German and French spot markets will be operated by a company incorporated in France, under French jurisdiction.

1 Introduction

In this report, the Project Parties present their design of the market coupling solution. The proposal is to implement the market coupling in two phases, starting with an ATC based network model.

This would be a temporary solution, to be followed by the flow based solution, as soon as enough confidence is built in the flow based approach amongst all stakeholders. This will be achieved by a sustained period of parallel running.

The design of the market coupling solution and the reasons for the two step implementation will be further explained in an number of chapters which are devoted to:

- The high level architecture and procedures of the solution
- The functioning of the algorithm
- The network models
- The economic validation
- The fall back arrangements
- The publication of data
- The governance framework
- The cost recovery mechanism
- The implementation plan

The purpose of this report is to inform the stakeholders on the market coupling solution and to reach regulatory approval of the solution. The report also provides the answers to the questions from the regulators which were expressed in the conclusions of RCC, 30th May 2008. Annex 1 contains a table in which all questions are listed, and in which references are made to the relevant sections in this report, where the answers are provided.

2 The Market Coupling Solution

This chapter describes the high level business procedures and timings that are needed to operate the CWE Market Coupling on a daily basis, and the main backups associated to these procedures. During the implementation phase, the operational procedures and working instructions will be set up within this high level framework.

When drafting the high level business procedures, the Project took into consideration the results from the consultation of market parties, organized from 5 to 8 of May. A high level conclusion of the consultation is that the market parties endorsed the procedures and the timings which were proposed by the Project. However, there was a number of remarks by individual market parties. These have been taken into consideration by the Project as far as possible. For the full overview of results of the consultation we refer to Annex 2.

To implement the procedures and timings, it is assumed that gate closure time of the Power Exchanges is harmonized at 12:00h. The time for the determination of flows between the CWE region and the Nordic countries (more precisely on NorNed and DK-DE interconnections) is assumed to be 20 minutes[1]. The MC algorithm is assumed to need a maximum of 10 minutes to compute the results, once it has all the necessary input from the TSOs and the PXs.

In the next sections the high level business process are further explained. They are devoted to:

- Definitions
- Requirements for the procedures
- The high level functional architecture
- Normal operational procedures
- Main back up procedures

2.1 Definitions

Normal Procedure: procedure describing the actions to be taken by Agents to operate the CWE Market Coupling in a clear weather scenario (when no problem occurs).

Back-up Procedure: procedure describing the actions to be taken by Agents in order to operate the CWE Market Coupling when a problem occurs (when for any reason, the information cannot be produced/exchanged or if a check (such as sanity check of I/O files) fails before the target time, or if it is known or may reasonably be expected that this will not happen before target time).

Fall-back Procedure: procedure describing the actions to be taken by Agents in case the information cannot be produced/exchanged either by normal or back-up procedure or if a check (such as protocol flows) fails before critical deadline, or if it is known that this will not happen before the critical deadline.

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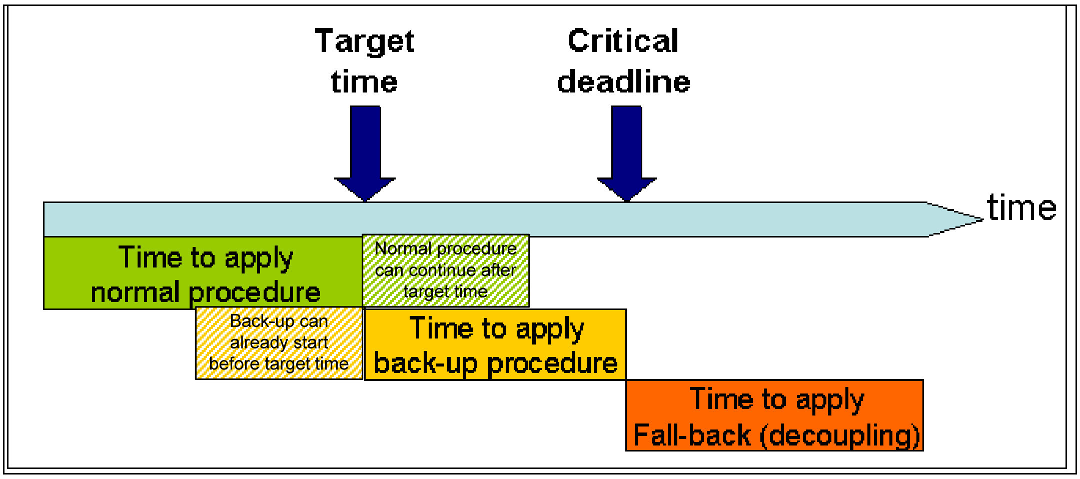
[1] These 20 additional minutes must still be confirmed by the operational experience of EMCC.

Target time (for a given procedure): estimated time to complete a procedure in a normal mode. If an incident occurs that does not allow applying the normal procedure, and for which a back-up exists, back-up procedure is triggered.

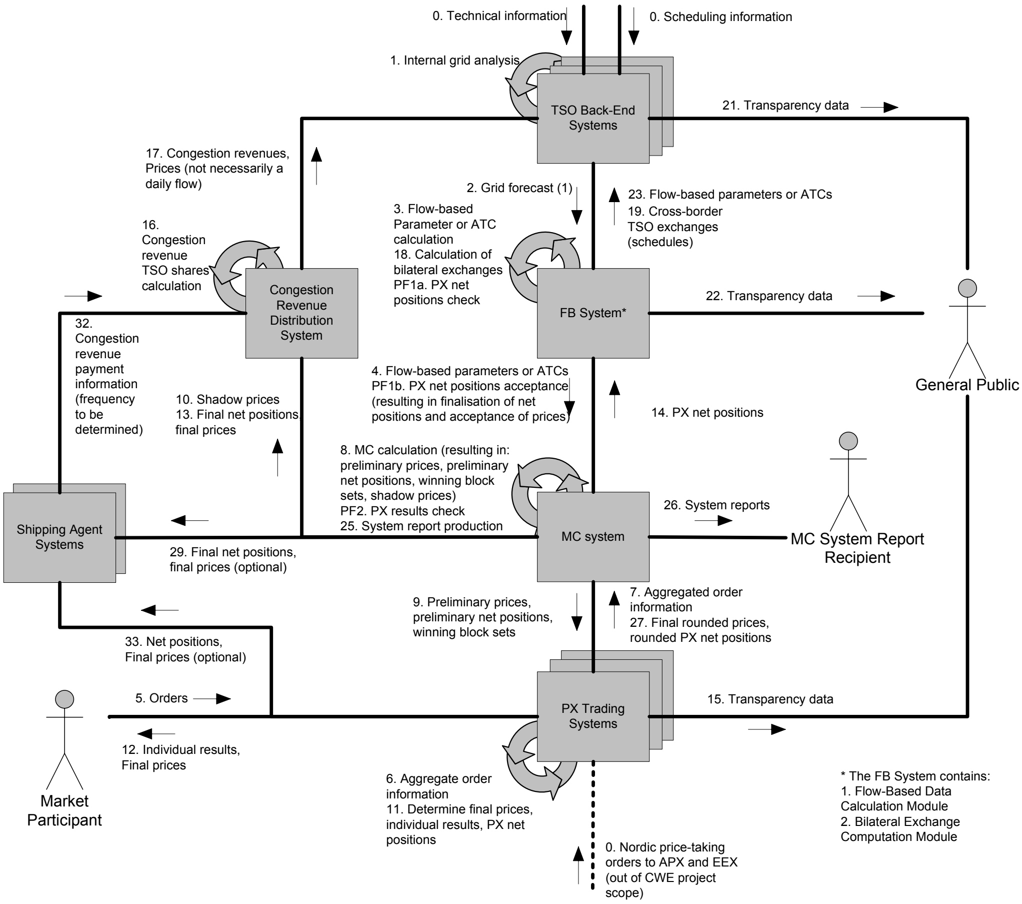
Critical deadline: latest moment in time to complete some procedure in normal or back-up mode. If an incident that does not allow applying normal or back-up procedure (if any) occurs before this time, fall-back is triggered.

Fig 2.1: Interrelationship between normal procedures, back up, and fall back



2.2 High level architecture

The picture below represents the high level functional architecture. In the following sub sections the architecture is further explained in terms of its systems, agents and information flows.



2.2.1 Systems

In the architecture diagram, the automated systems that are expected to play a role in the Solution are indicated with rectangles. These systems may either be existing systems adapted to the Solution or systems to be newly built.

The following systems are distinguished.

- The back-end systems of the 6 TSOs involved are grouped together as the 'TSO Back-End Systems'. This grouping is made on the assumption that these systems each treat essentially the same information.
- The trading systems of the 4 PXs involved are grouped together as the 'PX Trading Systems'. This grouping is made on the assumption that these systems each treat essentially the same information[2]
- The TSO system to be built that will supply the ATCs or the flow-based network representation used in the Solution (through its Flow-Based Data Calculation Module) and that will calculate the Cross-border TSO

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[2] Note that the business processes managed by TSOs systems and PXs systems are local processes which can slightly vary from one party to the other, provided the common processes and schedule are respected.

exchanges from the Net Positions (through its Bilateral Exchange Computation Module) is called the 'FB System'[3]

- The Systems that will be the counterparty for the cross-border transactions, calculate the final sum of the congestion revenue (on the basis of the net positions and the prices) and inform the Congestion Revenue Distribution System of this sum are called the 'Shipping Agent Systems'[4]. Currently, two such systems are assumed (ECC and APX), each of which will service two PXs and two countries[5].
- The TSO system to be built that will receive the information of the sum of congestion revenue and share it between the TSOs is called the 'Congestion Revenue Distribution System'.
- The system to be built that will calculate the market coupling result is called the 'MC System'.

2.2.2 Agents

The Agents are represented in the diagram as abstract human figures. An Agent is a non-automated entity interacting with one or more Systems or other Agents in the information perspective on the Solution. An Agent is distinguished according to the role he plays. For instance, one human being could appear in the architecture as two different Agents (for instance, 'Operator' and 'Operations Manager' – a distinction not relevant in our solution, but possibly relevant in other solutions). Conversely, millions of human beings appear as a single agent ('The General Public').

The following Agents are distinguished.

- The 'Market Participant' Agent represents the PX members.
- The 'General Public' Agent represents the recipient of all data publication due to transparency requirements.
- The 'MC System Report Recipient' Agent represents the 11 project partners, who, collectively, are the recipients of the regular MC System reports.

2.2.3 Information produced and exchanged

The information produced and exchanged is represented in the diagram by arrows with a label. The small arrows point in the direction of the information flow. The circular arrows indicate information produced in processes internal to a System. The label indicates the contents of the piece of information transferred or produced. The sequence of production and transfer of information is shown below. The arrows are numbered accordingly.

It should be stressed that only flows of information are shown in the diagram. Other flows, like electricity and money flows, are not expressed.

All information flows are assumed to occur on a daily basis, with the exception of the flow of 'Congestion revenues and Prices' from the Congestion Revenue Distribution System to the TSO Back-End Systems (#17), the flow of 'System reports' from the MC System to the MC System Report Recipient (#26), and the

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[3] Note that the exchange of information between the modules of the FB System is not shown in the diagram.
[4] Note that the shipping agent function is still under discussion. Based on the outcome of this discussion flows and systems may slightly change.
[5] Note that the legal entities behind the Shipping Agent Systems will also pay the amount of the congestion rent to the legal entity behind the Congestion Revenue Distribution System, but this is a money flow not shown in the functional architecture.

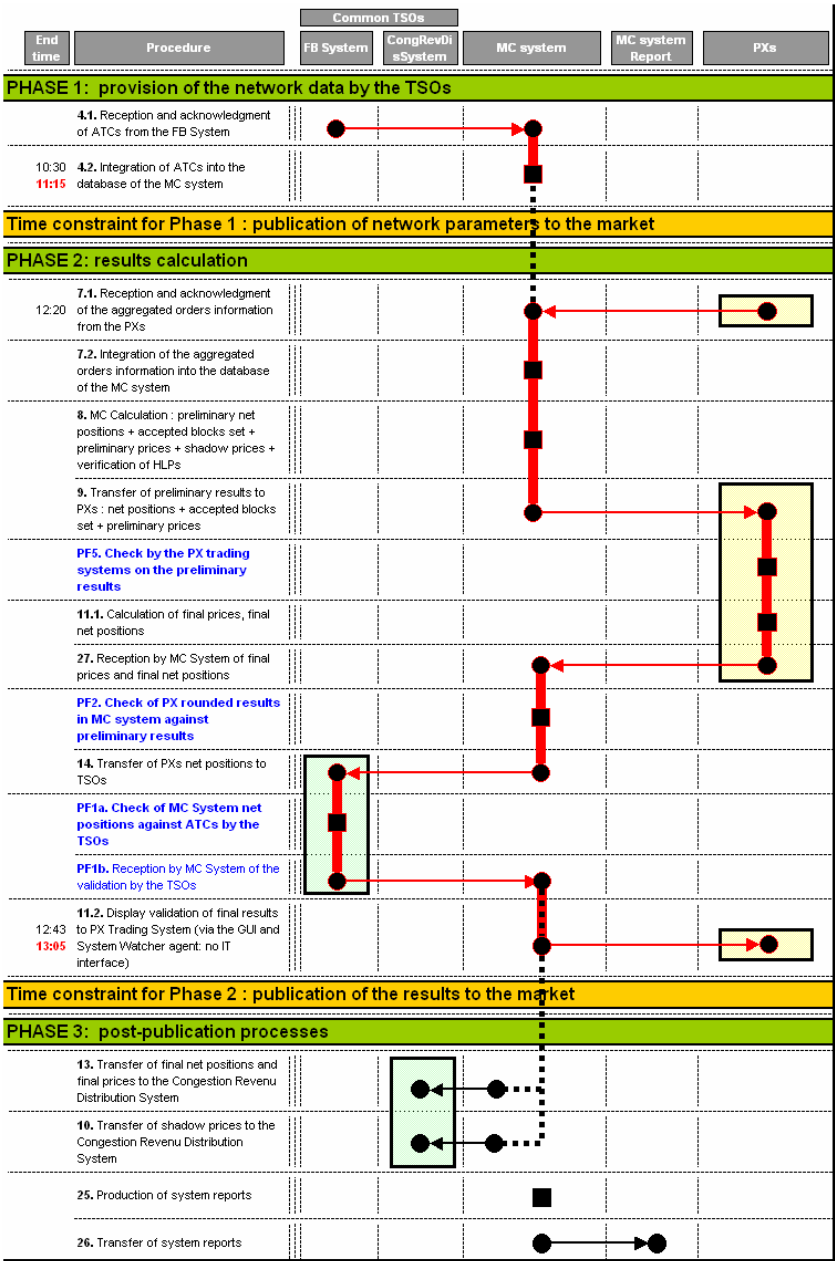
flow of 'Congestion Revenue payment information' (#32), which may have different frequencies.

ID	Step	Produced by	Sent by	Received by	Predecessor
1	Produces Internal grid analysis	TSO Back-End System			
2	Transfers grid forecast		TSO Back-End System	FB System	1
3	Produces flow –based parameters or ATCs	FB System			2
4	Transfers flow-based parameters or ATCs		FB System	MC System	3
5	Transfers orders		Market Participant	PX Trading System	
6	Aggregates order information (to supply and demand curves and anonymised block orders)	PX Trading System			5
7	Transfers aggregated order information		PX Trading System	MC System	6
8	MC Calculation : preliminary net positions + accepted blocks set + preliminary prices + shadow prices (only relevant for FB coupling) (5)	MC System			7, 4
9	Transfers (HLP-checked) preliminary results: net positions (rounded and non-rounded) + accepted blocks set + preliminary prices (rounded and non-rounded)		MC System	PX Trading System	8
10	Transfers shadow prices (only in FB coupling)		MC System	Congestion Revenue Distribution System	8
11	Calculates final prices, individual results, PX net positions	PX Trading System			9
12	Transfers individual results		PX Trading System	Market Participant	11
13	Transfers final net positions and final prices		MC System	Congestion revenue Distribution System	27, PF1b
14	Transfers PX net positions		MC System	Flow Based System	PF2
15	Transfers transparency data		PX Trading System	General Public	11
16	Calculates congestion revenue TSO shares	Congestion Revenue Distribution System			10, 13
17	Transfers congestion revenues TSO shares, prices		Shipping Agent System	TSO Back-End Systems	16
18	Calculates bilateral exchanges	Flow Calculation System			14
19	Transfers cross-border TSO exchanges (schedules)		FB System	TSO Back-End Systems	18
21	Transfers transparency data (after coupling calc.)		TSO Back-End System	General Public	19, 23
22	Transfers transparency data (before coupling calc.)	-	FB System	General Public	3
23	Transfers flow-based parameters or ATCs		FB System	TSO Back-End Systems	3
25	Produces system reports	MC System			PF1b
26	Transfers system reports		MC System	MC System Report Recipient	25
27	Transfers final rounded prices and rounded PX net positions		PX Trading Systems	MC System	11
PF1a	Calculates PX net positions check	FB System			14
PF1b	Transfers PX net positions acceptance		FB System	MC System	PF1a

PF2	Calculates PX results check	MC System			27
32	Transfers congestion revenue payment information		Shipping Agent Systems	Congestion Revenue Distribution System	29, 30
33	Transfers final prices, final net positions		PXTrading Systems	Shipping Agent Systems	27,

2.3 Daily operational procedures

The table below presents the sequence of the necessary steps during the daily operation of market coupling.



2.3.1 Phases during daily operation

As shown in the table above, the Market Coupling process is divided into 3 different phases. Each phase contains procedures performed between the start and the end of the phase. In the sub sections below, each phase is described more in detail.

2.3.1.1 Phase 1: provision of the network data by the TSOs

Phase 1 starts with the reception and acknowledgement by the MC System of the transmission constraints transmitted by the FB System. It ends with the integration of transmission constraints into the database of the algorithm. The procedures during this phase are:

- Normal procedures from #4.1 to #4.2.
- Back-up procedures associated to those normal procedures

The target time of the publication of transmission constraints to market participants is 10:30h. The critical deadline for the publication of transmission constraints to market participants is 11:15h. In case transmission constraints are not sent to the MC System before the critical deadline, the back up procedure will be applied, in which case the coupling will be done by the using a minimal set of ATC values, to be defined by the TSOs during the implementation phase, and to be introduced as parameters in the MC System. The advantage is to run the CWE MC (and avoid decoupling) even in case of problem with the network constraints, without jeopardizing the network security. This leads to using the same procedures and systems, with the same timings.

2.3.1.2 Phase 2: results calculation

Phase 2 starts with the reception and acknowledgment of the aggregated order information from PXs. This phase stops with the transfer of the confirmation of the validation of final results from the MC System to PXs trading systems. The procedures applied during this phase are:

- Normal procedures from #7.1 to #11.2
- Back-up procedures associated to those normal procedures

Target time of publication of the results to market participants is at 12:40h. The critical deadline of the publication of the results to market participants is 13:05h. If it is not possible to calculate the market results and to publish them before 13:05h, the fall back arrangement will be applied. For detailed description of the fall back mechanism we refer to chapter 6.

2.3.1.3 Phase 3: post publication procedures

Phase 3 starts as soon as possible when results are validated by the TSOs. And it ends with the transfer of the system report to the system report recipient. During this phase the procedures from #13 to #26 will be applied.

2.3.2 Protocol Flows (PF)

Some flows of information, presented in the previous section, require a confirmation from the receiving entity. Three Protocol Flows are defined and their description is given below.

2.3.2.1 Check of net positions against transmission constraints by the TSOs (PF1)

This check is done in information flows 14 (transmission of PXs net positions to the flow based system). The TSOs check if the final net positions do not violate the transmission constraints transmitted to the MC System. The protocol flow is divided in two steps:

- A step which consists of checking the final net positions against transmission constraints.
- A step which consists of notifying the acceptance of the final net positions by the FB System to the MC System.

In case the last step from the flow based system is a rejection, we will resort to the fallback for Phase 2, which is decoupling.

2.3.2.2 Check of PX rounded results in MC system against preliminary results (PF2)

This check is done in information flows 27 against information flows 9. The aim is to verify that results produced by the MC system and by the PXs trading system are compatible; in other words (rounded) preliminary and final results (prices and net positions) must be equal. PF2 can be written as follows:

For each market m, for each hour h:

- Rounded Net Position (m, h) from flow 27 = Rounded Net Position (market, hour) from flow 9
- Rounded Price (market, hour) from flow 27 = Rounded Price (market, hour) from flow 9 except for Volume Coupled PX

If the check fails, we go for decoupling (or if this backup solution is accepted and feasible, correct input data and restart the calculation).

2.3.2.3 Check by the PX trading systems on the preliminary results (PF5)

This check is done in information flows 9 (preliminary prices, preliminary net positions, winning block sets, for the PXs that are price coupled; preliminary net positions for the PX that is volume coupled). PXs want to check that these preliminary results are compliant with their own order book, and the aggregated order information they have sent.

Note that flow 27 exactly equals PF5, in that return of the Final Net Positions and Final Prices from the PX Trading Systems to the MC System is an acceptance. The alternative is a rejection; in that case, we go for decoupling (or if this backup solution is accepted and feasible, correct input data and restart the calculation).

2.4 Switch to flow based mode and impact on the operational procedures

The impacts of the future switch to flow-based mode on the operational procedures will be the following :

- Flow based parameters will be sent by the flow based system to the MC System instead of ATCs,

- Two levels of backups for flow-based parameters will be introduced :
    - First level of backup solution: in case the flow based System can not produce flow based parameters, it will send ATCs to the MC System.
    - Second level of backup solution: in case neither flow based parameters, nor ATCs are sent to the MC System before the critical deadline, the coupling will be done using a minimal set of ATC values, to be defined by the TSOs during the implementation phase, and to be introduced as parameters in the MC System.
- For protocol flow 1, the TSOs will check that the net positions respect the flow-based parameters : for each critical branch, as transmitted by the TSOs, the flow resulting from the multiplication of the PTDF matrix by the final net position is less or equal to the maximum admissible flow on this critical branch.

3 Functioning of the algorithm

3.1 Introduction

This chapter describes the model and the algorithm that has been chosen to solve the problem associated with the coupling of the day-ahead power markets in the CWE region.

Market participants submit orders on their respective power exchange. The goal is to decide which orders to accept and refuse and publish prices such that:

- The social welfare[6] generated by the accepted orders is maximal
- Orders and prices are coherent
- The power flows induced by the accepted orders, resulting in the net positions do not exceed the capacity of the relevant network elements

For several months, the Project studied in detail two different solutions (MLC and COSMOS) to deal with the CWE coupling problem in particular, but also considering more general aspects of market coupling such as constraints that would arise if coupling with neighboring markets. The investigations aimed at choosing amongst these three solutions the most suited for the CWE in a context of possible further extensions. The study followed a very strict pre-established procedure based on a list of desired criteria and was supported by a panel of independent experts (the Validators). After these extensive analyses the project partners chose unanimously to use COSMOS as calculation engine for the CWE project (see the earlier sent Progress Report for details about the selection procedure). This decision was supported by the Validators in a separate report. This report can be found in annex 3.

In summary, the COSMOS algorithm:

- naturally treats standard and "new" order types with all their requirements,
- naturally handles both Available Transmission Capacity (ATC) and Flow-Based (FB) network representations as well as possible alternative models and HVDC cable features,
- is not limited by the number of markets, orders or network constraints,
- finds quickly (within seconds) a very good solution in all cases (even with problems with 350000 hourly orders and 1800 block orders in more than 10 markets),
- continues improving this initial solution until the time limit (e.g. 10 min) is reached,
- generating several feasible solution during the course of its execution,
- unless it can show that the mathematically optimal solution has been found (which is most often the case).

In the two following sections, we detail which products and network models can be handled by COSMOS. Section 4 gives a high-level description of how COSMOS works, and section 5 and 6 provide additional information related to the functionalities and behaviors of the algorithm.

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[6] Social welfare is defined as: consumer surplus + producer surplus + congestion revenue across the region.

3.2 Exchange's constraints

Exchange's constraints are those applying to the orders submitted to the exchanges. Ideally, the orders would provide maximal flexibility so as to allow expressing the market actors' strategy at best. However, under uniform pricing – i.e. where the published prices apply to all trades and there are no side-payments possible, some type of products might cause the problems to be extremely difficult to solve at optimality (even finding feasible solutions may be challenging).

The list presented hereunder proposes a set of products which can be treated by COSMOS. However, it has to be understood that the local trading systems of the PXs will not necessarily support all these types of orders at the launch of the CWE coupling, but that the exact definition of such new products will be done locally by the PXs in consultation with their members. This means that the descriptions presented hereunder might evolve before being effectively used.

3.2.1 Order types implemented at CWE PXs

3.2.1.1 Hourly orders

Depending on markets needs and on already existing systems, hourly orders can be either stepwise (Belpex, APX) or linearly interpolated (Powernext, EEX, NPS).

3.2.1.2 Block orders

Block orders are neither partially nor paradoxically accepted, or in other words, all orders can only be either accepted fully, or rejected fully. Because of this constraint – called the "fill or kill constraint" - some block orders can be rejected even if they are in the money[7], in which case they are called Paradoxically Rejected Blocks (PRB). On the contrary, no block orders can be accepted paradoxically (i.e. accepted even if out of the money).

All 300 combinations of hours are possible, which allows representing the blocks available in all PXs of CWE and surroundings.

3.2.2 Order types supported by COSMOS, but not implemented at CWE PXs

3.2.2.1 Profile block orders

A profile block order is a more general order than standard block orders, as it allows submitting different volumes for each hour. Although not yet existing on any exchange, these orders are particularly interesting for production or consumption units with ramp up limits. From an algorithmic point of view, they make few differences compared to standard block orders. Nevertheless, it is not possible to submit profile block orders in the current trading systems of the CWE exchanges.

3.2.2.2 Flexible Hourly Orders

Flexible hourly orders – currently only available at NordPool Spot (NPS) - are defined as hourly fill or kill orders which are accepted "at the hour with highest price during calculation" (which thus supposes that their acceptance is dependent

1.

[7] A sell (respectively purchase) order is said to be in the money if the submission price of the order is below (resp. above) the average market price.

of the chosen algorithm). Similarly, in a surplus optimization approach such as COSMOS, they are defined to be accepted such that the total surplus is maximized.

3.2.2.3 Flexible Energy Orders

It is also possible to define an interesting second type of flexible order which however not yet exists on any trading platform. This order would include an energy limit on the total of energy sold within the day, and optionally an hourly power limit, but without restrictions about the fact that the order must be executed in full and/or at one hour only (i.e. fill-or-kill constraint). These orders might be interesting for generation units with energy limitations (e.g. dams, pumping stations …) or industrials who want to do arbitrages on the energy they bought for their own use. As they contain no fill or kill constraints, these orders are easy to treat from an algorithmic perspective.

3.2.2.4 Volume flexible orders

A volume flexible order is similar to a (profile) block order but instead of a "fill or kill" constraint, it has a "kill or fill at least x%", with x defined by the participant. The interest of such a product is that for instance it allows to model technical minimal limits of production units. COSMOS can easily deal with such orders, which are nonetheless not available for the moment at any exchange.

3.2.2.5 Linked Block Orders

A linked block order is a block order for which its acceptance is subject to the acceptance of another block order, and can be used for instance to model incremental sales in case a production unit is set to be running. Those orders are currently only available at NPS.

Similarly, one can define mutually exclusive block orders, where only a subset of a set of block orders can be accepted at once (e.g. sell during 8 hours at high price or during 12 hours at a lower price).

3.3 Network Constraints

In its current design, COSMOS is able to tackle without any difficulties the network constraints associated with the two commonly accepted network representations – ATC-Based and Flow-Based – as well as with HVDC cables and ramping constraints.

3.3.1 ATC-Based constraints

With an ATC-Based representation of the network, the cross border bilateral exchanges are only limited by the ATCs as provided for each hour and each interconnection in both directions. The algorithm will thus compute the cross border bilateral exchanges that are optimal in terms of social welfare.

ATC based modeling is the methodology currently in place for implicit allocation within the TLC region and for the explicit capacity allocation within CWE.

3.3.2 Flow-Based constraints

Flow-based network representations are set to model more exactly physical electricity laws.
In a flow-based representation of the network, the flows on a set of given critical network elements are equal to the product of a PTDF matrix with the vector of the areas' net positions. These (unidirectional) flows are limited by the

corresponding transmission capacities provided for each hour. Such constraints allow representing explicitly all critical elements and security constraints following the proposition of the R4CA group (possibly after a filtering of redundant constraints), but would also support more simplified network models such as proposed earlier by ETSO (e.g. one branch for each border and direction).

3.3.3 Other network constraints

With both network representations,

- The sum of the area net positions is zero,
- Ramping constraints possibly limit the change from one hour to the next hour:
  - in the flows of some particular network elements (NorNed, BritNed, Nordel),
  - in the sum of the flows of several network elements (Nordel),
  - in area net positions (Nordel).
- Losses may be taken into account on some particular network elements (BritNed) as a fixed proportion of the flows over these network elements
- Charges may be applied for the utilization of some network elements (BritNed). As a result, usage of this network element is subject to a price difference threshold between the two adjacent market areas.

3.4 Functioning of COSMOS

In this section we describe how COSMOS selects which orders are to be accepted or rejected, under the Exchange's and Networks Constraints.

The main difficulty associated with the task of determining which offers to accept and reject comes from the fact that some orders must satisfy the "kill-or-fill" property: these orders are required to be entirely accepted or rejected. These orders are usually called "block orders" or simply "blocks".

Without block orders, the problem is much simpler to solve. Indeed, the problem can then naturally be modeled as a Quadratic Program (QP)[8], which can be routinely solved by off-the-shelve commercial solvers[9]. The use of a commercial solver to directly solve this Quadratic Program would then be the most efficient solution.

The presence of block orders in the order book however makes the problem substantially more difficult. Indeed, if this requirement is ignored, the resulting Quadratic Program can be solved but some blocks will usually be partially accepted. Thus the solution is infeasible.

The main idea behind COSMOS to solve this issue is to use a method called branch-and-bound in the optimization literature. This general method is by far the most widely used nowadays for solving optimization problem involving "fill-or-kill" decisions. The interested reader can find good introduction to the method in classical textbooks[10]. We will only give a sketch of the method in this section.

1.

[8] A Quadratic Program (QP) is an optimization problem where an objective (function) of the second order is to be optimized under linear constraints.
[9] such as CPLEX, XPRESS or MOSEK. The problem would even simplify to a Linear Program in case interpolated orders were forbidden.
[10]See for example *Integer Programming* (Wiley-Interscience) by L.A. Wolsey.

The main idea behind branch-and-bound is to make only partial block selections. For example, COSMOS might, in the course of its execution, fix two blocks as rejected and three other blocks as accepted. COSMOS will then allow all the other blocks to be fractionally accepted and solve the resulting Quadratic Program. Suppose that the optimal solution of this maximization Quadratic Program has an objective value of 3000. Three situations can then occur.

Firstly, we have shown that any block selection extending this partial selection cannot lead to a solution with an objective value of more than 3000. If we have already found a feasible solution of value, say, 3100, then we can conclude that it is not worth looking at any block selection extending this partial block selection. Suppose that the number of blocks that have not been fixed is 100. Then we have actually proved that $2^{100} \approx 10^{10}$ = 10,000,000,000 different block selections can be disregarded! COSMOS will in this way gradually eliminate large chunks of possible block selections until it has covered them all.

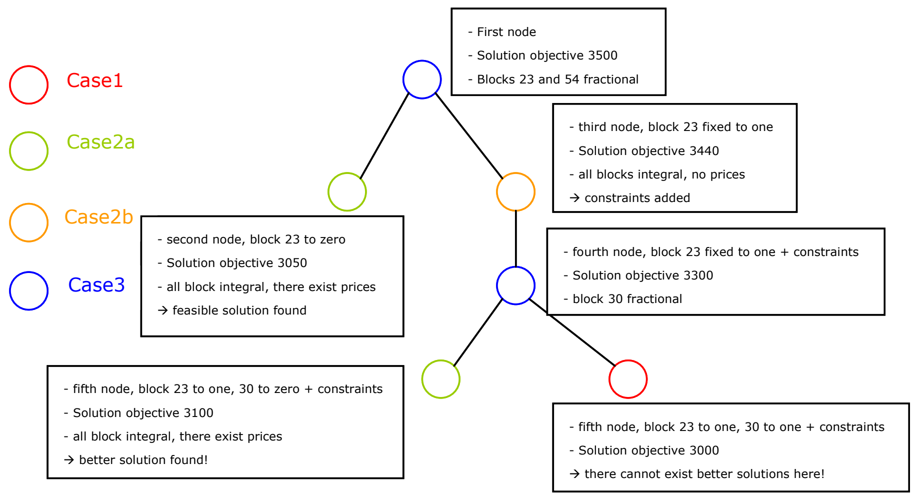
Secondly, it might happen, by chance, that all blocks are actually fully accepted or fully rejected in the optimal solution of the Quadratic Program (even those that were not fixed by the partial selection). In this case, we must still test if there exists acceptable prices associated with this solution. This leads to two sub-cases:

- Sub-case a: If such prices exist we have found a feasible solution. If this solution is better than the best one found so far, it is marked as such. Again, all other block selections extending this partial block selection cannot lead to better solutions than this one and can be disregarded.
- Sub-case b: If no such prices exist, then constraints are added and the Quadratic Program is solved again.

The third possibility is that the solution of the Quadratic Program holds fractionally accepted blocks (which is not allowed by the fill or kill condition), and we are not sure whether extending the partial block selection could lead to better solutions. In this case, we select one of the blocks that are fractionally accepted, and we extend the partial block selection with two new partial block selections: one in which this block is fully accepted, and one in which it is fully rejected. These two new partial block selections will be examined by COSMOS later.

COSMOS starts by examining the "partial block selection" in which no block is constrained to be accepted or rejected: all blocks are allowed to be fractional. During the course of its execution, COSMOS might sometimes increase the number of partial block selections that it has yet to consider (e.g. in the third case) or reduce it (in the first or second case). When there remains none, this means that COSMOS has finished and has found the best possible solution. Possibly, COSMOS will reach the time limit although there remains some partial selections that were not analyzed. In this case, COSMOS will output the best solution found so far without being able to prove whether it is the very best possible one.

Here is a small example of the execution of COSMOS:



3.5 Functional requirements fulfilment

The table below gives an overview of the fulfillment of all requirements, that have been set by the Project Parties (see for full description of the requirements annex 5). In the sub sections below, further explanation is given.

Already implemented	To be developed	Impossible to take into account	REQUIREMENTS to be HANDLED	CLASSIFICATION	
				Mandatory	Additional
			Hourly Order types		
X			Linear or stepwise orders	X	
X			Flexible Hourly Orders		X
X[11]			Flexible Energy Orders		X
			Block Order types		
X			“Standard” Block orders	X	
X			Linked Block Orders		X
X			Volume Flexible Block Orders		X
X			**High Level Properties (see annex 5)**	X	
			Network constraints		
X			Flow-based model(R4CA)	X	
X			Less sophisticate network representation (ETSO)	X	
X			ATC-based models	X	
X			Balancing constraint	X	
X			Ramping constraints		X
X			Losses constraints		X
X			Charge constraints		X

1.

[11] Multi-period order in the COSMOS implementation

Varia					
X			Winter and Summer time	X	
	X[12]		Price boundaries	X	
X			Rounding	X	
Performance					
X			Limited computation time	X	
X			Robustness/Reliability	X	
X			Fairness	X	

3.5.1 Mandatory requirements

Generally speaking, all the mandatory requirements that were requested by the Project - those directly necessary for the well-functioning of the CWE coupling with its current constraints - are met (see below for price boundaries issues).

3.5.2 Additional requirements & extendibility

The additional requirements aiming at supporting potential extensions in the product range or the geographical scope of the coupling (or possibly both of them) are also met.

Several "new" order types have been defined in the requirements, including amongst others all orders types that are currently available at the neighboring power exchanges (especially at NordPool Spot). Their implementation showed very good results. Furthermore, the method is sufficiently general to allow the inclusion of many other order types still to be specified. Indeed, COSMOS treats on the one hand all the linear constraints related to volumes and prices and on the other hand possible fill or kill aspects of some order types. Therefore, defining an additional product which has no fill or kill constraint will have a very limited impact at all, whereas the definition of a new order types with a fill or kill constraint might also imply limited algorithmic developments, but possibly (depending on the product characteristics) increase the complexity of the instances to be solved by COSMOS.

The additional network constraints with respect to HVDC cables (ramping, losses, charges,…) potentially applying for BritNed, NorNed, DK-D links, etc…were also implemented without any technical difficulties as they can be modeled through linear constraints.

The additional algorithmic complexity brought by these additional requirements is thus relatively limited, so that their inclusion in the industrial version will neither hinder the efficiency of the algorithm with respect to mandatory requirements, nor have a significant impact on the development planning, while offering the possibility to expand the features available in the future on the coupled exchanges and interconnections. Indeed, in the prototype of COSMOS, these additional requirements are implemented using the same logic as for the rest of the requirements. Therefore it is expected that the additional effort to implement these requirements in the industrial version of COSMOS to be very limited, essentially focusing on input and output handling (no substantial algorithmic differences).

1.

[12] This functionality should be adapted to take into account different (and negative) price boundaries at the PXs. For more details see section 3.5.3.

3.5.3 Price boundaries and requirements

Since the introduction of negative prices will not occur at the same moment at all exchanges (i.e. EEX plans to introduce negative prices in the German hub in the course of 2008), algorithmic requirements had to integrate the fact to deal with negative prices and with different price boundaries.

In COSMOS, orders and prices are real numbers, and take negative values without any difficulties.

Generally speaking, different price boundaries can also be implemented in COSMOS, but not together with the network price properties as commonly defined (it is for example impossible to obtain negative prices in one market, forbid negative prices in another, and guarantee that prices are equal when there is no congestion). Adaptations of the requirements in order to take these cases into consideration are still under discussion, these discussions actually focusing on the best solution from a market model point view, whereas the technical/algorithmic aspects are not considered as problematic.

In addition, flow-based models in general hinder the possibility to impose boundaries on prices at all, regardless of whether they are positive or negative[13]. Thus rules to enforce price boundaries with flow-based models are still to be determined (it is the model – not the algorithm – which makes it difficult).

3.6 Algorithm behaviour criteria

3.6.1 Optimality and quality of the solution

During the course of its execution, COSMOS will typically generate several feasible solutions. The best one under an agreed criterion can then be selected among these solutions at termination of the algorithm. In this sense, COSMOS is able to treat several objective functions.

In its current implementation, COSMOS optimizes welfare while possibly avoiding paradoxically rejected orders (PRBs) largely in the money. This choice is based on several arguments:

One of the main services offered by an exchange to its client is to find for them mutually beneficial deals (buyers and sellers at compatible prices). Fairness implies uniform pricing, meaning that all these transactions will be settled at an identical price, for each market and each hour. Clearly, in this perspective, the goal of the exchanges algorithm is to find the maximum number of such deals (under network operating limits and uniform pricing). Indeed would a participant whose order has been rejected realize that he could have found a counterparty for his offer, he will most probably withdraw from the exchange the next day.
Under welfare-maximization, the exchange can always explain to its clients the reason this particular solution was made. The argument is that any other valid solution would results in fewer win-win deals, the measure being the volume times the price difference between sellers and buyers (welfare).

Other objective functions suffer from drawbacks. Minimizing the number of PRB - blocks that are rejected although they are in the money- or their magnitude

1.

[13] Cfr. Discussions on "counter intuitive flow-based results".

(DeltaP[14]) is for example quite unreasonable: given a feasible solution, simply rejecting a (rightfully) accepted block might reduce the DeltaP. Indeed, rejecting a purchase block from a valid solution will in general reduce demand and thus prices. Suppose a given feasible solution where most of the PRBs are supply blocks. Rejecting a rightfully accepted purchase block will actually reduce the DeltaP (max DeltaP or average DeltaP). But this new solution is clearly not desirable both from the exchange and from the participants' perspective (it amounts to discard an order from the order book, even though this order does no cause any trouble). Similar examples can be constructed when minimizing the turnover loss from PRBs. As a consequence, departing from welfare maximization is somewhat undesirable.

On the other hand, it is clear that rejecting block orders paradoxically although they are deep in the money is also unwanted. For example, the optimal solution in terms of welfare might be one with a small block being PRB with a large deltaP. This is because accepting this small block would modify prices such that – even if the price variation is small as the block itself is small – a larger block that is closer to the market equilibrium would become paradoxically accepted. Thus small blocks might become PRB because of the presence of larger blocks. This clearly constitutes a fairly good reason for participants to complain, especially smaller participants that are not able to submit large blocks.

For these reasons, the objective (function) of the COSMOS algorithm selects the solutions with the largest welfare, but discards the solutions with paradoxically rejected blocks that are very deep in the money.

3.6.2 Simplicity

COSMOS is based on the branch and bound technique, which is considered as the state-of-the-art method for problem with "fill or kill" constraints. The difference between the COSMOS algorithm and the classical branch and bound approach being rather limited, it can be considered that the method used is rather simple for persons familiar with such optimization techniques.

On the other hand, the branch and bound method in general, and the COSMOS algorithm in particular, uses sound and robust mathematical concepts, which can be explained and justified quite easily even to non-experts in this field. In particular, the number of parameters to be tuned (branching and node selection rules) is relatively small and have only a limited influence on the behavior of the algorithm. This increases the confidence that COSMOS will behave well on extreme or unusual instances. Moreover, these rules can be decided a priori based on 30 years of practical experience with branch-and-bound algorithms.

3.6.3 Time control

COSMOS is tuned to provide very quickly a first feasible solution. It can be shown that the upper bound in terms of computing time to obtain a first feasible solution is linear in terms of number of block orders. In practical cases, the first feasible solution has been found within less than 15 seconds on all the instances of the size of CWE ever tested.

Due to the combinatorial aspects of the problem, this is obviously not true for the computing time to obtain the optimal solutions. Nevertheless, most of the

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[14] DeltaP equals the difference between the average market price and the order's submission price for PRBs. It thus measures the deepness of the paradoxes, since *in the money* orders are expected to be accepted.

instances were solved at optimality, the remaining showing quite small distances to optimality.

3.6.4 Scalability

Computational tests show that the COSMOS algorithm scales very well to instances of large sizes. This can mean more markets and/or more orders per market. Also COSMOS continues to behave excellently on instances with more or larger block orders. This is something that market participants would clearly appreciate.
One of the advantages of branch and bound techniques is that many computations are independent of one other, so that they can be performed simultaneously on several processors, if available. This thus also naturally applies to COSMOS. The consequence on scalability is that investing in more processing power (multi processor grids) will either reduce the computing time, or increase the quality of the solutions, or both. In the prototype version of COSMOS, this parallelization possibility is not implemented, but the industrial implementation will allow parallel computing if required.

3.6.5 Robustness and Reliability

There is no evidence of issues related to robustness and reliability. The algorithm has so far already passed without significant difficulties an enormous amount of tests which were cross-checked by an independent checking module under strict tolerances. There thus seems to be no real algorithmic concerns with respect to reliability. In particular, problems without NECs, problems with negative prices or problems with exotic orders and extremely large blocks are all handled by COSMOS without special treatment.

3.6.6 Transparency

Generally speaking, COSMOS is based on sound and robust concepts and has a good degree of transparency. In particular, COSMOS is perfectly clear and transparent as to what are feasibility and optimality. More precisely, COSMOS will typically consider (sometimes implicitly) all feasible solutions and choose the best one according to the agreed criterion (welfare-maximization). This criterion indeed also relates to the simplicity criteria described above, on which COSMOS performs well (see also the validators report in annex 3).

Also, COSMOS optimizes the total welfare, so that the chosen results are well explainable to the market participants: published solutions are the ones for which the market value is the largest. In addition, in order to avoid undesirable solutions, COSMOS will not output solutions in which blocks that are unduly deep in the money are rejected paradoxically.

COSMOS can also potentially be modified to avoid the "counter intuitive effects" arising with flow-based models. Methods to tackle these issues are currently under analysis by the project partners. The relative degree of transparency of such approaches compared to the "counter intuitiveness of the optimal flow-based results" is nonetheless still an open question.

3.6.7 Data sensitivity of the parameter setting

Most of the parameters of COSMOS are justified on the basis of theoretical aspects and were not tuned based on simulations. However, rough estimations on numerical examples showed that these choices were appropriate. Parameters will thus not be changed in later versions or because of changes in market conditions.

This statement however does not really apply to the stopping criterion, as it will be influenced by market design and hardware issues (see also section on scalability).

3.6.8 Further geographic and product extensions

COSMOS is a general method for solving the market coupling/splitting problems with "fill or kill" constraints. The ability of the algorithm to handle new products or new requirements is thus excellent as long as the type of constraints remains of the same type (linear constraints, with possible fill or kill conditions), but it is difficult to tell how the algorithm can be extended to other constraint types (in particular non-convex ones).
However, it is not expected that new products or requirements imply non-linear constraints. Thus the developments needed to add new features will most probably focus – if we assume linear constraints - more on the definition of the model and on the technical implementation (I/O format) than on pure algorithmic aspects.

Performance issues related to new requirements can not be assessed without specifications, but from the scalability feature described above, it is expected that COSMOS is largely extendible and can definitively be considered as an enduring solution.

In particular, all the requirements that the project partners estimated to be necessary to guarantee the extendibility of the COSMOS solution (linked and flexible orders of NPS, ramping constraint of Nordned , charges and losses of BritNed) were implemented and showed excellent results. COSMOS would thus support extensions in terms of geographical scope and in terms of product range without major difficulties.

4 Limitations due to the grid

4.1 Interim ATC model

Due to the fact that the Market Coupling is proposed to start with an ATC model, followed by the flow based model, the current ATC model needs to be adapted to serve as an intermediate solution.

The ATC model that will be used in the CWE Market Coupling will be an intermediate grid model only. The project Parties are fully committed to implement the flow based model that can maximize capacity for the region, while safeguarding the grid security.

The TSOs are studying the possible coordination improvements to the current ATC methodology. An update of the status will be provided at the PLEF meeting of 15 September and regularly thereafter.

4.2 Grid limitations after switch to flow based

Once the switch to the flow based market coupling is performed, the grid will be represented by the flow based network model. In the Orientation Study, the Project Parties explained in detail how the flow based methodology will function in the Market Coupling. This methodology was discussed with regulators in an expert meeting. In the next sections, we further explain the flow based methodology in respect of the meeting with regulator's experts.

4.2.1 Critical branches

The exact determination of critical branches is decided by each TSO, with respect to the expertise of their internal network, expertise on the criticality of each element in its network and the conditions (load, generation, topology, etc) forecast for day D. However, the CWE TSOs are aiming at a common procedure for the definition of critical branches. The development of such procedure requires close cooperation between TSOs, as being discussed in support group 2 of the Pentalateral Energy Forum.

The list of critical branches that is created by each TSO contains all tie-lines of its control area plus a selection of internal branches. There are a number of reasons why selected internal branches can be part of the critical branch list.

In the first place, cross-border trade impacts the grid as a whole. Therefore not only tie-lines but also the internal branches have to be incorporated in the critical branch list so that the grid security can be safeguarded. In fact, we apply what has been mentioned in article 3.1 of the Congestion Management Guidelines:

> In cases where commercial exchanges between two countries (TSOs) are expected to significantly affect physical flow conditions in any third country (TSO), congestion management methods shall be coordinated between all the TSOs so affected through a common congestion management procedure.

An internal critical branch can only become 'critical' if it is significantly impacted by the net export positions of the four countries.

In the second place, the detailed grid model is one of the key advantages of the

Flow Based approach: the Market Coupling is constrained by a grid model that contains individual branches instead of aggregated limits on bilateral exchanges only. Therefore, if one of the critical branches turns out to be limiting for the Market Coupling, detailed information about the constraint is available, such as its location and even the influence in welfare due to this constrained critical branch. This is very valuable information for the future development of a regional capacity plan and regional grid reinforcements, which would not be available if internal branches are excluded from the market coupling.

4.2.2 Pre congested cases

A pre-congestion is when there is no capacity available on a critical branch. When discussing pre-congestions, it must be understood that a pre-congestion merely indicates that certain parts of the grid are heavily loaded, which is in correspondence with the operational experience and the observations in the recent past. A pre-congestion is not by definition limiting the market coupling, since a pre-congestion still allows trade: sometimes the regional trade will be such that a flow is induced on the pre-congested element that actually relieves the line so that the pre-congestion is solved. Sometimes, the pre-congested element is not impacted by the executed bids and offers. And certainly in no case the market is forced to actively alleviate heavily-loaded elements (by accepting with priority the bids and offers that contribute to such alleviation).

When studying the issue of pre-congestions, TSOs identified that a part of the pre-congestions is due to modeling issues and data quality. Indeed all the approximations and automations necessary to produce ex-post flow-based data for the whole year 2007 have led to partially representative data. Based on the used data we see pre-congestions in 17,5% of all hours. This percentage corresponds to 40% of congested days. During the transition period, in which the Project will closely monitor the flow based market coupling behavior, we will be able to present a more realistic overview of the pre-congestions and their causes. Indeed, during the transition period, the TSOs will produce PTDF matrices in the same way as they would have been produced during real operation, instead of building approximated matrices, as used in the economic assessment (see for more details paragraph 5.2).

4.2.3 Long term transmission rights

Irrespective of the type and the timeframe of allocation, the physical capability in itself remains constant. Consequently, the volume of long term capacity and the remaining capacity volumes of later allocation rounds are interdependent unless the option to nominate transmission rights is fully abandoned (e.g. FTRs). This means that the reduction/increase of either capacity share (e.g. long term versus day ahead) does not automatically mean a loss/win of capacity to be allocated but a redistribution among allocation timeframes only.

5 Economic Assessment

The Project Parties have assessed the flow based market coupling solution in comparison with CWE ATC market coupling and current arrangement, i.e. extended TLC in terms of economic behaviour. This chapter provides all the details related to the assessment. It is described in the next sections which are devoted to:

- The issues investigated
- The network data and order books used in the assessment
- The results of the assessment

5.1 Issues investigated

The purpose of the exercise was to assess the economical consequences of the flow based market coupling, and to assess the impact of "non-intuitive" situations, both from a theoretical point of view as well as an empirical point of view.

5.1.1 Non intuitive situations

"Non-intuitive" situations are for example where the cheapest market is importing, or the most expensive market is exporting. This may be generalised by solutions not respecting the following property:

- For any k, the group of the k cheapest markets is globally not importing.

Market results respecting this property will be named "intuitive solutions". It can be shown that there exists always an ATC model with positive capacities for which an intuitive solution is optimal.
It means that the ATC approach always gives an "intuitive" solution, and when the FB approach gives an "intuitive" solution, it is always possible to find a set of ATCs for which the solution would have been the same with the ATC approach, and that when the FB gives "non intuitive" solution, no ATC model with positive capacity will be compatible, because imposing any ATC model will reduced the total utility. "Non-intuitive" situations are currently observed with flow-based models under welfare maximization.
From a theoretical point of view, a FB model can produce "non-intuitive solutions", with flows from cheap markets to expensive markets (called "adverse flows").

5.1.2 Other issues investigated

The aim of the validation tests was to give an indication on how often "non intuitive solutions" under FB occur and what is their impact, given the 2007 historical data. However, the magnitude of the impact depends strongly on other parameters such as the resilience of the markets.

In this study, the following aspects have been analysed:

- Impact of social welfare, i.e. study of
    - the total welfare change
    - the changes in welfare distribution, between markets;between consumers, producers and TSOs;
- Impact on baseload prices;
- Impact on volatility, i.e. of
    - the impact on baseload price volatility;

    - the impact on within-a-day price volatility;
- Impact on Net Cleared Volume per market and in total;
- Impact on convergence indicators i.e. study of
    - the price convergence
    - the price divergence
    - Comparison with isolated prices and the possible theoretical fact that the clearing price of the coupled markets may be out of the range determined by the isolated prices (this can however not be guaranteed with intuitive results in the presence of block orders either)
- Assessment of the number of hours where the (optimal) market clearing prices are out of boundaries (i.e. do not respect the local exchanges minimum and maximum prices);
- Impact on the number of hours where curtailment occurs;
- Impact on curtailment resulting from the introduction from negative prices on EEX.

The comparison with the historical situation has also been made on the abovementioned market indicators.

5.2 Data used for analysis

The market validation phase has been conducted with the following input data:

- PXs : 331 days historical data of 2007
- TSOs : 331 days reconstructed FB parameters for 2007

  331 days historical ATC for 2007.

For reasons listed in the subsection below, it must be stressed that there are limitations of the data used in the analysis having an impact on the comparative analysis presented hereunder. In particular, whereas it was not possible to estimated a priori the "effects and directions" underlying most of the assumptions taken, it is expected that the consequence of the reason explained in sub section 5.2.1.1 is an overestimation of the benefits of market coupling compared to its effective efficiency.

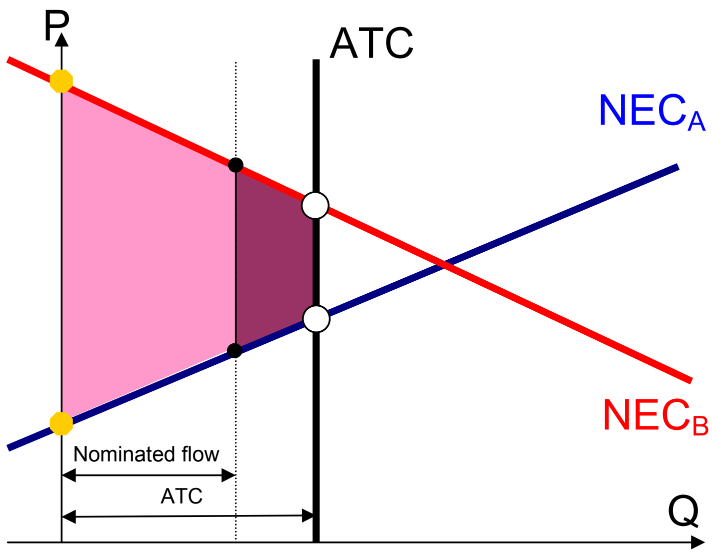
It has also to be noted that those limitations remains applicable when comparing ATC and flow based models: since the simulations starting points has smaller price differences than the actual ones, convergence is reached easier, regardless of the network model used.

5.2.1 Limitations due to PX data

The order books used in the simulations presented below were directly extracted from the Power Exchanges data bases. In general, in the CWE market coupling, since the market situation differs from the historical one, it is questionable whether the order books would have been the same, and so whether historical order books should be used for the simulations. In particular, two major differences between the historical situation and the CWE-MC simulations have to be identified and are explained in the subsections below.

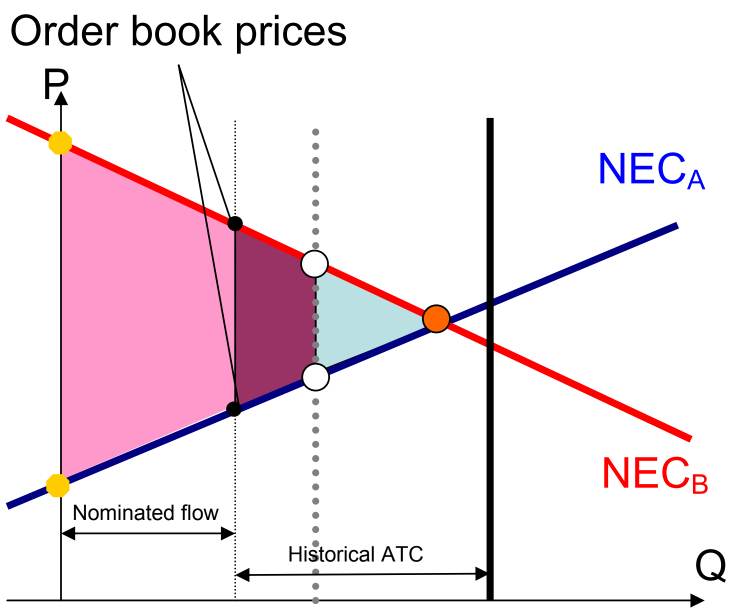
5.2.1.1 Cross-border flows due to explicit auctions

Out of the four electrical borders of the CWE region, only two were implicitly auctioned during 2007. The two others (DE-NL and DE-FR) were allocated via an explicit auction mechanism. In an explicit auction mechanism, some market participants (especially arbitrageurs) anticipate a price difference between two markets, and submit purchase bids on one market and sell bids on the other (depending on the anticipated direction). In the simulations performed, this fact has been omitted. An example of its consequent overestimation of the MC benefits is presented below.



In this figure, the black dots represent the results of an explicit auction, and the rose area the welfare gain due to this cross-border transaction. Clearly, the solution is suboptimal because additional arbitrage trades were possible (i.e. buy from A and sell to B until congestion). On the contrary, the white dots represent the optimal implicit auction solution, whereas the plum area shows the positive difference in welfare between the two solutions.

The simulations performed in this study and presented hereunder used the historical order books – which thus show prices similar to the black dots – and the historical capacities (ATC in this example, although the remark is also valid with the reconstructed FB parameters). Graphically, this can be illustrated by the following figure:



As one can see by comparing the two figures, in this example it had been possible to equalise prices, whereas it would in reality not be possible. This is because capacity was auctioned implicitly in this simulation “on top of” the historical explicit auction in 2007 which were reflected in the order book.

Indeed in an implicit auction, nomination of daily cross-border capacity is performed by the shipping agent, and daily cross-border arbitrage volume will decrease significantly as it is largely substituted by the shipping agent’s role. To conduct realistic simulations, the submitted bids due to cross-border arbitrage should then be removed from the order books. Since it is very difficult to detect “arbitrages behaviours” directly from the different orders of the different participants, it is not an easy task to know how the order books should be altered.

The Parties are still analysing this effect, and the first results are at the end of this chapter.

5.2.1.2 ATC versus flow based systems

Participants submitted orders based on their knowledge of the available capacities which are adverted in ATCs. To what extent the order books would have been different if flow based parameters would have been published and used is unknown, and could not be predicted (not even the directions could be guessed). Consequently, in the conducted simulations, this effect has been ignored.

5.2.2 Limitations due to TSO data

Since the flow based approach is a completely new development at the TSOs, it was obvious that neither the flow based parameters nor the D-2CF basecases were available. Instead, the TSOs made the effort to create a 2007 dataset that approximates the necessary data as good as possible given the tight time schedule. The purpose of this section is to put the data that has been delivered by the TSOs for the market validation tests into perspective. The origin and treatment of the data deviates from the procedures that will be applied by the TSOs when the market coupling is in operation. This section underlines those differences.

Met opmaak: opsommingstekens en nummering

It must be noted that the methodology used to create the PTDF matrices may have had an impact on the number of pre-congestions. The data show pre-congestion in 17.5% of all hours corresponding to pre-congestion in 42.6% of all days. The implication of this is that the results of the economic validation have to be placed in that perspective. After the start of the market coupling, the flow based market coupling will run in parallel, using PTDF matrices that will be produced on a daily basis. This will allow the project Parties to re-assess the number of pre-congestions and the economic impact of flow based market coupling.

Equally, the improved methodology to be used to calculate ATCs may be different from the historical approach. This could impact the results shown in this chapter and if there is a material difference, the economical assessment will be revised.

5.2.2.1 DACF instead of D-2CF

The D-2CF procedure is a completely new development at the TSOs, so besides the relatively small set of D-2CF files that have been used for the R4CA testing purposes, no D-2CF files are available for 2007. As the D-2CF procedure finds its origin in the well-established DACF (Day-Ahead Congestion Forecast) procedure, DACF files have been used as a basis for the 2007 dataset that is provided by the

TSOs. The TSOs create four DACF files in day-ahead to study the grid security for the day after.

5.2.2.2 The use of 4 daily timestamps instead of 24

Only four DACF files per day are available as input for the grid model that serves as a basis for the computation of the flow-based parameters. As 24 timestamps are required for the market validation tests, and the FB parameters can only be computed for the 4 DACF timestamps, the FB parameters are extrapolated to time stamps where DACF data sets are not available. However, the extrapolation could consider only a subset of information to be altered instead of the full replacement of nearly all data which would be required to obtain a more realistic flow situation. Note that 24 D-2CF basecases per day will be used in the daily operation of the FBMC.

5.2.2.3 Highly-automated process instead of feedback with expertise

The time that was available for the TSOs to deliver the huge amount of data only allowed a highly-automated process without any manual interactions or feedback loops. In the standard process (see High Level Business Plan of FBI WG) such feedback will be implemented before sending the Flow Based parameters to the market.

5.2.2.4 10 % FRM (Flow Reliability Margin) instead of individualized FRM

Every critical branch has a reliability margin (FRM) that covers the uncertainty that is a.o. related to the creation of a grid model two days ahead (the well-known 'chicken-egg' problem). The FRM that have been used to create the 2007 dataset is a fixed number for every critical branch: 10% of the Fmax, the maximum allowed flow on a branch. This figure is still based on the December 2007 findings of the WG R4CA. The FRM is planned to be refined in the near future, leading to an evolving, individual reliability margin for every critical branch. The R4CA will take up this refinement exercise when their new software prototype is available.

5.2.2.5 Default Generation Shift Key instead of individualized ones

GSK represent the repartition on the grid of generation increases/decreases. GSK thus have a significant impact on the flow-based parameters, and as such on the pre-congestions as well. In order to create the 2007 dataset, only default generation shift keys have been used. The definition, use, and testing of customized GSKs will be taken up by the R4CA when their new software prototype is available. The improved GSK are foreseen to be used by a number of TSOs in order to enhance the quality of data for the daily process

It has to be noted that the abovementioned limitations due to TSO data are not exclusively due to incomplete data availability for the 2007 dataset. Indeed, the concepts of FRM and especially GSK implicitly assume that the physical nodes of bids on the PXs are known ex ante during the process of setting up the flow model. This assumption, as an inherent future of flow based market coupling, may be problematic. For example: a 1000 MW purchase on Belpex caused by the unforeseen outage of a nuclear unit in the North or the South of Belgium, will have a significantly different flow as result. Nevertheless, the FRM and GSK for Belgium should capture the uncertainty related to these effects ex ante. These effects reinforce the objective need for a transition period during which ATC and flow based are validated in parallel.

5.3 Results

This section presents the results obtained from the economic assessment. Because of its length, the main results are capped below.

Regarding the comparison between the results obtained under the flow-based and the ATC modes, the following observations have been made from the simulations that have been conducted under FB model and compared to ATC model:

- the total social welfare decreases;
- the congestion revenue decreases;
- the price volatility does not differ significantly;
- the total market clearing volume increases;
- the market prices converge somewhat less.
- On a few particular days, large differences were observed on most of the indicators between FB and ATC. Removing these stressed days from the analysis increases the convergence of the abovementioned results between the FB and the ATC mode.
- On these stressed days, the ATC model provides on average more capacity than the FB model and often the ATC flows exceed the FB security domain (other days were not studied); differences between corresponding results are therefore difficult to analyse The existence of particular network situations on these days is still to be explored.

Regarding the phenomenon of adverse flows that occur under FB model, the following has been observed:

- the adverse flows do happen under FB (whereas they do not under ATC);
- the adverse flows happen on all markets;
- the adverse flows benefit mostly to Belgium (high isolated price, low resilience), particularly in case of pre-congestions.
- a method where adverse flows are not allowed does not produce satisfactory results with the current FB data because of the combination of low liquidity on some markets on some hours and of the number of pre-congestions prior to the coupling.

The results of the market validation phase show that the occurrence of the side effects of the FB model is however rather limited. Concerning the other indicators that have been monitored, the results show the following:

- no price out of the defined price boundaries have been observed under FB nor under ATC;
- the number of simultaneous curtailments is reduced under FB;
- under ATC market coupling, the introduction of a negative price limit on EEX at -3000€ does not increase the number of hours with curtailed volume on the other markets;
- under FB market coupling, the introduction of a negative price limit on EEX at -3000€ leads to a propagation of the curtailment to the other markets (in particular the Netherlands and Belgium).

Finally the simulated results in the CWE-MC under ATC compared to the historical results in the TLC+ EEX framework showed:

- an increase of the market clearing volume;
- a lower price volatility;
- a better price convergence;
- fewer hours with curtailed volume.

However, these results are to be taken with caution since the order books / capacity may have been overestimated in the CWE-MC framework.

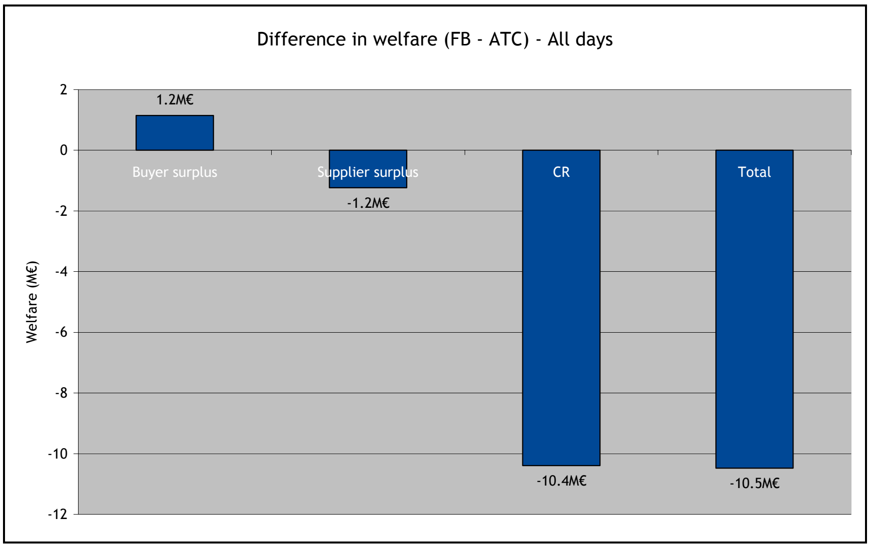
Compared to the historical situation (the CWE region with an explicit auction mechanism between TLC and EEX), the simulation of coupling the CWE region with an implicit auction mechanism showed an increase of the social welfare by 41.8 million Euros per year.

5.3.1 Main market indicators: comparison flow based versus ATC models

5.3.1.1 Social welfare

5.3.1.1.1 Total welfare change

The graph hereunder shows the difference in buyer surplus, supplier surplus, congestion revenue and total social welfare between FB mode and ATC mode.



RESULTS
The total social welfare is lower in FB than in ATC by 10.5 M€. The lower social welfare under FB is mainly due to the lower congestion revenue (-10.4M€). The value of the total social welfare is largely dependent on the arbitrary value of the maximum order price limit of 3000€, implying that no proper reference is available for the total social welfare[15].

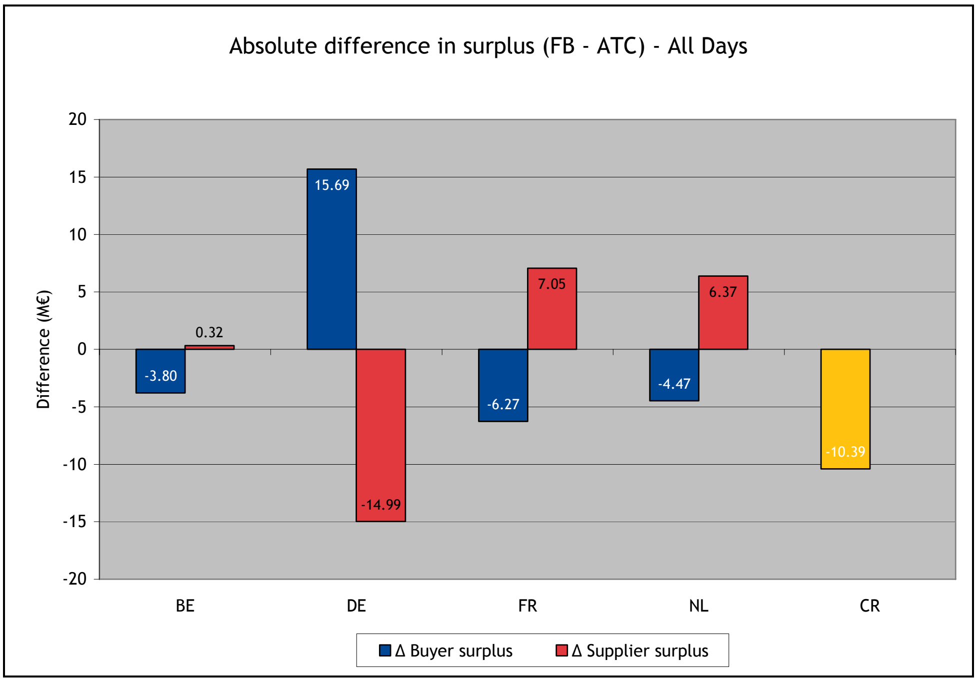
1.

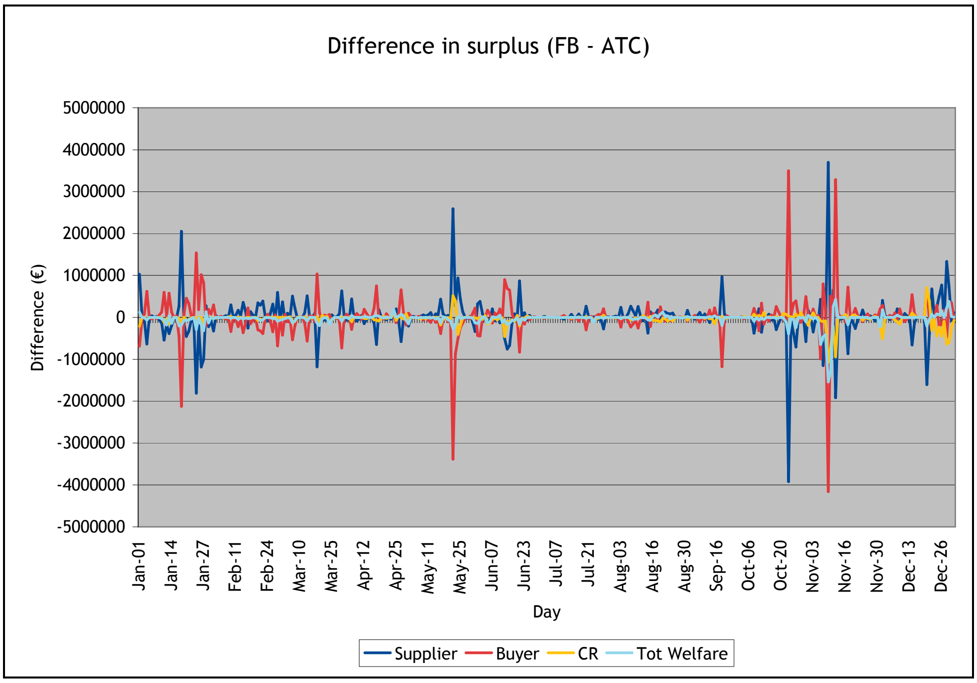
[15] The total welfare with the current Pmax of 3000€ would be ca. 350’000 M€

The difference in welfare observed between the reconstructed FB data and the historical ATC data is mainly due to the fact that in average less capacity is made available under FB than under ATCs.

5.3.1.1.2 Change in welfare distribution (between markets, consumers, producers and TSOs)

The histogram hereunder shows per market the difference between the buyer surplus and the supplier surplus between FB mode and ATC mode; the difference in congestion revenue between the two modes is also represented. The second graph shows the difference over the year in buyer surplus, seller surplus and congestion revenue between FB and ATC modes.





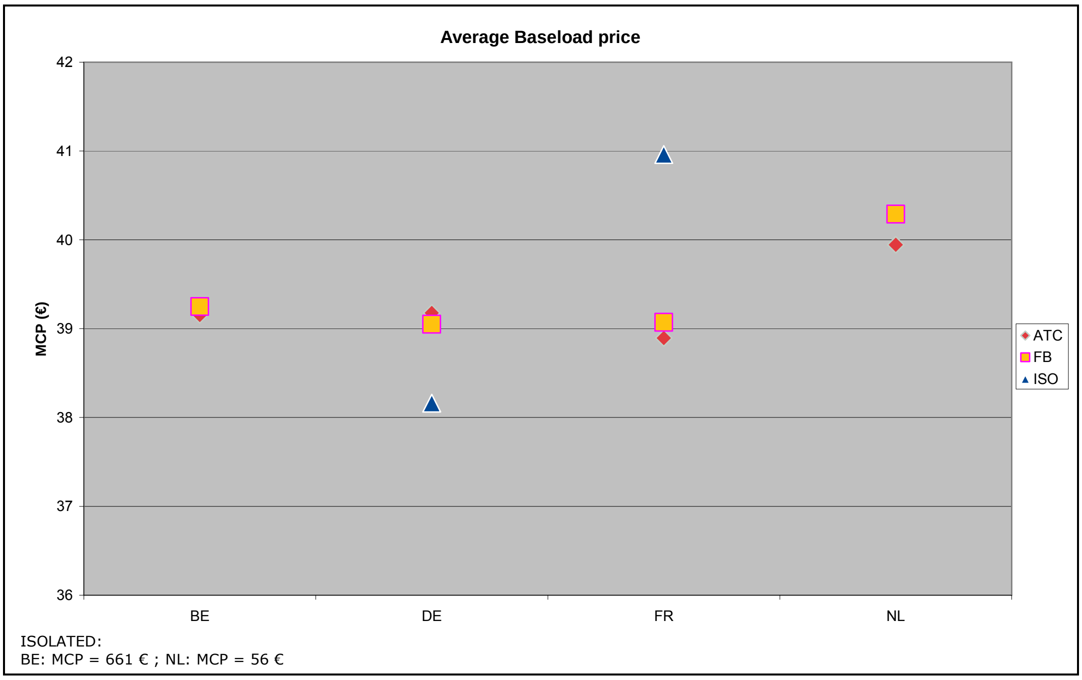
RESULTS
The buyer surplus is higher in FB than in ATC (+1.15M€), whereas the supplier surplus is lower in FB than in ATC (-1.24M€). The buyer surplus is higher in Germany under FB (+15.7M€), whereas the supplier surplus is higher in Belgium (+0.32M€), France (+7.05M€), the Netherlands (+6.37M€) under FB. The congestion revenue decreased by 10.4 M€ under FB compared to ATC. These results are linked to the fact that the average prices are slightly higher under FB than under ATC in Belgium, France and the Netherlands, whereas the average price slightly decreases under FB in Germany.

On a few particular days, the difference in buyer surplus, supplier surplus and congestion revenue between the two network modes are particularly large (for example, on one specific day of November (18/11), there is a difference of more than 3.5 M€ in the buyer surplus under FB compared to ATC).

5.3.1.2 Base load prices

5.3.1.2.1 Average base load prices

The chart hereunder shows the average base load price of each market under FB and ATC modes, and in isolated mode.

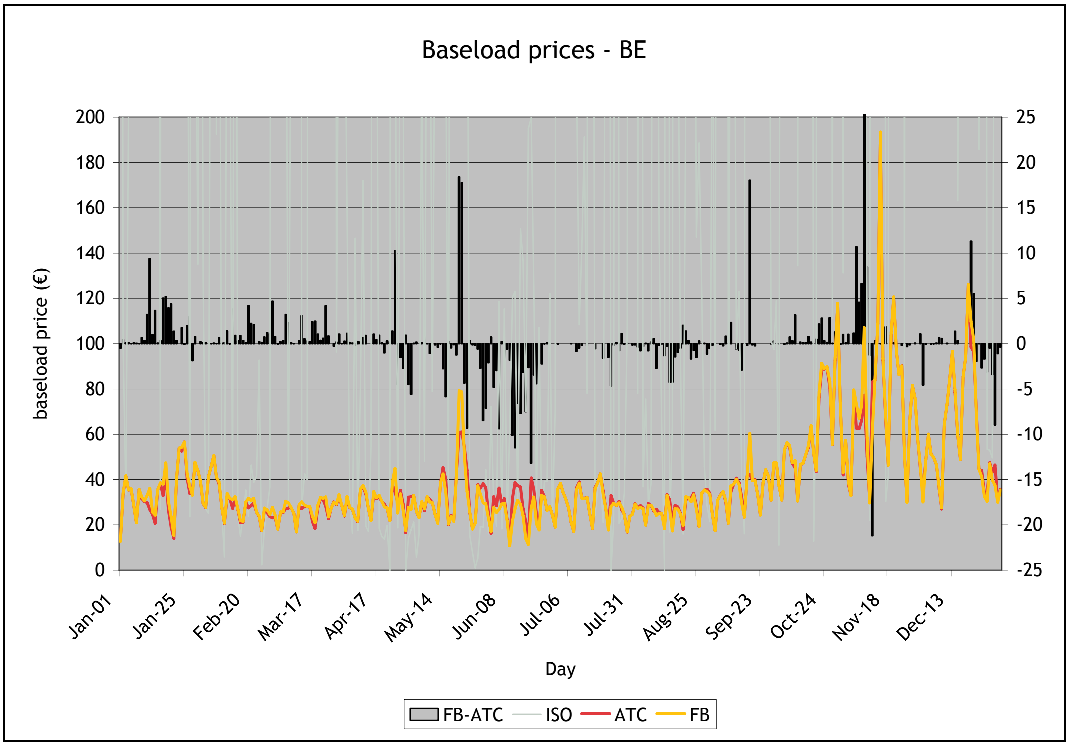


RESULTS
There is a good convergence of prices on average under FB and under ATC. Comparing FB and ATC modes, Market Clearing Prices rise slightly under FB in Belgium, France and the Netherlands, whereas the Market Clearing Price decreases in Germany but the difference is not significant enough to draw a definitive conclusion.

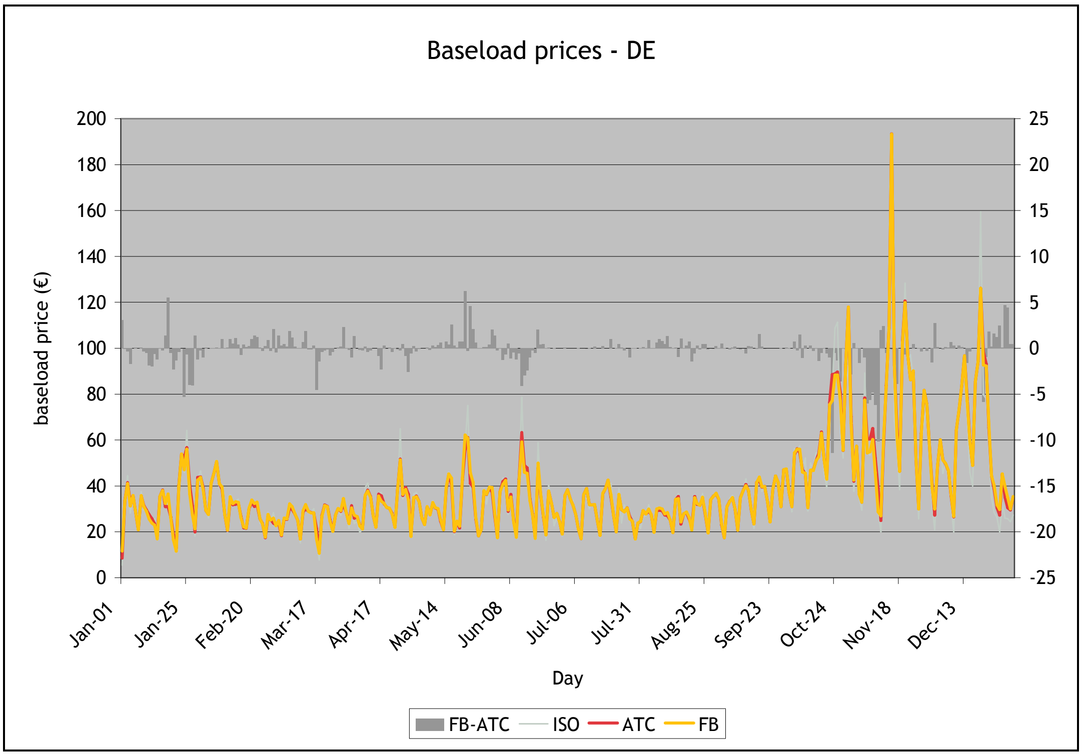
One possible explanation is that too much capacity in ATC, not respecting the FB security domain was given. More precisions will be given once more information is available. Further investigation on these particular days is needed. As presented in a following section, on some specific days, the differences observed between the two network modes can be large.

5.3.1.2.2 Base load prices per market

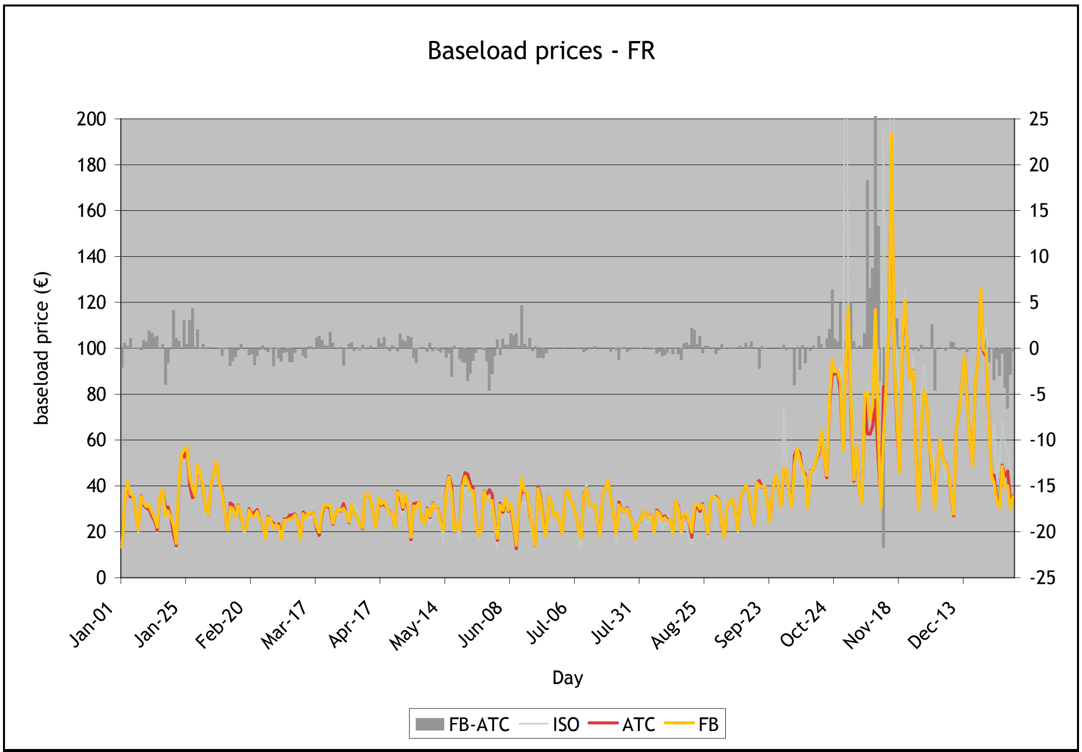
The charts hereunder show the evolution of the baseload price over the year under FB, ATC mode, and in isolated mode per market.

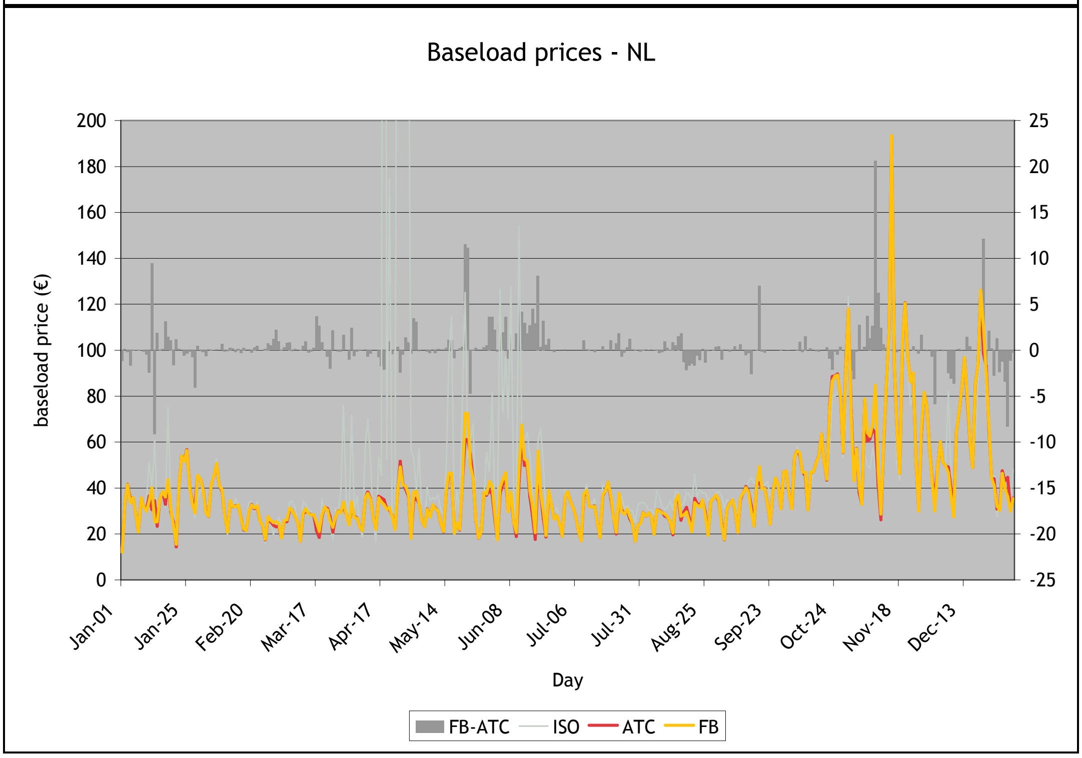


Baseload prices - BE
baseload price (€)
200
180
160
140
120
100
80
60
40
20
0
25
20
15
10
5
0
-5
-10
-15
-20
-25
Jan-01
Jan-25
Feb-20
Mar-17
Apr-17
May-14
Jun-08
Jul-06
Jul-31
Aug-25
Sep-23
Oct-24
Nov-18
Dec-13
Day
FB-ATC
ISO
ATC
FB



Baseload prices - DE
baseload price (€)
200
180
160
140
120
100
80
60
40
20
0
25
20
15
10
5
0
-5
-10
-15
-20
-25
Jan-01
Jan-25
Feb-20
Mar-17
Apr-17
May-14
Jun-08
Jul-06
Jul-31
Aug-25
Sep-23
Oct-24
Nov-18
Dec-13
Day
FB-ATC
ISO
ATC
FB



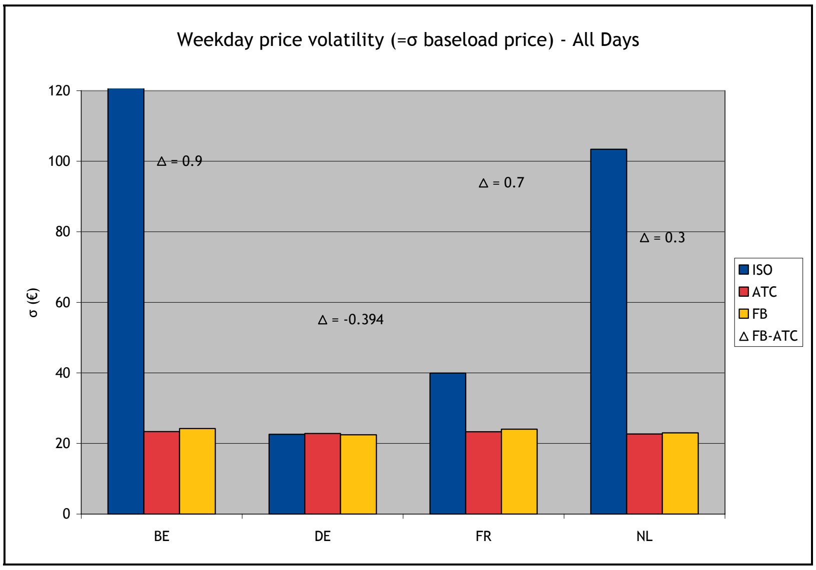


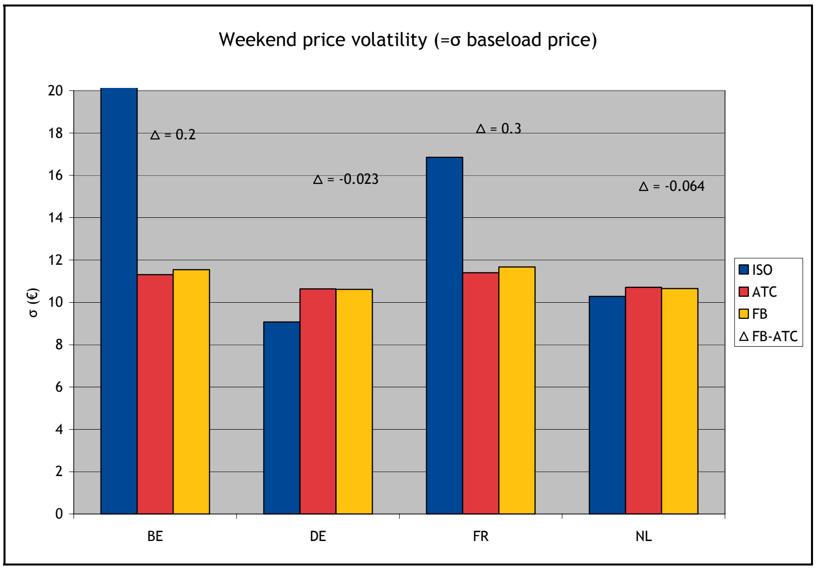
RESULTS
In general, there exists a good overlap between the base load price curves under ATC and under FB. However, large differences are observed on specific days.

5.3.1.3 Volatility

5.3.1.3.1 Impact on daily price volatility

The following two graphs show the daily volatility for the weekday prices and for the weekend prices. The price volatility has been plotted in the current CWE-MC framework with three different network modes (ATC and FB and isolated),





RESULTS

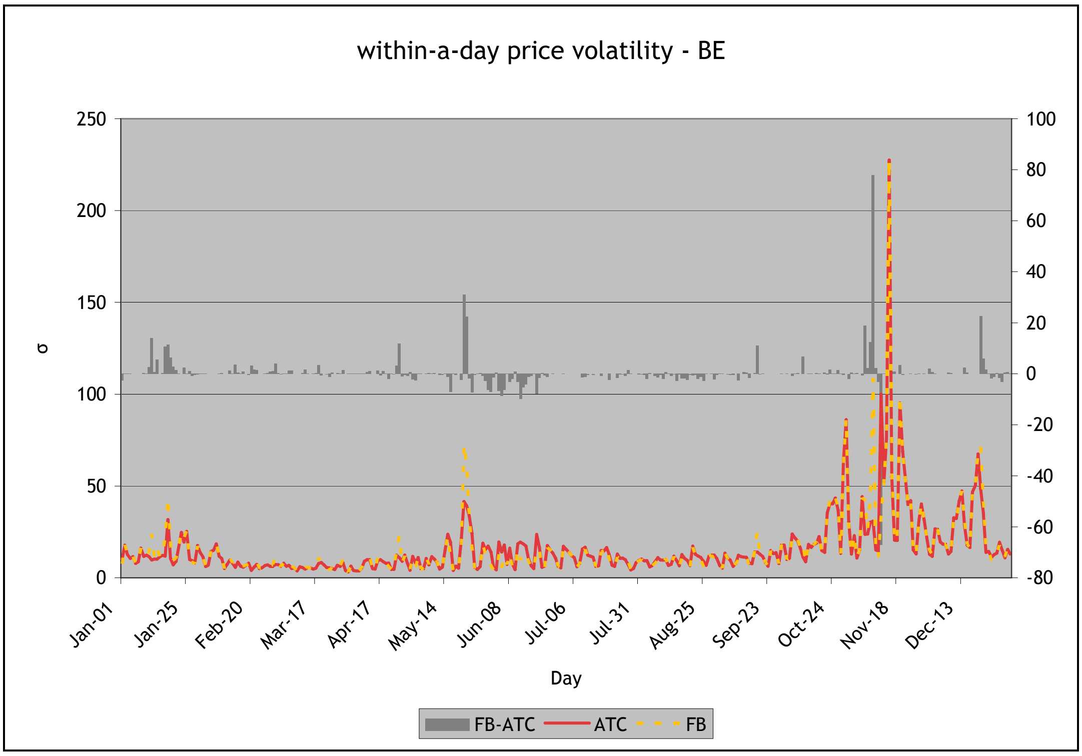
Comparing ATC and FB mode in the CWE-MC, it appears that the weekday volatility increases in FB compared to ATC by 0.9€ on the Belgium market, 0.7€ on the French market, 0.3€ on the Dutch market, decreases by 0.4€ on the German market. Regarding weekend volatility, the largest increase compared to ATC is observed in France with 0.3€.

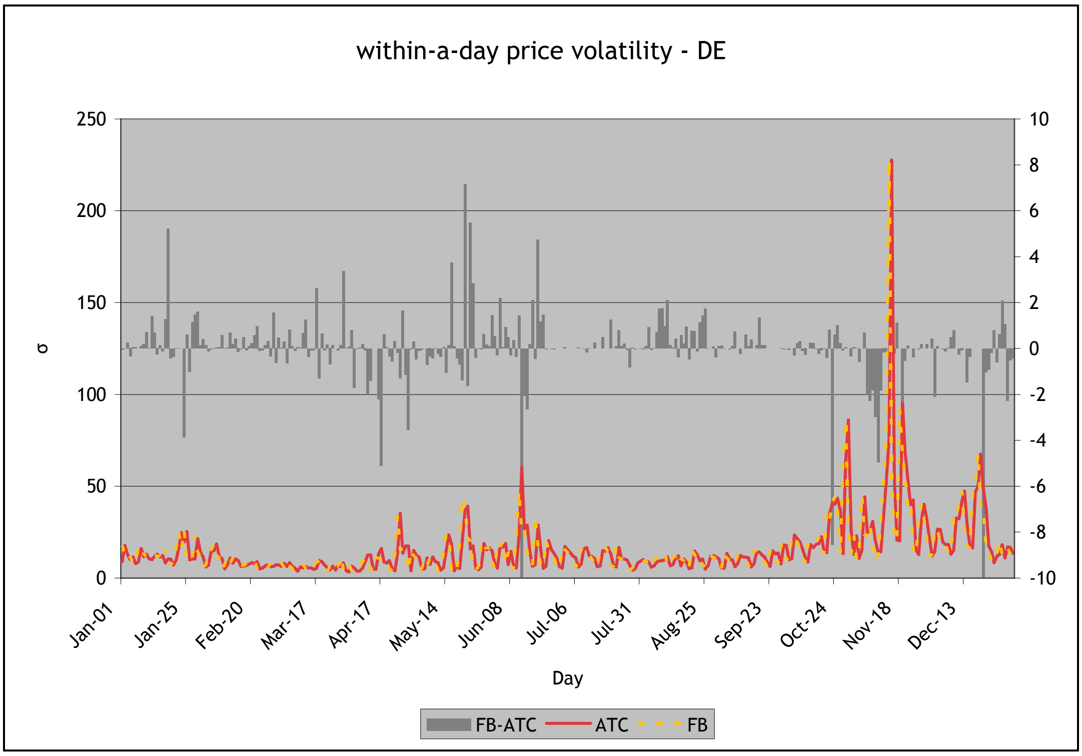
By analysing the standard deviation of the prices over the year, it can be observed that, although the daily price volatility with FB model is slightly higher than under ATC, the difference is not significant enough to allow drawing definitive conclusions.

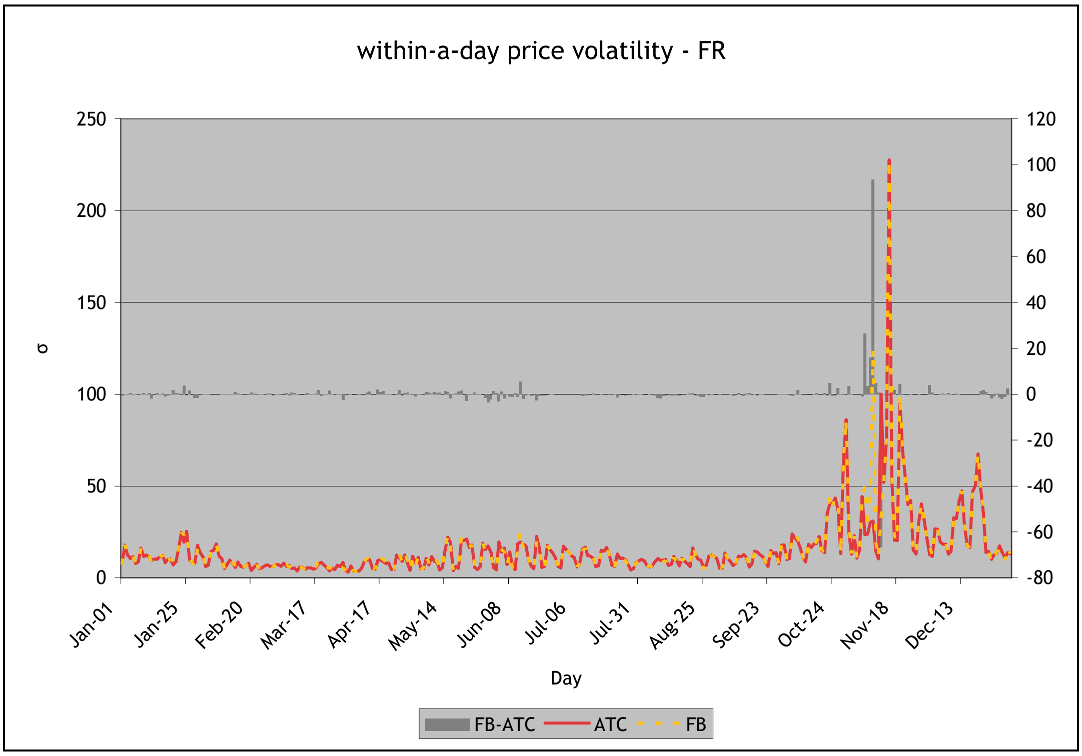
In average there is no significant difference on the daily price volatility under FB and under ATC. To refine the current analysis, the study of the peak price volatility will be envisaged by the Project. Finally, acceptable price volatility does not ensure price predictability. Price predictability needs to be further investigated.

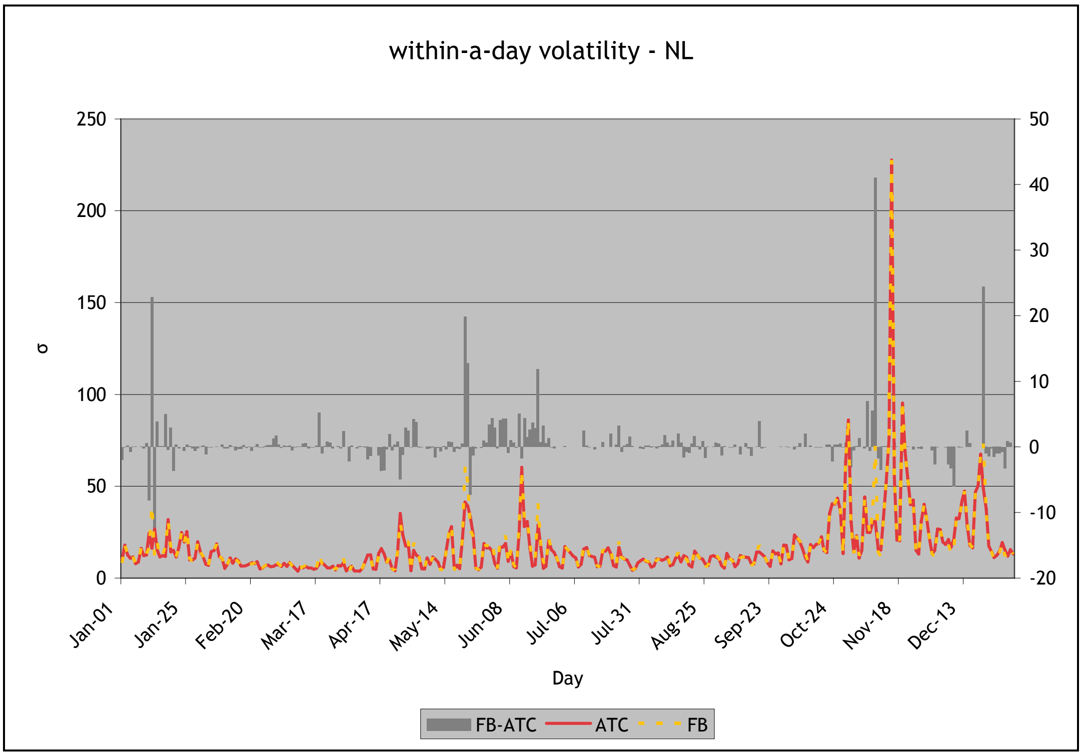
5.3.1.3.2 Impact on within-a-day price volatility

The four graphs hereunder show for each market the within-a-day volatility over the year in FB and in ATC mode, as well as the difference between both (in grey).




within-a-day price volatility - DE
250
200
150
100
50
0
σ
10
8
6
4
2
0
-2
-4
-6
-8
-10
Jan-01
Jan-25
Feb-20
Mar-17
Apr-17
May-14
Jun-08
Jul-06
Jul-31
Aug-25
Sep-23
Oct-24
Nov-18
Dec-13
Day
FB-ATC
ATC
FB


within-a-day price volatility - FR
250
200
150
100
50
0
σ
120
100
80
60
40
20
0
-20
-40
-60
-80
Jan-01
Jan-25
Feb-20
Mar-17
Apr-17
May-14
Jun-08
Jul-06
Jul-31
Aug-25
Sep-23
Oct-24
Nov-18
Dec-13
Day
FB-ATC
ATC
FB



RESULTS

On a few instances the within-a-day volatility is particularly more important in FB than in ATC on the Belgian market (5 instances have a standard deviation larger by 15€ or more; with a maximum standard deviation of 78€), on the German market (3 instances with a standard deviation larger by 5 € or more; with a maximum standard deviation of 7€), on the French market (4 instances with a standard deviation larger by 5€ or more; with a maximum standard deviation of 93€), and on the Dutch market (10 instances with a standard deviation larger by 5€ or more ; with a maximum standard deviation of 41€).

On a few other instances the within-a-day volatility is particularly higher in ATC than in FB on the Belgium market (11 instances have a standard deviation larger by 5€ or more; with a maximum standard deviation of 67€), on the German market (4 instances with a standard deviation larger by 5 € or more; with a maximum standard deviation of 10€), on the French market (1 instance with a standard deviation larger by 5€ or more, with a standard deviation of 67€), and on the Dutch market (4 instances with a standard deviation larger by 5€ or more ; with a maximum standard deviation of 14€).On these particular days, the absolute difference of within-a-day volatility between ATC and FB model can thus be very large (ex. 09/11).

But, on these particular days, in average, the within-a-day volatility is more often higher under FB than under ATC for the Belgian, French and Dutch market, and more often lower under FB than under ATC for the German market. An explanation could be that on these days:

- The ATC and FB domains are rather different and the optimum reached in ATC is not included in the FB domain, and/or the other way around, the optimum reached in FB is not included in the ATC domain

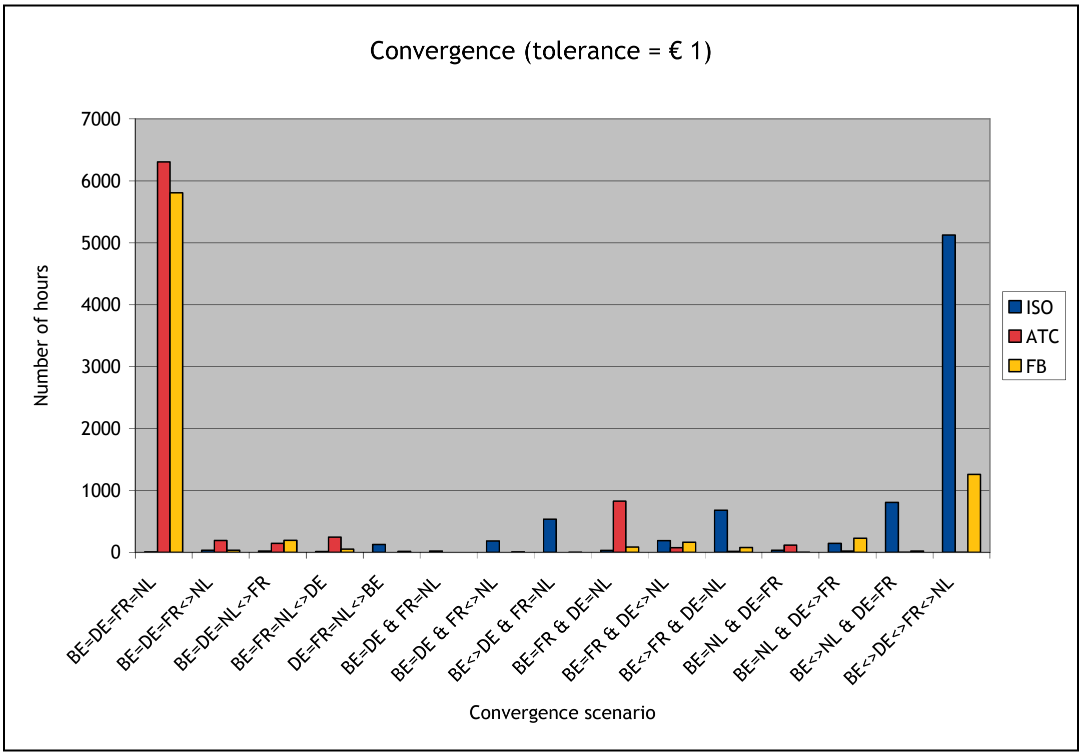
- Some order books are sometimes particularly low resilient
- The combination of both phenomena mentioned above.

On many other instances, the absolute difference between the within-a-day volatility in FB and in ATC is not very large, and the within-a-day volatilities in FB and in ATC can be considered comparable.

5.3.1.4 Convergence indicators

5.3.1.4.1 Price convergence

Prices had been considered convergent (equal) if they differed by less than 1€. The histogram hereunder shows the convergence of prices between the four markets. For each price situation (4 Market Clearing Prices equal, Market Clearing Price in France = Market Clearing Price in Belgian, Market Clearing Price in Germany= Market Clearing Price in the Netherlands= Market Clearing Price in France, all Market Clearing Price different), the number of hours where the situation happens is given.



RESULTS

The results show that under ATC the two situations the most likely to happen are:

- either all prices are equal
- or France and Belgium have the same Market Clearing Price and at the same time Germany and the Netherlands have the same price.

Under FB, the two situations happening the more often are:

- either all prices are equal
- or all prices are different.

In terms of price convergence, the results showed the following:

- There is full convergence (4 Market Clearing Prices equal) in ATC in 79.4% of the hours.
- There is full convergence (4 Market Clearing Prices equal) in FB in 73.1% of the hours.
- There is partial convergence (at least 2 Market Clearing Prices equal) in ATC in 99,9% of the hours.
- There is partial convergence (at least 2 Market Clearing Prices equal) in FB in 84,2% of the hours.

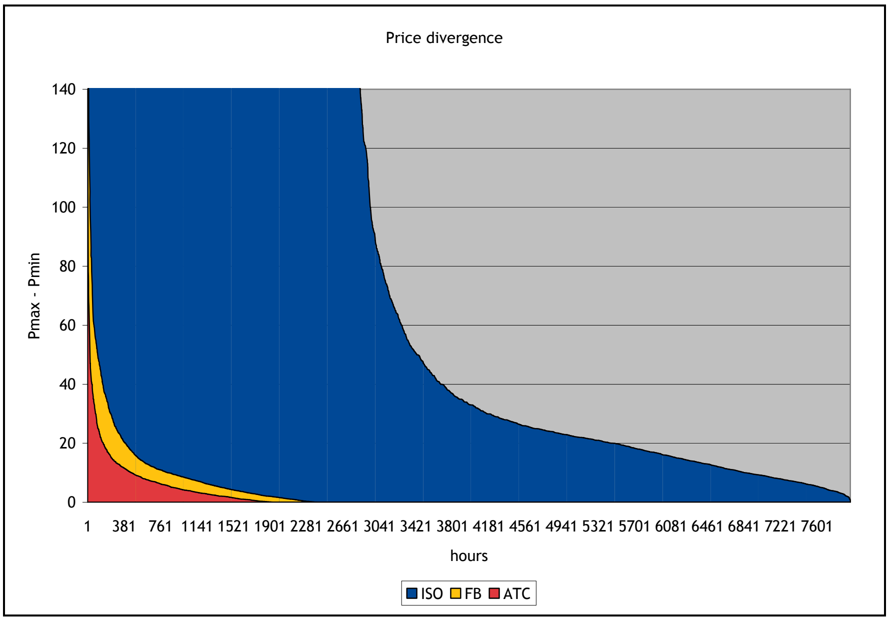
There are fewer hours where the four Market Clearing Prices are equal on the four markets in FB than in ATC. Globally the price convergence is less good under FB than under ATC.

No congestion implies necessarily four identical prices (whether in FB or in ATC). But as soon as there is a congestion in FB, the four prices are different (they can be equal if considering a certain tolerance), whereas one single congestion would only create two different prices in ATC. This is due to the fact that in FB each price area contributes in a different way to the flow on a congested element and, accordingly, results in diverse prices in the region.

Another reason is that less capacity was made available in general under FB than under ATC (otherwise the cases with full convergence in ATC would also lead to full convergence in FB).

5.3.1.4.2 Price divergence

The graph hereunder shows the difference between the highest price and the lowest price in FB and ATC modes, as well as in isolated mode.



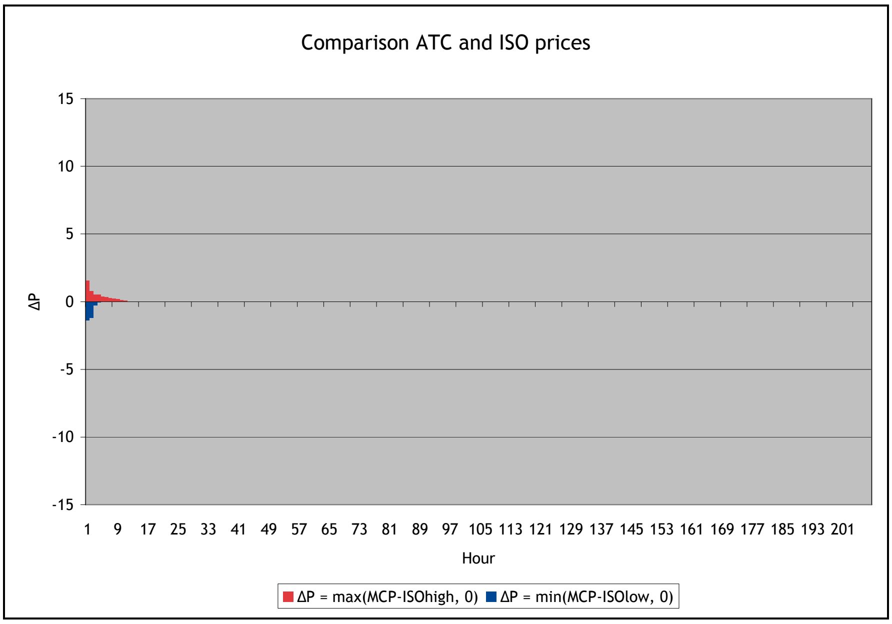
RESULTS

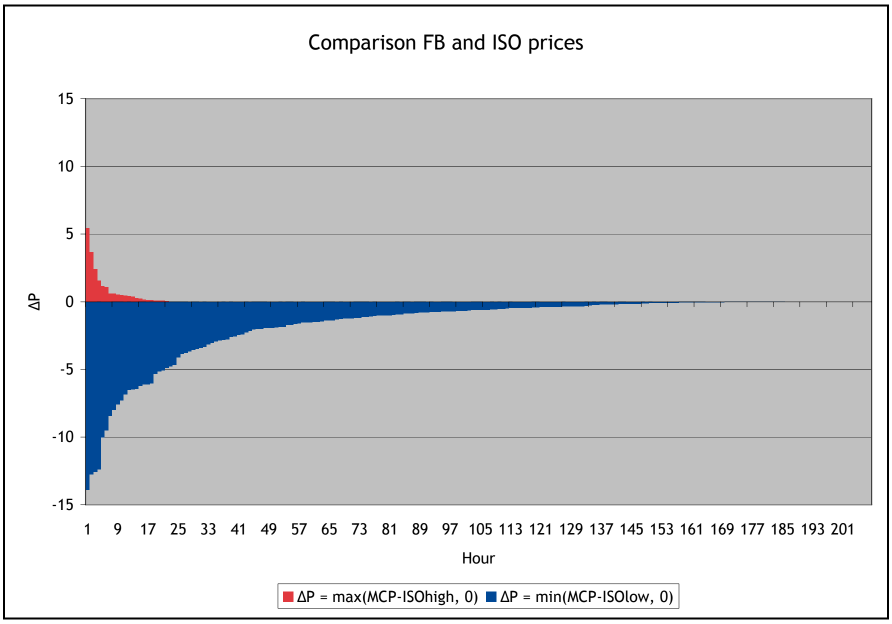
In case the full convergence is not achieved (corresponding to 26.9% of the cases under FB, 20.6% under ATC), the difference between the highest and the lowest Market Clearing Price is higher under FB than under ATC. Globally the market prices tend to diverge more under FB than under ATC. This difference in price divergence ranges from a few eurocents to a few dozen of Euros. This opens the question whether the aim is to have converging prices as much as possible, or to have right price signals.

5.3.1.4.3 Market Clearing Price out of the bounds defined by isolated prices

The two graphs hereunder present both in FB and in ATC modes,

- the number of hours where the Market Clearing Price is higher (red) than the highest price of all markets in isolated mode,
- and the number of hours where the Market Clearing Price is lower (blue) than the lowest price of all markets in isolated mode.





RESULTS
In FB, in 2.3% of the number of hours, the Market Clearing Price is below the lowest isolated price by at least € 0.01. In ATC, it happens in 0.05% of the cases.

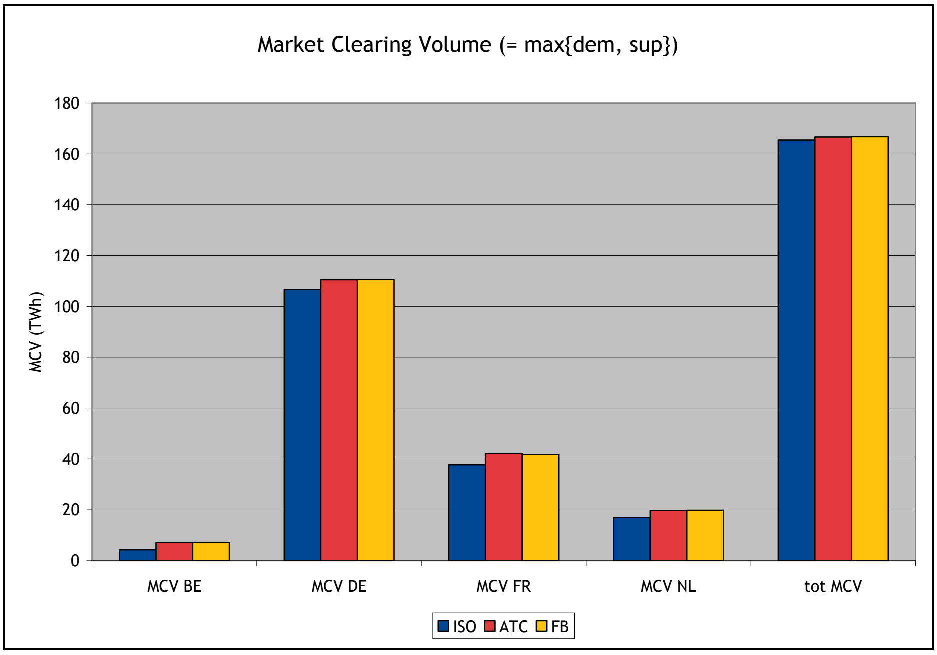
In FB, the largest difference to the lower bound defined by the isolated prices reaches -13.9€. In ATC, this difference reaches -1.4€
In FB, in 0.29% of the number of hours, the Market Clearing Price is above the highest isolated price by at least € 0.01. In ATC, it happens in 0.2% of the cases.

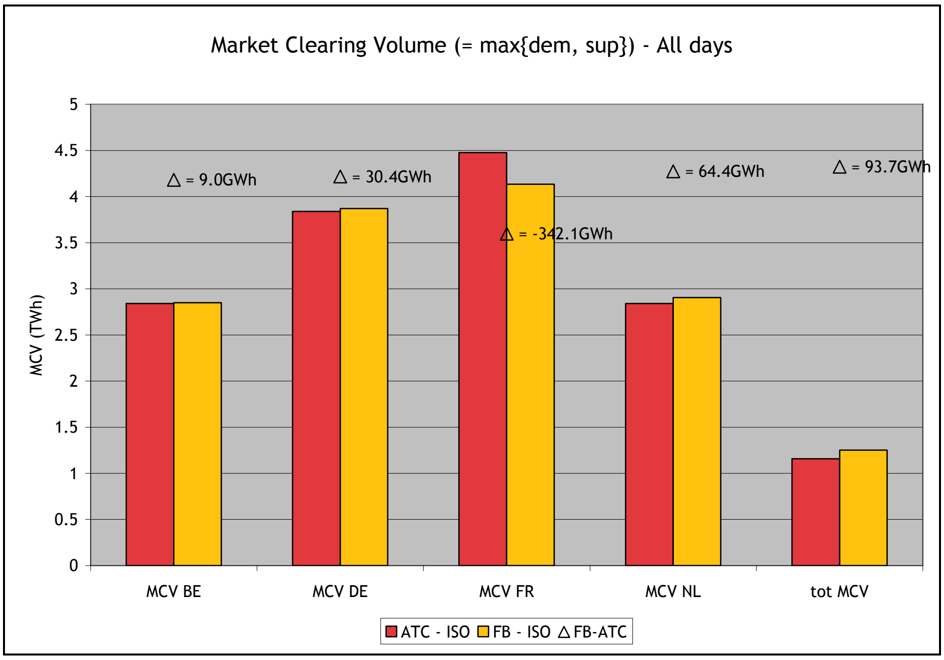
In FB, the largest difference to the upper bound defined by the isolated prices reaches 5.5€. In ATC, this difference reaches 1.6€.

The results show that prices can go out of the bounds defined by the isolated prices in FB. It can also happen with ATC because of block considerations.
However this phenomenon occurs more often in FB than in ATC, and also more frequently for the lower bound. Although in general market prices tend to get closer when the markets are coupled, there exist some instances where this is not the case with the FB methodology. In a first approach, having prices out of the bounds defined by the isolated prices does not appear to be a problem in itself as long as price predictability is not affected and the out of bound measure is not extremely large.

5.3.1.5 Market clearing volume

The first graph shows the Market Clearing Volume under FB and ATC modes and in isolated mode on each market. The second graph hereunder presents the Market Clearing volume per market under FB and ATC from which the Market Clearing Volume per market in isolated mode has been subtracted. This definition of the Market Clearing Volume is the one currently published by the Power Exchanges, i.e. the maximum between the demand volume and the supply volume.





Note that the total Market Clearing Volume is not equal to the sum of the Market Clearing Volume of each market, since the Net Export Position are counted twice (on the importing and on the exporting markets).

RESULTS

The market coupling increases the Market Clearing Volume on each market, compared to the isolated mode. Comparing FB and ATC modes, the Market Clearing Volume is higher under FB in Belgium (+9GWh), Germany (+30.4GWh) and the Netherlands (+64.4GWh), and lower in France (-342.1GWh) than under ATC.

For comparison purpose, the Market Clearing Volume on each market under market coupling is ca. 7TWH in Belgium, 110TWh in Germany, 42TWH in France, 20TWh in the Netherlands.

The total Market Clearing Volume is higher in FB than in ATC (+93.7GWh). All markets see their Market Clearing Volume increased in FB compared to ATC except France.

5.3.1.6 Stressed and non-stressed days analysis

Because of the large differences between the FB and the ATC results on some particular days, it has been foreseen to investigate what would the results on the different market indicators be and if the observations of the previous study would remain valid if these particular days (named "stressed days") are excluded from the analysis. A separate investigation of the stressed days has also been envisaged to explore the differences observed between FB and ATC modes.

5.3.1.6.1 Stressed days: definition

Different definitions can be considered for "stressed days". In this study, the 15 days where the absolute value of the congestion revenue difference between ATC and FB modes are the highest have been defined as "stressed days" (11 days the congestion revenue is higher under ATC than under FB, 4 days it is the opposite). This definition led to the following dates as stressed days (value of $CR_{FB} - CR_{ATC}$ in brackets):

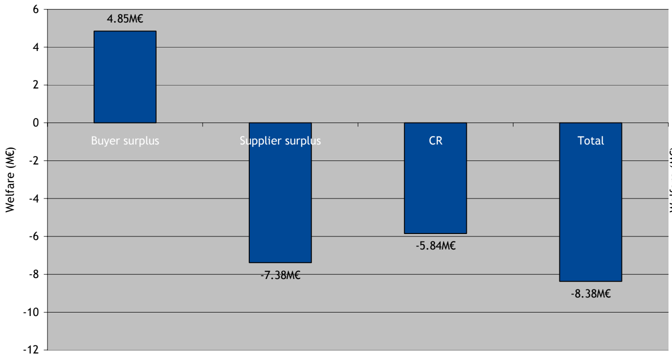
22 May 07	(517 747 €)
23 May 07	(391 952 €)
24 May 07	(-404 669 €)
12 June 07	(-456 716 €)
9 November 07	(-1 076 086 €)
10 November 07	(-720 262 €)
12 November 07	(-942 782 €)
2 December 07	(-511 075 €)
20 December 07	(706 992 €)
21 December 07	(389 427 €)
22 December 07	(-314 696 €)
24 December 07	(-443 857 €)
26 December 07	(-450 657 €)
28 December 07	(-634 832 €)
29 December 07	(-598 949 €)

5.3.1.6.2 Analysis on non-stressed days

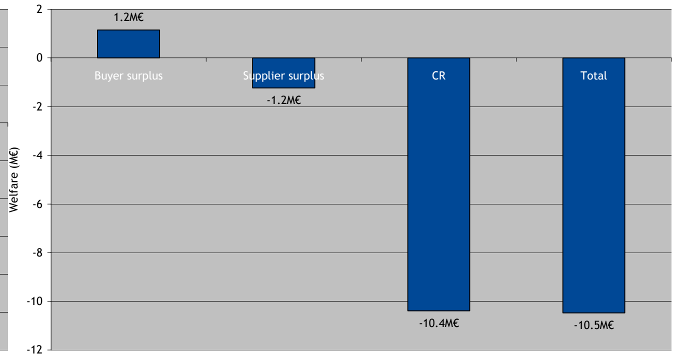
The following charts show a comparison between the results obtained by removing the stressed days from the analysis (i.e. only considering the "non-stressed" days or "regular" days) and the results obtained on all days, on the principal market indicators.

The four market indicators considered where the social welfare, the baseload price, the weekly baseload price volatility, and the market clearing volume. In the left column, the results for the non-stressed days are presented; in the right column, the results on all days are presented. Regarding the baseload price only the results for Belgium has been presented; similar results can be observed on the three other markets.

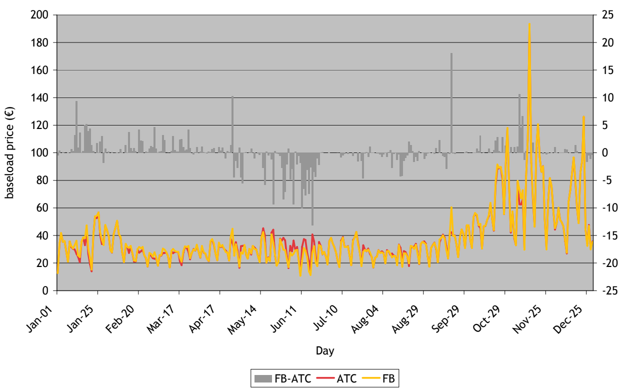
Difference in welfare (FB - ATC) - non-stressed days



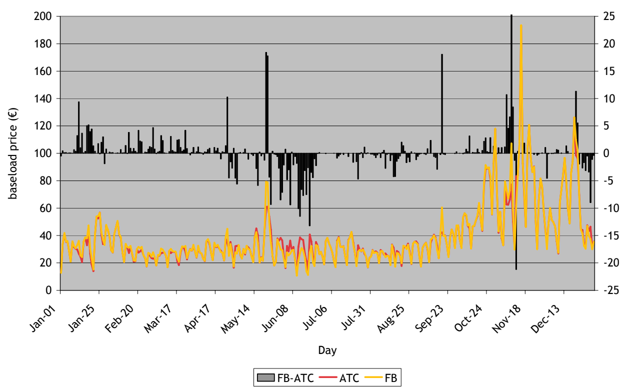
Difference in welfare (FB - ATC) - All days



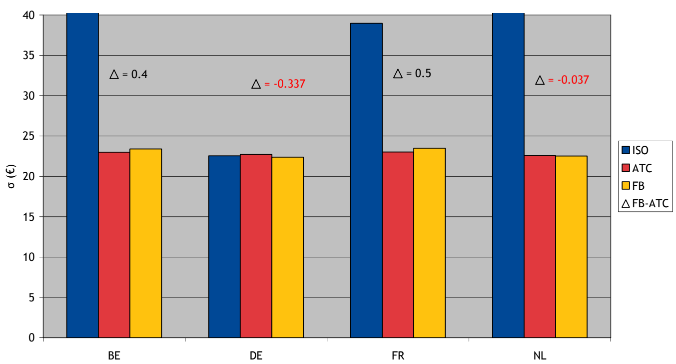
Baseload prices - BE non-stressed days



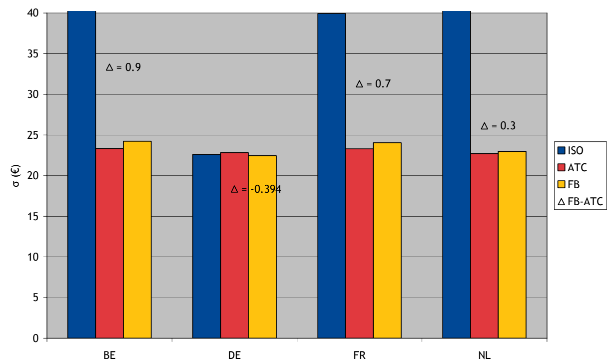
Baseload prices - BE - All Days



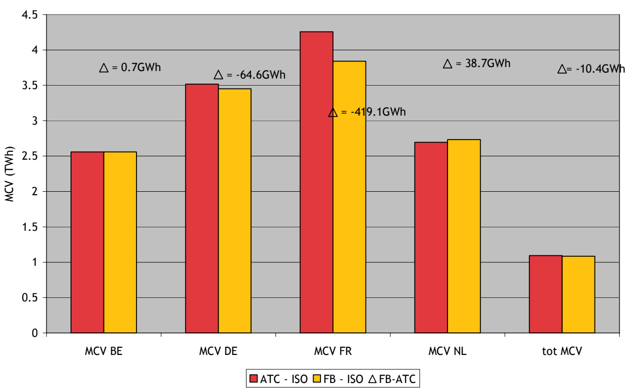
Weekday price volatility (=σ baseload price) - non-stressed days



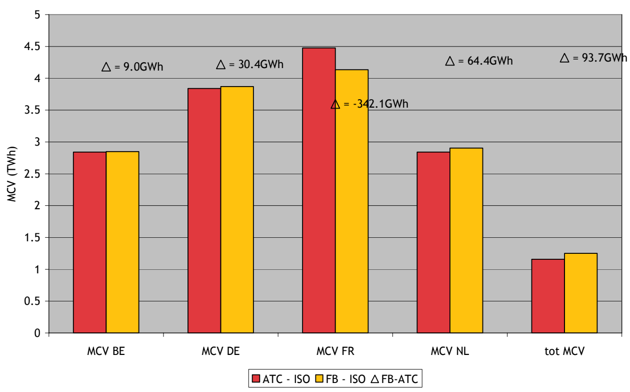
Weekday price volatility (=σ baseload price) - All Days



Market Clearing Volume (= max{dem, sup}) - non-stressed days



Market Clearing Volume (= max{dem, sup}) - All days



RESULTS
The graphs hereinabove show that, by removing the stressed days from the analysis, there is an even better overlap of the results obtained with the FB and the ATC mode on the following market indicators: social welfare, congestion revenue, base load prices and weekly base load price volatility. The market indicators of the market validation are highly influenced by a few cases.

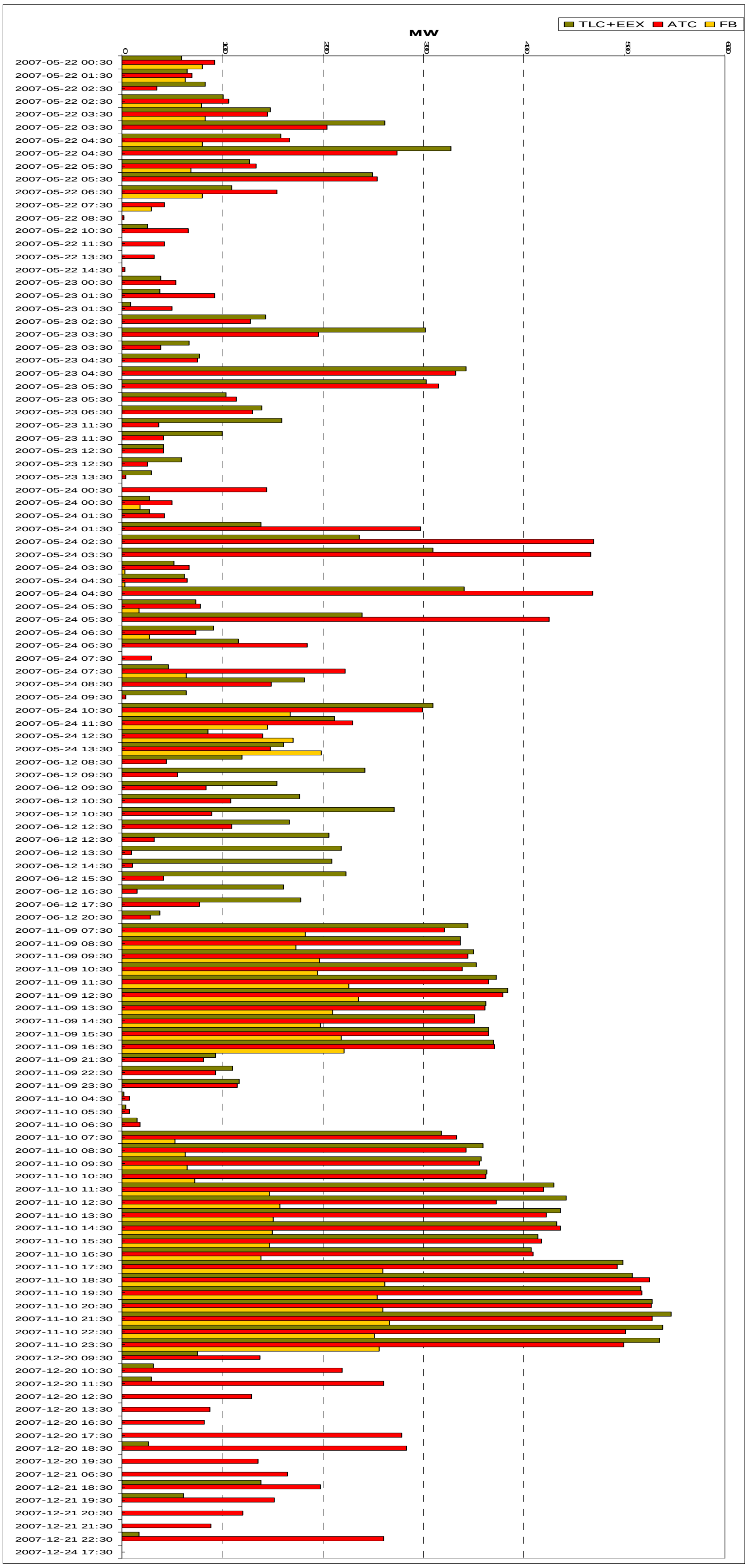
The distribution between buyer and suppliers revenue remain the same, although removing the stressed days from the analysis tends to favour the buyers to the detriment of the suppliers, i.e. the buyers would benefit more from a coupling with a FB mode versus an ATC mode, and the suppliers would benefit less, than originally envisaged. However, the observation made previously on the increase of market clearing volume under FB compared to ATC would be invalid if the stressed days are removed from the analysis. That is by not considering the 15 defined stressed days, a market coupling under FB would result in a slightly smaller market clearing volume than under ATC (-10.4GWh out of ca. 160TWh).

5.3.1.6.3 Analysis on stressed days

RESULTS ON MAIN MARKET INDICATORS
On the 15 defined stressed days, higher price volatility differences as well as fewer overlaps between the principal market indicators have been observed between FB and ATC mode. The difference in social welfare between ATC and FB models observed on the 331 days is due for ca. 2 M€ to the stressed days.

STRESSED DAYS AND NETWORK SECURITY
The following chart presents the largest positive overload(s) per timestamp of the stressed days using the FB model as reference to compare the three different sets of net export positions (TLC+EEX, ATC and FB). An overload is defined as the amount in MW created by the market above the margin (MarketFlow - Margin). Negative margins can also be present in the network (and were used for this analysis) but in the FB parameters delivered to the market, they are set to 0. A negative margin corresponds thus to an overload before the start of the market coupling. This explains why even with the FB net export positions, positive overload can occur.

The chart shows that on many timestamps of the defined stressed days the flows under ATC exceed the security margin defined within the FB model. Although on some timestamps, the FB flows on a few particular critical branches also exceed the security margin, there is still a large difference between the flows on a few particular critical branches under ATC and under FB on most of the timestamps.
To be complete the analysis should be done on all timestamps to better measure the differences between the flows under ATC and FB and their respective satisfaction of the security margin.


TLC+EEX
ATC
FB
MW
0
100
200
300
400
500
600
2007-05-22 00:30
2007-05-22 01:30
2007-05-22 02:30
2007-05-22 02:30
2007-05-22 03:30
2007-05-22 03:30
2007-05-22 04:30
2007-05-22 04:30
2007-05-22 05:30
2007-05-22 05:30
2007-05-22 06:30
2007-05-22 07:30
2007-05-22 08:30
2007-05-22 10:30
2007-05-22 11:30
2007-05-22 13:30
2007-05-22 14:30
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2007-06-12 20:30
2007-11-09 07:30
2007-11-09 08:30
2007-11-09 09:30
2007-11-09 10:30
2007-11-09 11:30
2007-11-09 12:30
2007-11-09 13:30
2007-11-09 14:30
2007-11-09 15:30
2007-11-09 16:30
2007-11-09 21:30
2007-11-09 22:30
2007-11-09 23:30
2007-11-10 04:30
2007-11-10 05:30
2007-11-10 06:30
2007-11-10 07:30
2007-11-10 08:30
2007-11-10 09:30
2007-11-10 10:30
2007-11-10 11:30
2007-11-10 12:30
2007-11-10 13:30
2007-11-10 14:30
2007-11-10 15:30
2007-11-10 16:30
2007-11-10 17:30
2007-11-10 18:30
2007-11-10 19:30
2007-11-10 20:30
2007-11-10 21:30
2007-11-10 22:30
2007-11-10 23:30
2007-12-20 09:30
2007-12-20 10:30
2007-12-20 11:30
2007-12-20 12:30
2007-12-20 13:30
2007-12-20 16:30
2007-12-20 17:30
2007-12-20 18:30
2007-12-20 19:30
2007-12-21 06:30
2007-12-21 18:30
2007-12-21 19:30
2007-12-21 20:30
2007-12-21 21:30
2007-12-21 22:30
2007-12-24 17:30

RESULTS ON STRESSED / NON-STRESSED DAYS

After removing the (15) stressed days from the analysis, the observations of the comparison between the results under ATC and under FB on the main indicators remain valid. An exception is the market clearing volume that decreases on the regular days between FB and ATC.

On non-stressed days, the overlap between ATC and FB results is even better on the social welfare, the congestion revenue, the baseload prices, the price volatility and the price convergence.

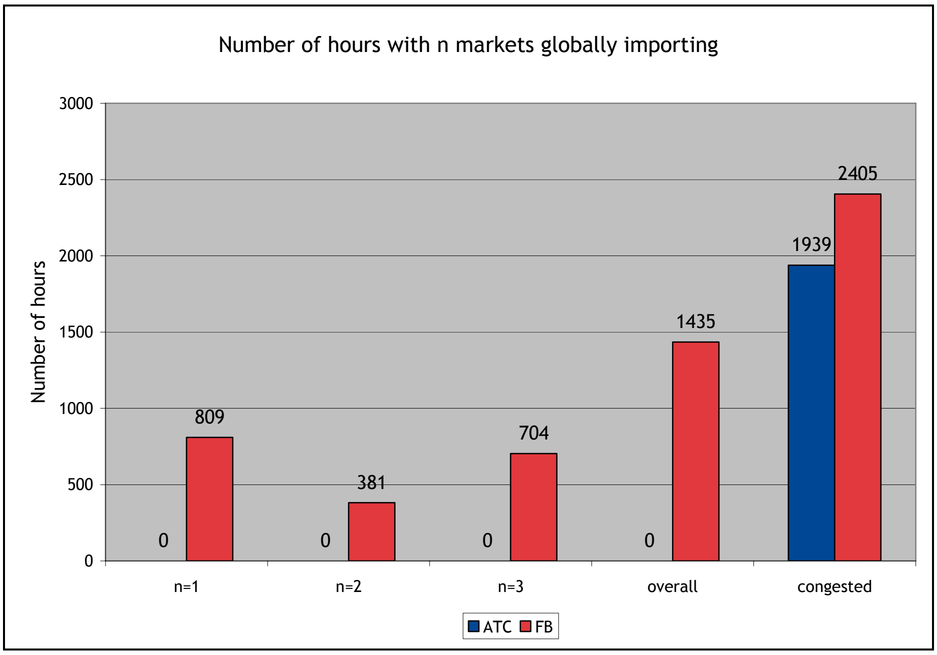
On stressed days, it can be noticed that the flows under ATC exceed the defined FB security margin on a few particular critical branches. This is true for the FB model as well, although the overload is clearly smaller. Detailed investigation is to be conducted with the TSOs for a better understanding of the network situation on these days, and of the differences between the ATC and the FB results. More generally the network security as parameter for the market validation analysis has not been included in the scope of this analysis, but further analysis aiming at comparing the network security under ATC and under FB should be conducted.

5.3.2 Adverse flows

From theoretical observations, it appears that price formation is rather different under ATC and under FB network modeling. In particular, whereas with ATC-based models the cheapest markets are always exporting (and equivalently the most expensive markets are always importing) this statement is no longer true with FB. The fundamental reason lays in the fact that flow factors in FB models can be different for each market and that optimal solution might thus be one in which some value is lost on some borders (flows from expensive to cheap markets) in order to allow more value to be created on other borders. Such situations were called "adverse flows" by opposition to the situations where the prices are "intuitive" that do necessarily occur in ATC but not necessary in FB.

5.3.2.1 Import in the lowest priced markets

The histogram hereunder presents the number of hours where the group of the n markets (n=1, n=2, n=3) with the lowest price is globally importing, as well as the number of congested hours, under FB and ATC modes.



RESULTS

This graph shows the number of hours under FB where the group of one, two or three markets with the lowest price is importing (column "overall"). We can deduce that under FB, there are 60% of the congested hours (1435/2405) or more generally of 18% (1435/7944) of all the hours, where the n cheapest markets globally import (or equivalently where the 4-n most expensive markets globally export). Under FB, in 33.6% of the congested hours, the market with the lowest price imports. In 29.3% of the congested hours, the market with the highest price exports. As expected, such situations do not occur in ATC. To assess whether some markets are more subject to adverse flows, a detailed analysis per market -presented in the next section- has been conducted.

<u>RESULTS PER MARKET</u>

The table hereafter shows the distribution of adverse flows per market, i.e. for each market, the number of hours over the year where the market has the lowest price and is importing, and the number of hours over the year where the market has the highest price and is exporting. The results are also given as percentage of the total number of hours.

Number of Hours		
	Cheapest market imports	Most expensive market exports
BE	341	27
DE	315	355
FR	151	217
NL	7	137

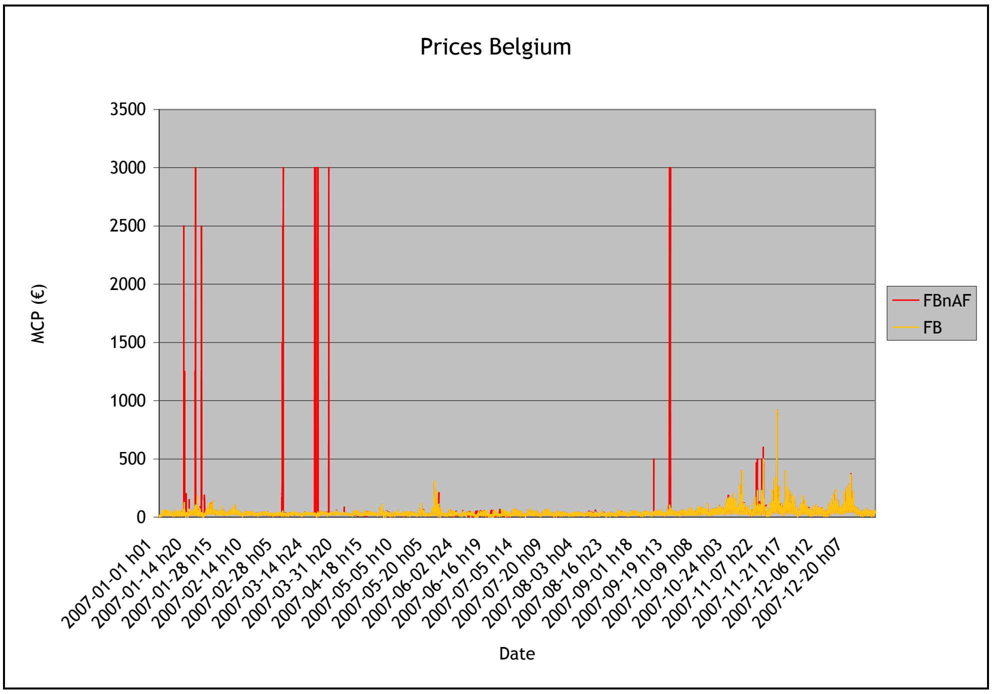
Percentage over the year		
	Cheapest market imports	Most expensive market exports
BE	4.3%	0.3%
DE	4.0%	4.5%
FR	1.9%	2.7%
NL	0.1%	1.7%

As one can see, adverse flows are not specific to a particular market, and occur on all markets. Non-intuitive situations occur the most in Germany (8.5%), and the least in the Netherlands (1.8%).

5.3.2.2 Comparison of flow based model with flow based model where adverse flows are inhibited

In order to measure the effects linked to the existence of adverse flows, a comparative analysis between the Flow-Based model (FB) and a "Flow-Based model with no adverse flows allowed" (FBnAF) has been initiated. Therefore, an algorithmic solution countering adverse flows (thus enforcing prices to be intuitive, or equivalently enforcing all the groups of n cheapest markets to export) has been implemented in COSMOS.

The graph hereafter shows the evolution of the Belgian Market Clearing Price (MCP) over the year with the Flow-Based model (FB) and with the Flow-Based model without adverse flows (FBnAF). Only the Belgian market prices are shown because the largest differences were observed on this market.



RESULTS

It can be observed that on specific hours, there exist large price differences between the results under the Flow-Based model and under the Flow-Based model where no adverse flows were allowed. On these hours, under the Flow-Based model with no adverse flows, the market clearing price on the Belgian market reaches its maximum price limit of 3000€ (the isolated price of Belpex - i.e. the price with no import/export - was also 3000 € for these hours)[16].

Such huge differences in prices (almost 3000€), even if only on a few hours, have huge impacts on most of the indicators to be studied. Moreover, the values of these indicators will in such a case be strongly dependent on the value of the maximum price of Belpex, which is currently arbitrarily set at 3000€. In other words, would the maximum price of Belpex be Pmax= 5000€ the indicators would show even a stronger degradation in the quality of the results, even though they would reflect exactly the same market conditions (see below). For this reason, all possible indicators will not be presented.

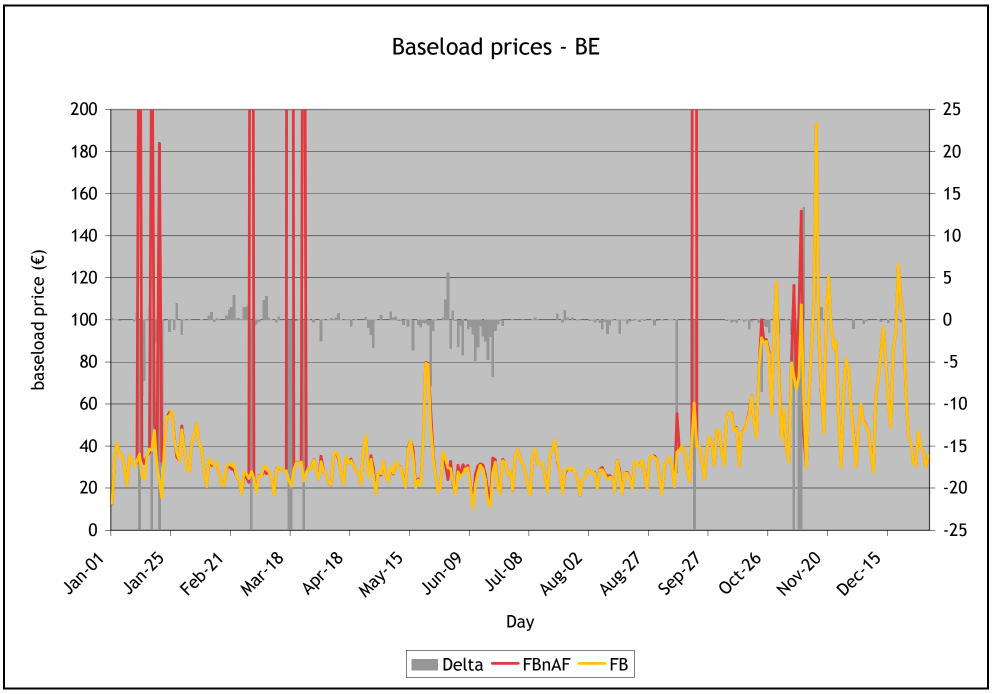
In order to depict the fact that the largest differences are observed almost exclusively on the Belgian market, comparisons of base load prices for the four exchanges are still given.

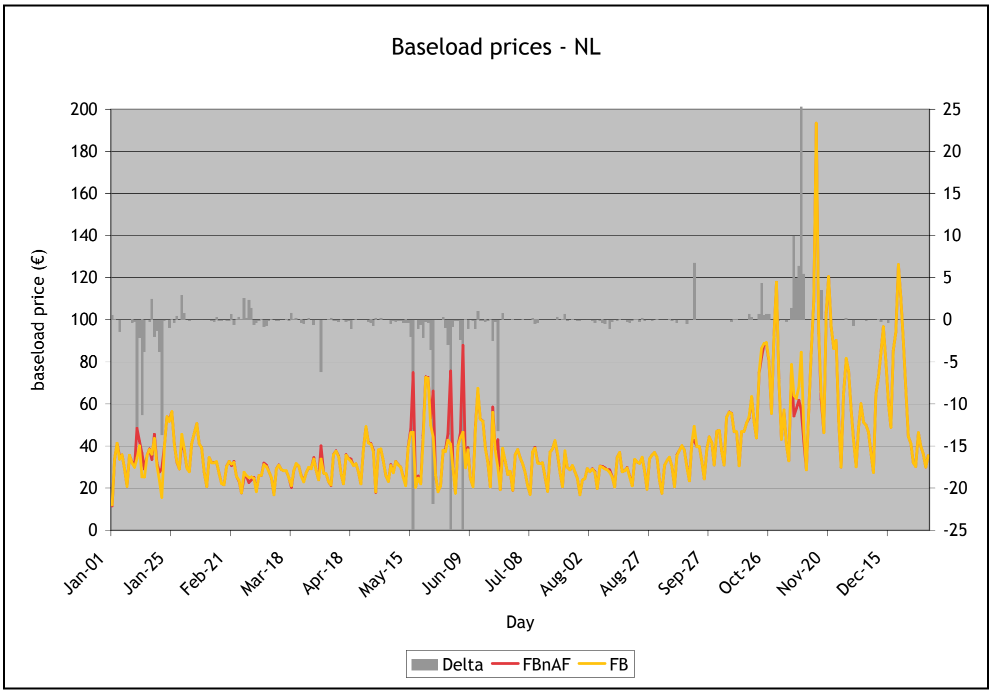
5.3.2.2.1 Comparison of base load based prices under FB with-no-adverse-flows/FB

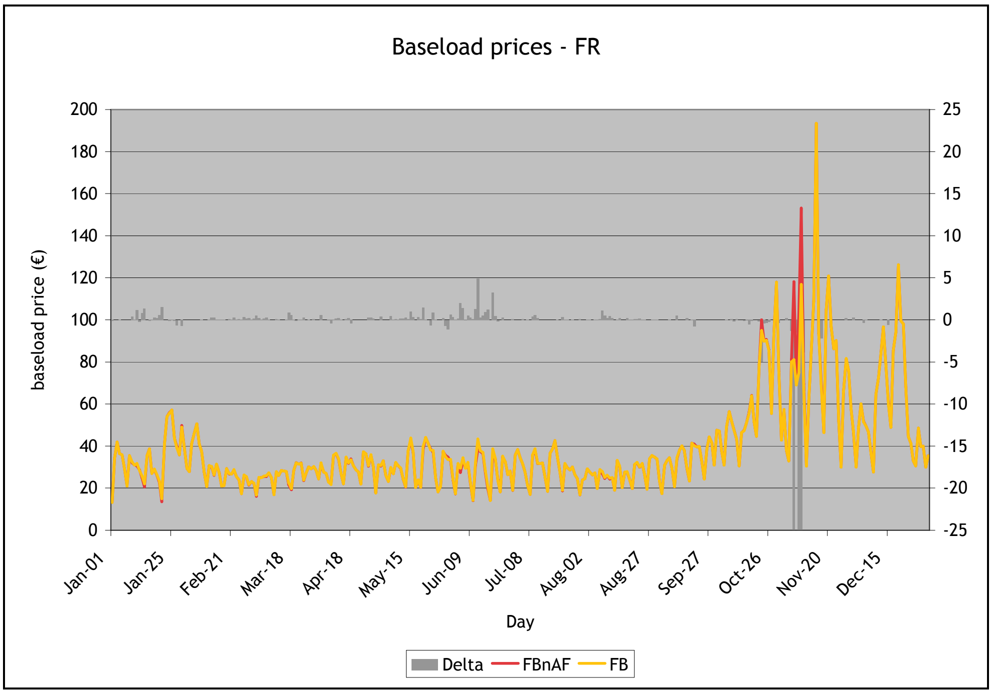
The four graphs hereafter show for each market the evolution of the base load price over the year under the Flow-Based model (FB) and under the Flow-Based model where adverse flows have been prohibited (FBnAF).

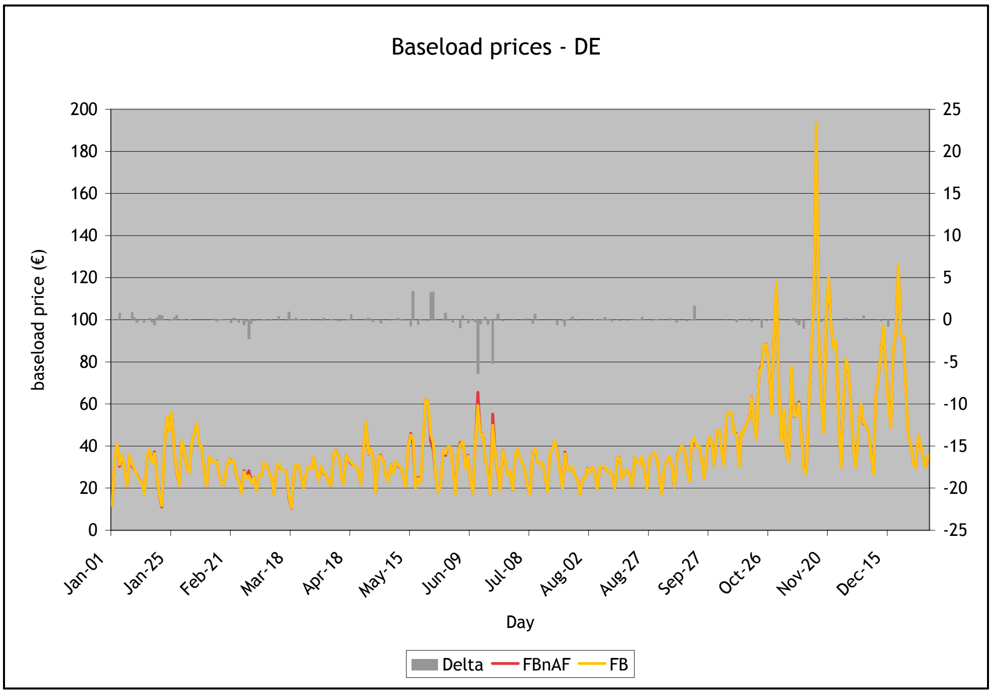
1.

[16] Note that the Belgian price is also quite frequently one cent, which was for these hours also the isolated (and minimal) Belgian price.


Baseload prices - BE
baseload price (€)
200
180
160
140
120
100
80
60
40
20
0
25
20
15
10
5
0
-5
-10
-15
-20
-25
Jan-01
Jan-25
Feb-21
Mar-18
Apr-18
May-15
Jun-09
Jul-08
Aug-02
Aug-27
Sep-27
Oct-26
Nov-20
Dec-15
Day
Delta
FBnAF
FB


Baseload prices - NL
baseload price (€)
200
180
160
140
120
100
80
60
40
20
0
25
20
15
10
5
0
-5
-10
-15
-20
-25
Jan-01
Jan-25
Feb-21
Mar-18
Apr-18
May-15
Jun-09
Jul-08
Aug-02
Aug-27
Sep-27
Oct-26
Nov-20
Dec-15
Day
Delta
FBnAF
FB





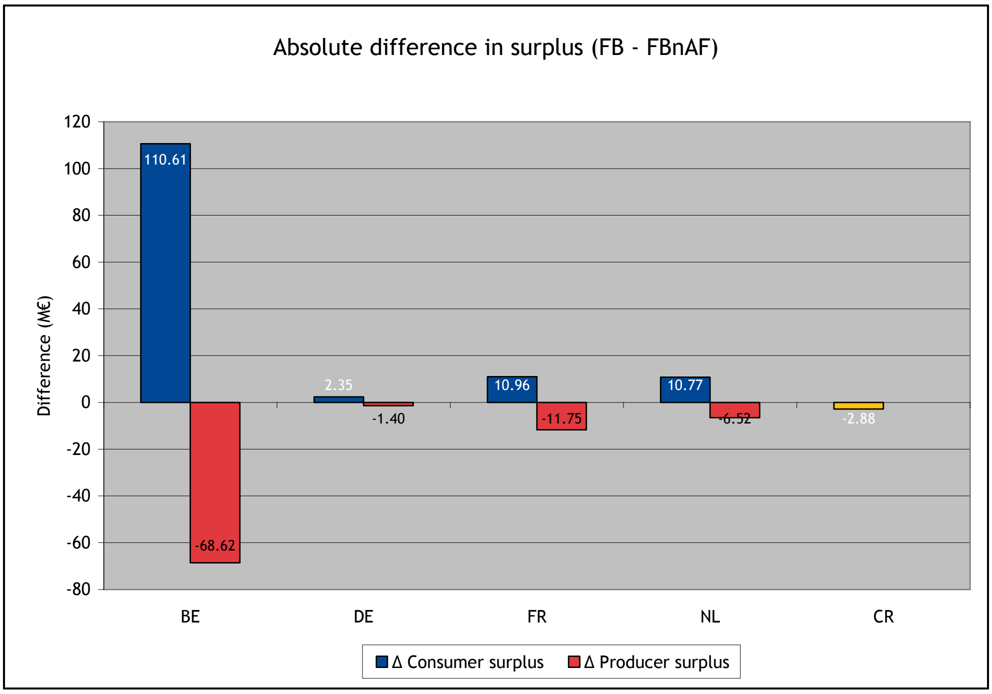
RESULTS

On most of the days, similar base load prices can be observed under both models on all markets. In France, the Netherlands, on specific days, quite large discrepancies between the base load prices under the Flow-Based and the Flow-Based with-no-adverse-flows models can be observed. In Belgium, these differences are even larger (essentially due to the maximum prices on some hours), whereas on the contrary the German market is quite minorly affected.

Clearly, large differences on some particular hours/days impacted quite largely many indicators. In particular, as the Belgian price hits its ceiling of 3000 € several times, many indicators saw their value worsening. A very strong degradation of the Belgian volatility has then been observed. The following paragraph shows how the social welfare is also impacted by the extreme prices on some hours.

5.3.2.2.2 Comparison of social welfare distribution (markets, consumers, producers and TSOs)

The histogram hereunder shows per market the difference between the buyer surplus and the supplier surplus between FB mode and FBnAF mode; the difference in congestion revenue between the two modes is also plotted.



RESULTS

A very large difference in social welfare both on the buyer and on the supplier side between the Flow-Based model and the Flow-Based with-no-adverse-flows mode is observed on the Belgian market. On the contrary, welfare distribution on other markets is less affected.

Regarding the total social welfare, prohibiting adverse flows induces a reduction of social welfare of 43.5M€. These large differences in social welfare between the Flow-Based model and the Flow-Based with-no-adverse-flows model are due to the differences of results on the Belgian market with price reaching 3000€ on some hours (hence more surplus for sellers and less for buyers). The value of the difference of social welfare is however strongly dependent on the maximum price limit on the Belgian market (i.e. a higher Pmax would have conducted to a larger difference in social welfare) and should thus not be understood per se as the "value withdrawn from the market by preventing adverse flows".

However, in any case the welfare generated by market coupling with a FB model with no adverse flows will be lower than the welfare under FB. This is because the model where no adverse flow is allowed contains additional constraints (i.e. the "no adverse flows" constraints) and will thus always provide equal or smaller welfare.

5.3.2.2.3 A problematic day in Belgium: example and reason

In general, one can say that Belpex has a low liquidity, which concretely means that the prices it would publish without relying on market coupling would not always reflect appropriately the situation of the Belgian market. For instance, its "isolated price" (the price of Belpex without any import/export) regularly hits the maximal or minimal price. Fortunately, the low resilience of this market allows finding a suitable price with a limited amount of import or export from France or the Netherlands via the TLC mechanism.

As an example, on the 17/01/07 at 17h, Belgium had an isolated price of 3000€/MWh whereas it ended with a price of 39,96 €/MWh and imported 628 MWh.

In the FB model, the PTDF constraints used for this hour presented 4 pre-congestions. For simplicity purposes, only 2 of these constraints are shown:

$$-0.07NEX_{BE} + 3.5NEX_{DE} - 6.2NEX_{FR} + 1.2NEX_{NL} \leq 0$$
$$0.4NEX_{BE} - 22.1NEX_{DE} + 23.5NEX_{FR} - 8.9NEX_{NL} \leq 0$$

As one can see from these two equations, Belpex can not import from neither FR, DE nor from NL with the other two markets in balance. Indeed, it is mathematically not possible to set a negative net position (thus an import) for BE and a positive one (thus an export) at any other market if the two remaining positions are null.

In market coupling terms, this means that Belgium can not import unless an exchange of energy between two markets "releases" some capacity on the pre-congested critical branches. But sometimes, the only way to release capacity this way is to exchange energy from an expensive to a cheap market (from France to Germany in this case). And, since FR and DE have quite good resilience, the loss of value induced by this adverse flow is largely compensated by the value "earned" on the Belgian market (almost 3000 € per imported MW).

In such situations only two possibilities can thus be envisaged :

- either intuitive prices are enforced and Belgium is not allowed to import. Belgian price would then be 3000€.
- Or non-intuitive flows are allowed in France, the Netherlands and Germany to allow Belgium importing (thus increasing the welfare).

Note that the similar situations were observed with exports at the minimum price.

In some sense, the Belgian prices observed if no adverse flows are allowed in FB are equivalent to prices with no import capacity in ATC (because there exists no ATC model with strictly positive capacities that respect such PTDF constraints). It is then important to remind that minimal import and export daily capacities were guaranteed on each border since the TLC launch, and that this effectively helped providing reliable prices in the entire TLC area and in Belgium in particular. Note also that Belpex did not start before TLC for the same reasons.

RESULTS
Adverse flows under Flow-Based model benefit the most to the Belgian Market. Indeed, in situations where the resilience and liquidity are very low on the Belgian market, adverse flows allows imports from Belgium even in case of pre-congestions, resulting in a lower market clearing price on the Belgian market.

An open question is still whether adverse flows are acceptable or not. Indeed,

- this phenomenon allows a maximisation of the total net utility regarding the available capacity, meaning, in this sense, a complete transparency of the results; Preventing this phenomenon to occur without adapting the FB methodology accordingly will be accompanied by a reduction of the total net utility.
- this phenomenon can be seen as unfair, for the markets that are "utilized" to relieve congestion on some lines in order to increase the exchanges between other markets;
- the acceptability of this phenomenon by the market participants as well as the consequences on their behaviour is unknown;
- were countermeasures envisaged, their acceptability by the market parties is unknown.

Countering the adverse flows did not show satisfactory results under the current conditions. In certain cases, this analysis shows that better results with a Flow-Based with-no-adverse-flows model could be ensured if there were no pre-congestions in the network prior to the market coupling anymore. This last point raised a more general question by some Parties concerning warranty of a minimal capacity, being under ATC or under FB, for the CWE-MC. This issue seems to be of great importance, especially for market with lower liquidity.

5.3.3 Other indicators

5.3.3.1 Price out of boundaries

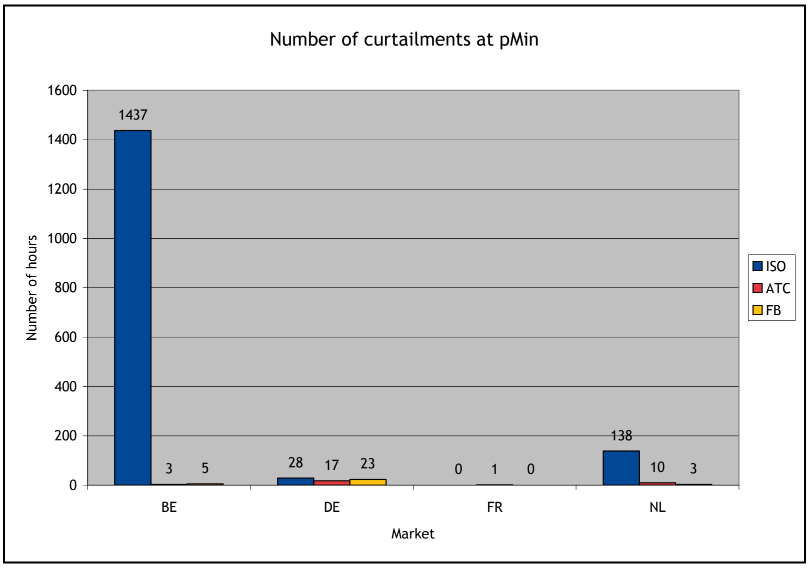
RESULTS
On the 331 days, under FB, there is no hour with any market clearing price out of boundary. Although the results showed that there is no hour with any market clearing price out of the price boundaries of each market, this situation can theoretically happen under FB model. To prevent this risk of happening, a price-limiting rule needs to be implemented within COSMOS.

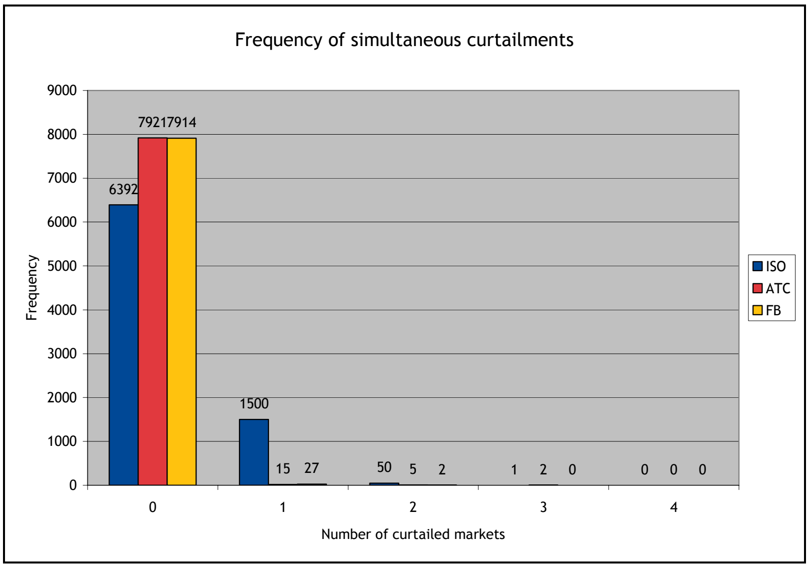
5.3.3.2 Curtailment

Note that the simulations have been conducted prior to the implementation of a curtailment rule within the algorithm. The results hereafter give an indication on the number of hours where some volume may be curtailed. However, after a curtailment rule is implemented, one of two markets that were simultaneously curtailed in this analysis may not be curtailed anymore (for example if the rule stipulates a non-propagation of the curtailment).

The first graph hereunder shows the number of curtailments at the minimum price limit (Pmin) per market under FB model, under ATC model, and in isolated mode.

The second graph shows the number of hours where one, two, three, or four markets are simultaneously in curtailment, under FB model, ATC model and in isolated mode.





ANALYSIS

In the results, curtailment always happens at the minimum price limit (Pmin) and never at the maximum price limit (Pmax). Generally, market coupling reduces the number of hours where a market is in curtailment. Comparing isolated cases and market coupling under FB, the number of curtailed hours dropped in Belgium by 1432, in Germany by 5 and in the Netherlands by 135. Comparing the number of hours when a market is in curtailment, it can be noticed that it happens as frequently under FB as under ATC (31). However, the distribution between markets changes: there are under FB more hours of curtailment in Germany (+6) and in Belgium (+2), whereas there are less in France (-1) and in the Netherlands (-7).

Simultaneous curtailment

The number of simultaneous curtailments decreases in FB compared to ATC (-5).

There are only two hours under FB model where there is curtailment on more than one market simultaneously.

5.3.3.3 Impact of introducing negative prices at EEX

To study the impact of the introduction of a negative order price limit at -3000€ on the German market, different scenarios have been elaborated. Each simulated scenario is characterized by a proportion of the original price taking sell orders (i.e. orders posted originally in the historical 2007 order books at 0€) to be set at a negative price within a pre-defined negative price-range, the other original price taking orders remaining posted at 0€.

The aim of this study is to measure the impact of introducing negative orders on EEX on the number of curtailed hours and on the curtailed volume on each market.

5.3.3.3.1 Studied scenarios

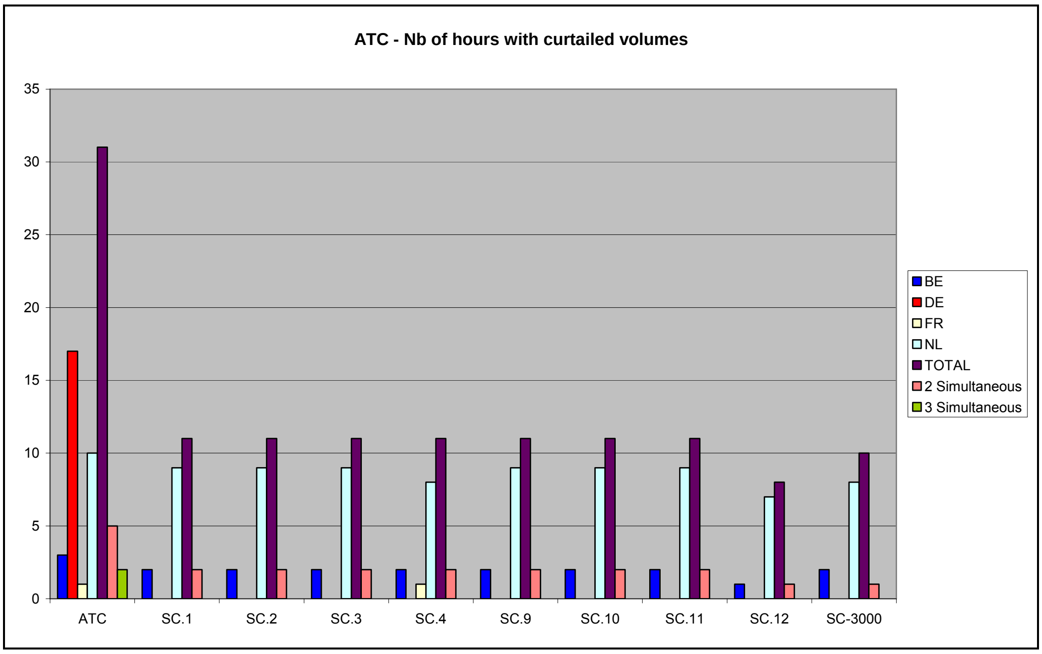
Reference scenario: CWE-MC with all original price taking sell orders in the German orders books posted at 0€ (historical 2007 order books). The following scenarios have been conducted:

Scenarios	
1	25% of price taking sell orders @ negative prices in range [-0,1 ; -100]
2	50% of price taking sell orders @ negative prices in range [-0,1 ; -100]
3	75% of price taking sell orders @ negative prices in range [-0,1 ; -100]
4	100% of price taking sell orders @ negative prices in range [-0,1 ; -100]
9	25% of price taking sell orders @ negative prices in range [-0,1 ; -3000]
10	50% of price taking sell orders @ negative prices in range [-0,1 ; -3000]
11	75% of price taking sell orders @ negative prices in range [-0,1 ; -3000]
12	100% of price taking sell orders @ negative prices in range [-0,1 ; -3000]
-3000	100% of price taking sell orders @ -3000€

The prices for the orders set at a negative price were randomly selected in the defined price-range. Simulations have been conducted on 331 days under ATC mode and under FB mode. The results are presented in the following sections.

5.3.3.3.2 Impact on the number of curtailments under ATC

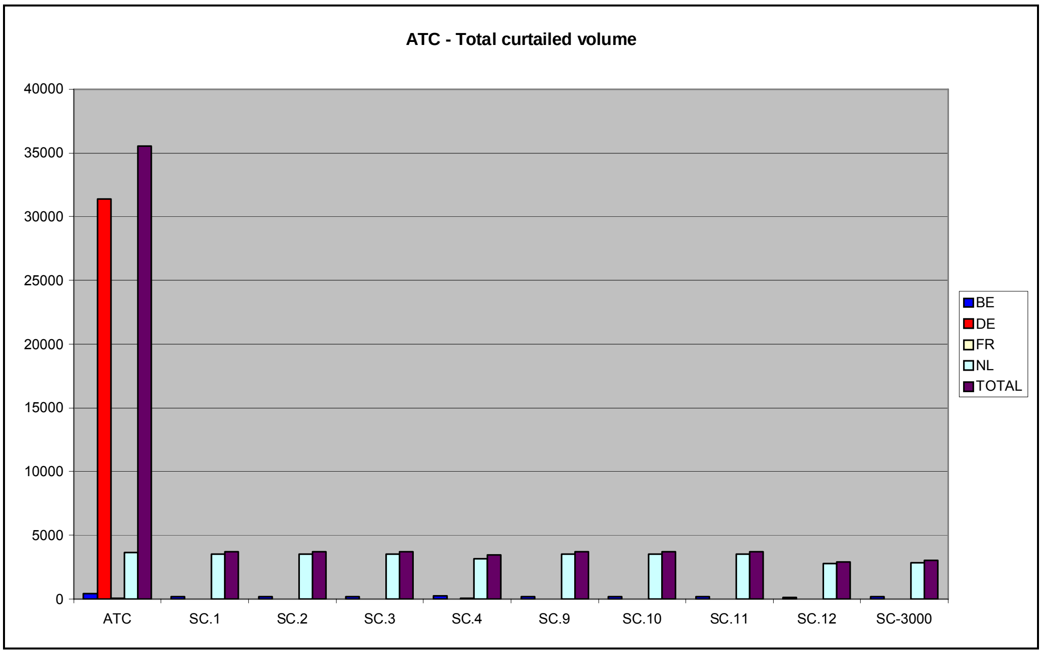
The histogram hereafter shows the number of hours over the 331 days where curtailment occurs on each market for each scenario (sc1 to sc12; sc-3000) as well as for the reference case under ATC mode.



RESULTS
Under the reference case in ATC, the total number of curtailed hours is 31. In each other scenario, the total number of curtailed hours is reduced to less than 11 hours. Introducing negative price limit on EEX eliminates all curtailments on the German market. Compared to the reference case, there are equally or less curtailed hours on the Belgium, Dutch and French markets in any scenario. Compared to the reference case, in any scenario, there are no simultaneous curtailment cases involving three markets at the same time and less simultaneous curtailment cases involving two markets at the same time.

5.3.3.3.3 Impact on the curtailed volume under ATC

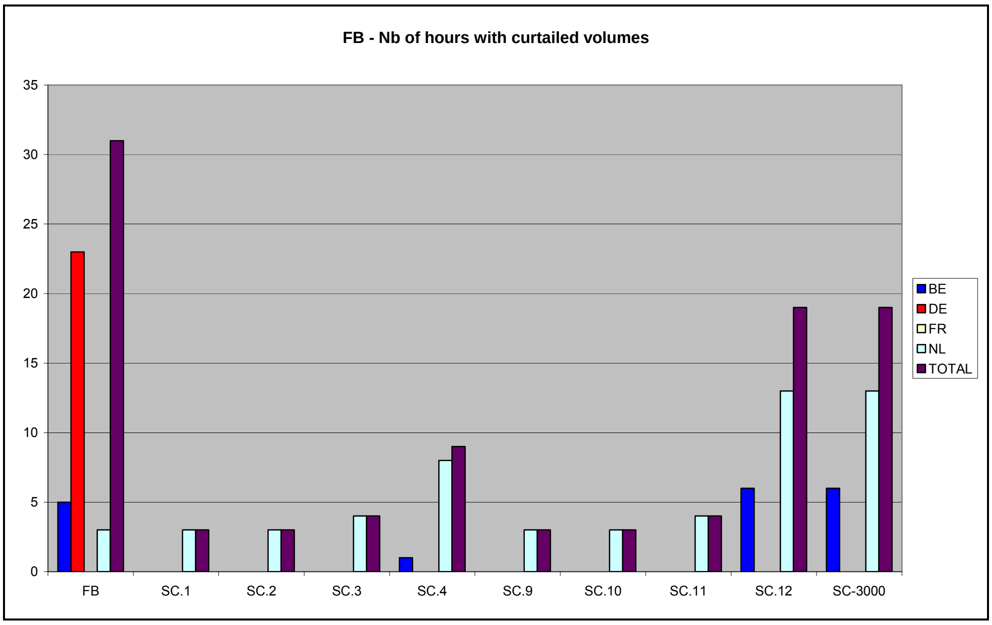
The histogram hereafter shows the total curtailed volume over the 331 days on each market for each scenario (sc1 to sc12; sc-3000) as well as for the reference case under ATC mode.



RESULTS
The results on the curtailed volume follow the results on the number of curtailed hours. Compared to the reference case, the total curtailed volume is reduced in each scenario. There is no curtailed volume in Germany anymore after the introduction of negative price limit in any scenario. In all scenarios, on the other markets, the curtailed volume is either reduced or equal to the curtailed volume in the reference case.

5.3.3.3.4 Impact on the number of curtailments under FB

The histogram hereafter shows the number of hours over the 331 days where curtailment occurs on each market for each scenario (sc1 to sc12; sc-3000) as well as for the reference case under FB mode.



RESULTS

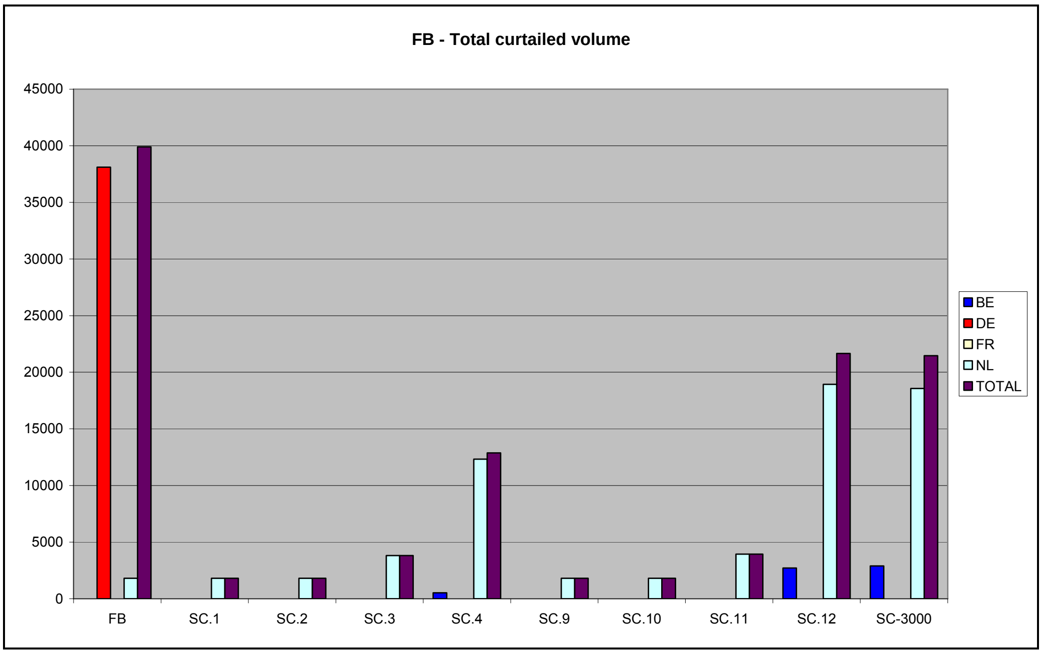
In the reference case (CWE-MC under FB with historical order books, i.e. price taking sell orders in Germany at 0€) the total number of curtailed hours is 31, amongst which the orders in Germany are curtailed in 23 hours. In the reference case, the orders in France are never curtailed, the orders in the Netherlands are curtailed 3 hours over the year, and in Belgium 5 hours.

Whatever the simulated scenario for the introduction of negative price bids on EEX, no curtailment was observed on the German and on the French markets.
In scenarios where 100% of the original price taking orders are set at a negative price (sc4;sc12 and sc-3000), the number of hours where some order volume is curtailed increases on the Belgian market (up to 6 hours) and especially on the Dutch market (up to 13 hours).

Compared to the reference scenario, the total number of hours with curtailed volume even increases under sc12 and sc-3000 where 100% of all original price taking orders are set at a negative price either in the [-0.1€;-3000€] range or at -3000€.

5.3.3.3.5 Impact on the curtailed volume under FB

The histogram hereafter shows the total curtailed volume over the 331 days on each market for each scenario (sc1 to sc12; sc-3000) as well as for the reference case under FB mode.



RESULTS
The results on the curtailed volume follow the results on the number of curtailed hours. There is no curtailed volume in Germany anymore after the introduction of negative price limit in any scenario. In all scenarios, on the Dutch market, the curtailed volume is either higher or equal to the curtailed volume in the reference case; on the Belgian market, the curtailed volume increases under sc4, sc12 and sc-3000. It is to be noted that although the number of hours with curtailed volume increases in sc12 and sc-3000, the total curtailed volume is reduced in each scenario.

Based on the conducted simulations, the consequences on introducing a negative order price limit on EEX are the following:

- no volume submitted at Pmin on the German market is rejected anymore;
- under ATC mode, the curtailed volume on the other markets is not impacted or even reduced;
- under FB mode, the number of hours with curtailed volume increases on the Belgium and especially on the Dutch market.

Especially under FB mode (but also under ATC mode), a curtailment rule is needed to prevent the curtailment to propagate to other markets. Nevertheless, simulations showed rather limited impacts so that the issues encountered with the introduction of negative prices in Germany can be considered as limited.

5.3.4 CWE-MC under ATC mode

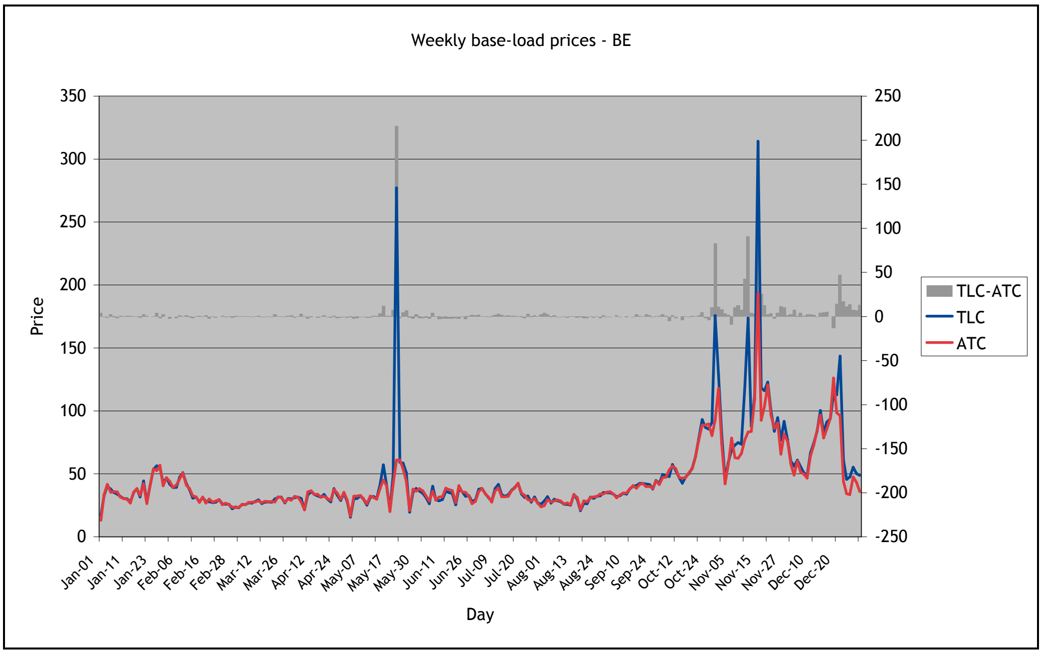
5.3.4.1 Comparison historical situation with ATC MC

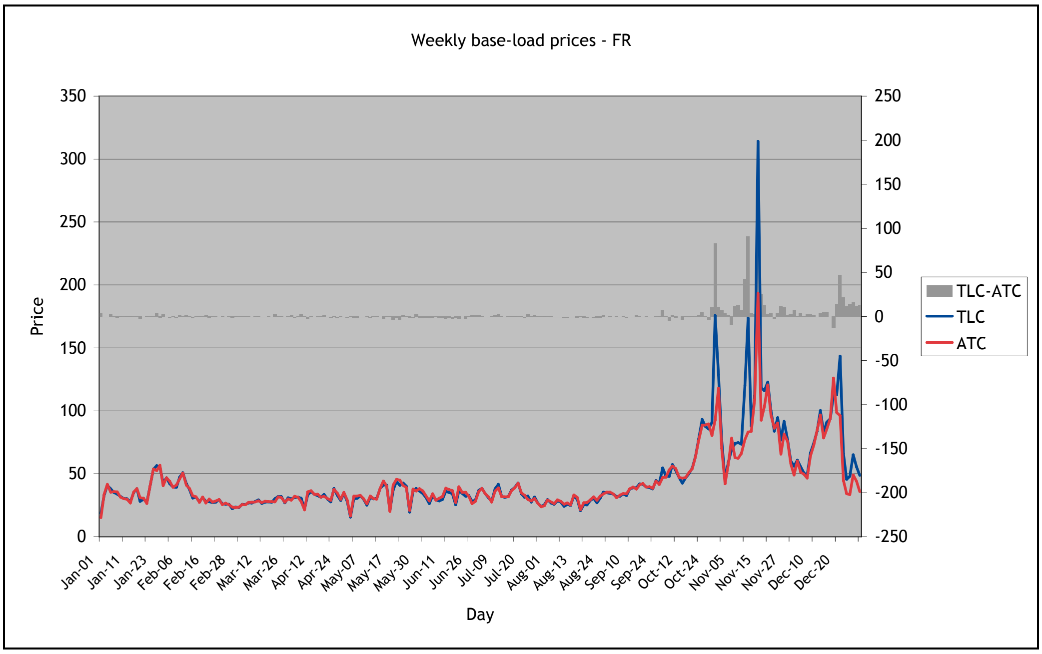
Historical order books have been used for the simulation in the CWE-MC under ATC. Since the historical order books also reflect an explicit auction mechanism between FR/DE and DE/NL, the direct comparison proposed here with historical TLC results is biased. The hereafter-mentioned results should be taken with the appropriate reserve.

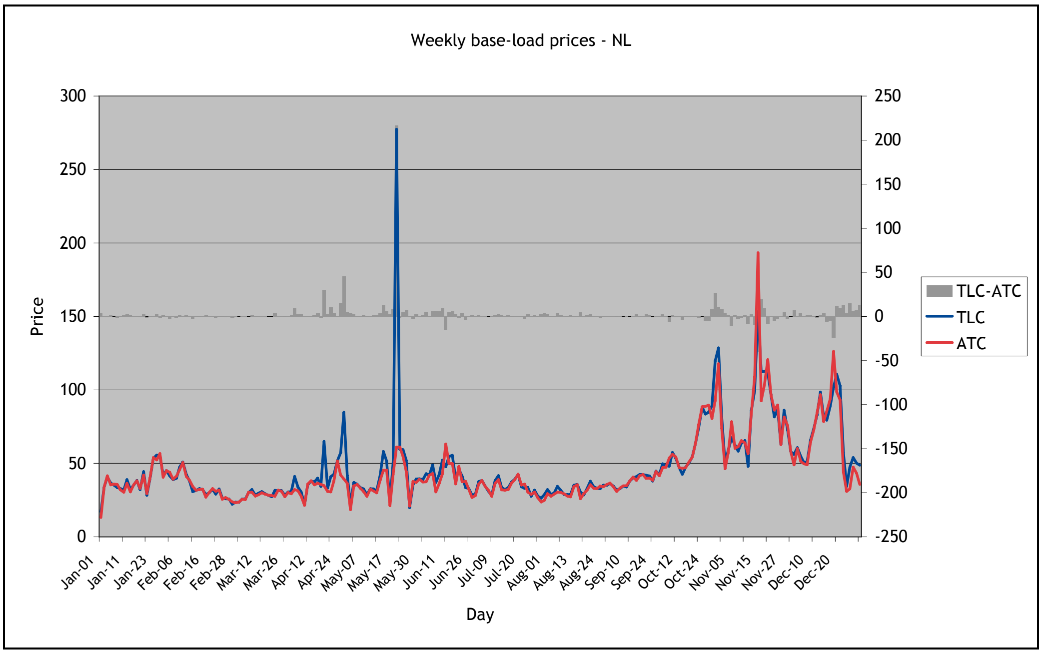
NOTE: Historical data on the German market was not available (except for the order books and the number of hours with curtailed volume).

5.3.4.1.1 Comparison of base load prices TLC with CWE MC

The following charts show for each TLC market, the historical base load prices in LC and the simulated base load prices in CWE-MC under ATC.



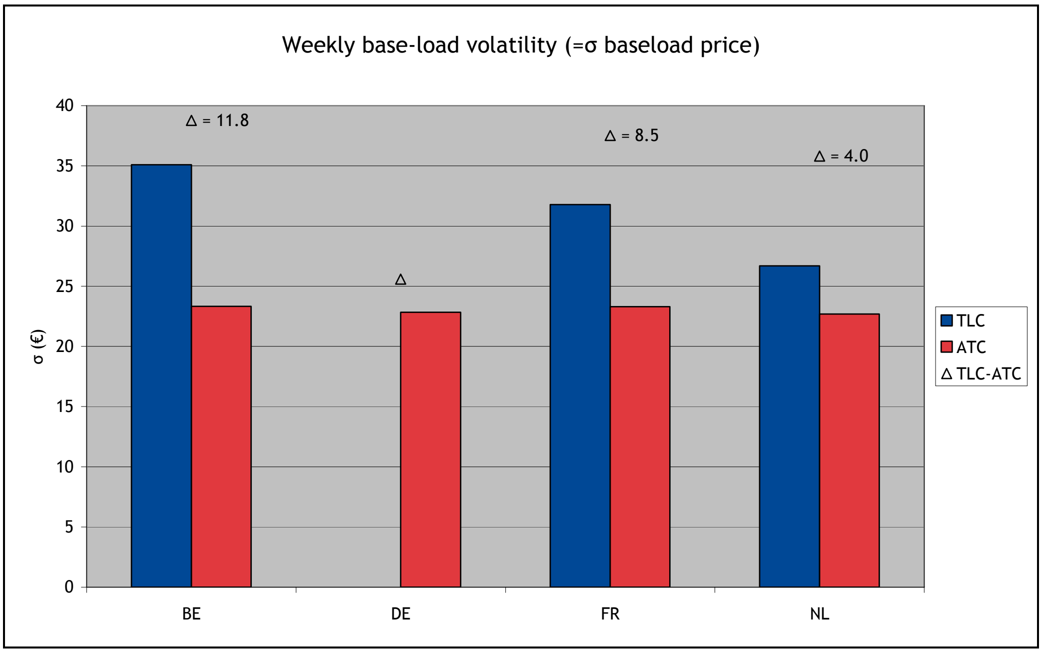




RESULTS
For each market, on most of the days, there is no significant difference between the base load prices in TLC and in CWE-MC under ATC. However, there exist a few particular days where the discrepancy between the base load price in TLC and in CWE-MC under ATC is important, with a lower base load price under CWE-MC than under ATC.

5.3.4.1.2 Comparison of price volatility TLC/CWE MC

The histogram hereunder shows for each TLC market the weekly base load price volatility in the TLC (historical data) and in CWE-MC under ATC (simulated), as well as the difference in weekly base load price volatility between the two market coupling ways.

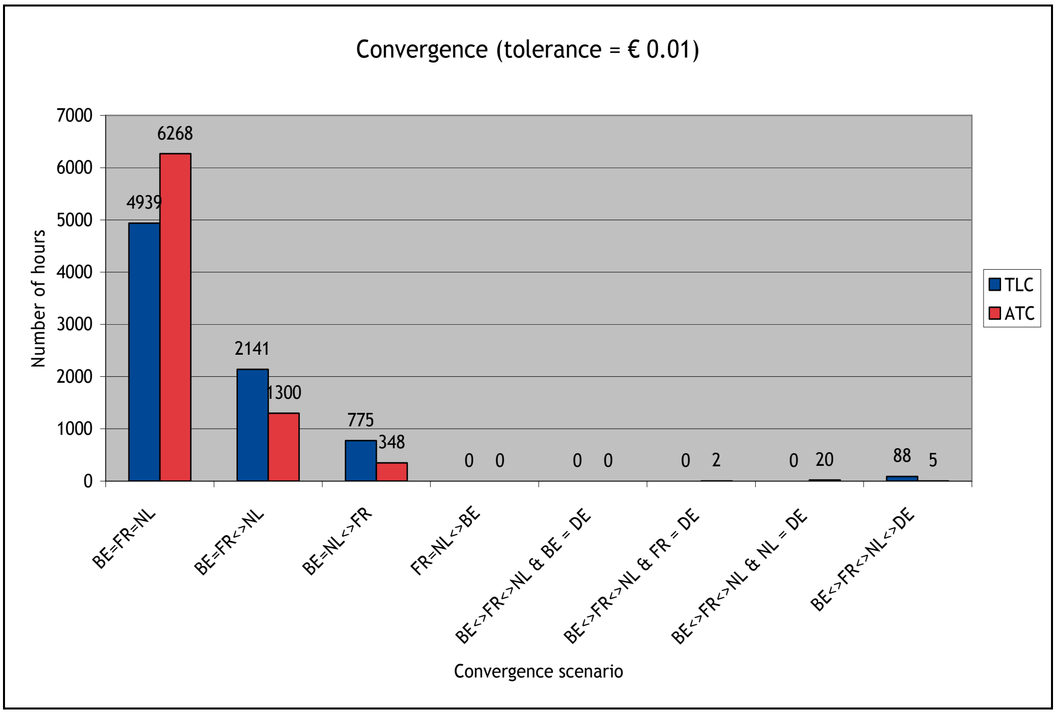


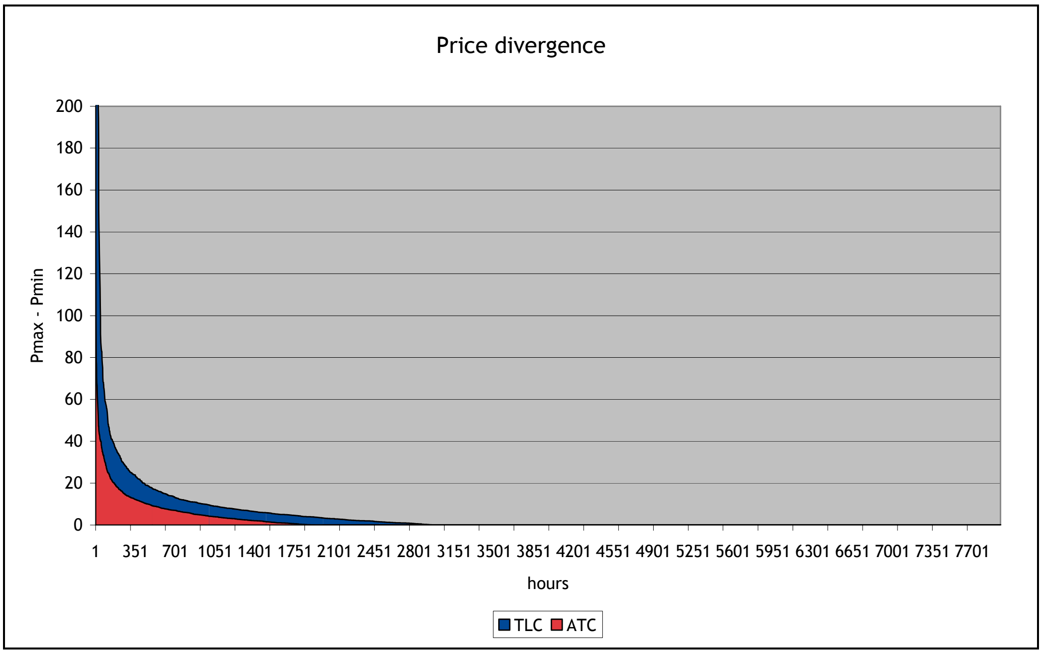
RESULTS
On each market, the results show lower base load price volatility in CWE-MC than in TLC (-11.8€ in Belgium, -8.5€ in France, and -4.0€ in the Netherlands).

5.3.4.1.3 Comparison of price convergence TLC/CWE MC

The first following graph shows both in TLC and in CWE-MC under ATC, the number of hours where the three TLC markets have the same price, two of the three TLC markets have the same price, all TLC markets have a different price but one is equal to the German price, all four prices are different. The tolerance used to consider that two markets have an equal price is 0.01€.

The second following graph shows the price divergence between the different markets, i.e. all price difference between the maximum price and the minimum prices of the three TLC markets ranked by decreasing order, both in the TLC and in the CWE-MC.

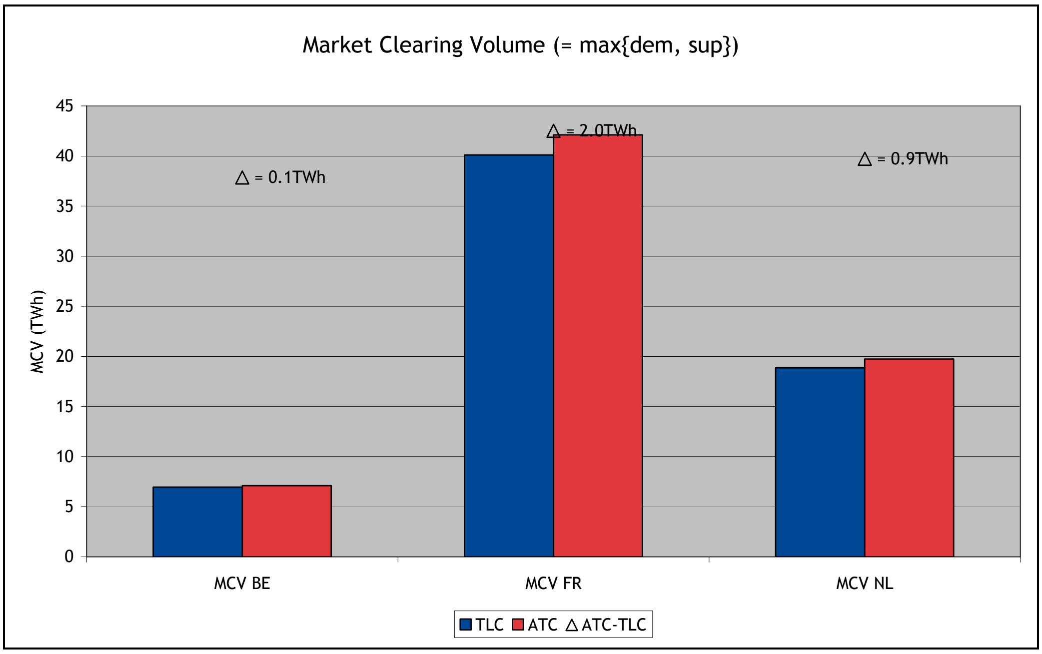




RESULTS
There are more hours with full convergence (i.e. 3 TLC markets with the same price) in CWE under ATC than in TLC. There are more hours with partial convergence (i.e. at least 2 TLC markets with the same price) in CWE under ATC than in TLC. There is also less price divergence in CWE under ATC than in TLC. The price convergence between the three TLC market prices is better in CWE under ATC than in TLC.

5.3.4.1.4 Comparison of market clearing volume TLC/CWE MC

The chart hereafter shows for each market the total market clearing volume in the TLC (historical data) and in CWE-MC under ATC (simulated), as well as the difference in volume between the two market coupling ways.

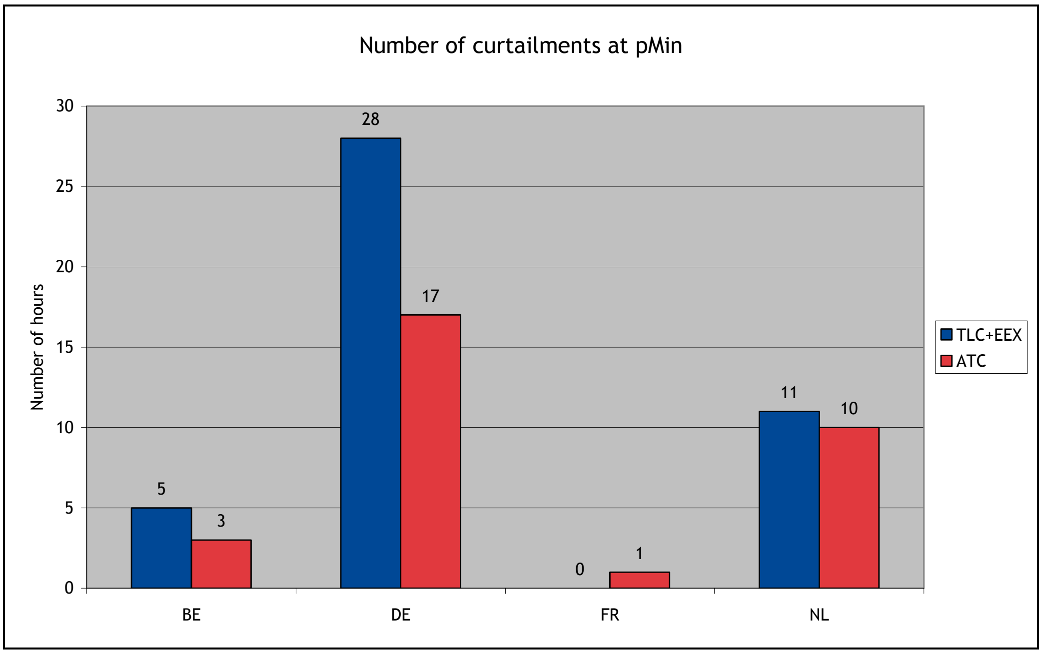


RESULTS

On each TLC market, there is an increase of the Market Clearing Volume between the TLC and the CWE-MC under ATC: +0.1TWh in Belgium, +2.0TWh in France, and 0.91TWh in the Netherlands.

5.3.4.1.5 Comparison of the number of curtailments TLC/CWE MC

The histogram hereafter shows the number of hours with curtailed volume for each market both in TLC and in CWE-MC under ATC.



RESULTS
The number of hours with curtailed volume is reduced in CWE-MC under ATC compared to TLC in the Netherlands (-1hour), in Belgium (-2 hours), and in particular in Germany (-11 hours).

In view of the results, with the CWE-MC under ATC, an increase of the market clearing volume, lower price volatility, better price convergence, and fewer curtailments are expected compared to the TLC.

5.3.4.1.6 Comparison of the social welfare between TLC and CWE MC (ATC based)

The aim of this analysis is to estimate the welfare that would have been gained if the German market would have been coupled to the three TLC markets through an implicit auction mechanism in 2007 .

For the historical situation, the welfare has been calculated with Cosmos using as input data the historical order books and the historical ATC at disposal for the TLC market coupling (i.e. the values of the ATC on the FR-DE and on the NL-DE borders have been set to 0). The historical simulations are thus only slightly different from the actual historical situation since they only differ by the algorithm used.

For the CWE-MC situation, in order to get a proper comparison, the computed scenario used as input data the same historical order books and the historical ATC but from which the daily nominated capacities on the FR-DE and on the DE-NL borders have been removed (i.e. the first reservation on the input data has been taken into account). In this case, the whole CWE region is ATC coupled but on the interconnectors to/from DE only the capacity which was not nominated in 2007 has been auctioned .

Compared to an explicit auction mechanism between TLC and EEX (historical situation), coupling the CWE-region with an implicit auction mechanism will produce an increase of the social welfare of 41.8 million Euros per year (this amount has been interpolated from the 318 days of data).

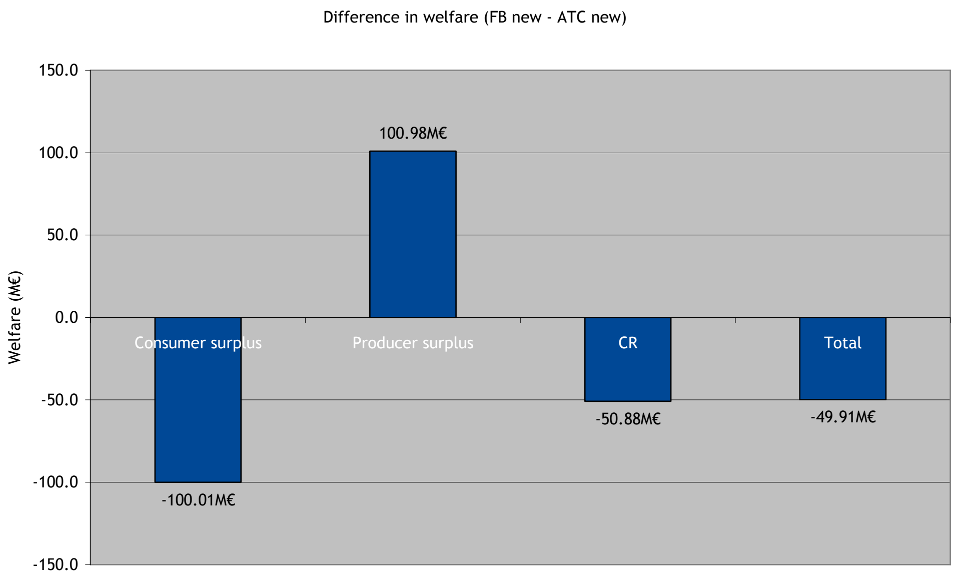
Please thus note that this amount only considers the change in welfare gained by the implicit auctioning of the "German borders", and does not take into account any externalities. The gain of value induced by a change of the algorithm has also not been taken into account.

5.3.5 Limit of the comparison

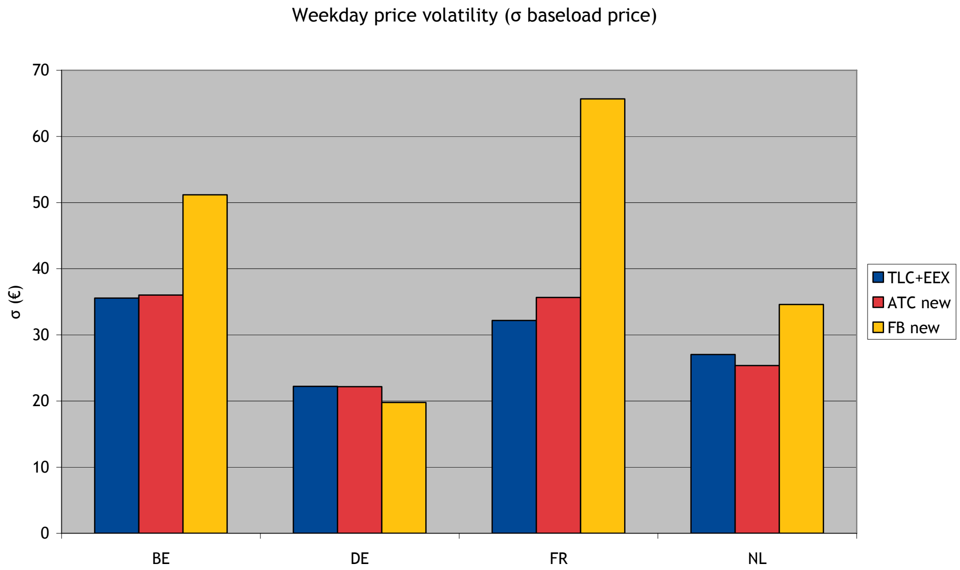
The effects of explicit auction on the historical order books were not removed from the historical order books for the simulation. Although it is difficult to assess which proportion of the order books should be removed in an implicit auction mechanism, it is expected to have an impact on all indicators.
The Project is currently studying how to correct the order books appropriately.
An assumption to take into account this bias in the order books is to remove from the price taking order volume of the exchanges at each side of a border an amount equivalent to the daily explicitly auctioned volume that has been nominated. Such a correction has been made on the cross-border interconnections FR/DE and DE/NL; the results obtained with such an assumption are currently being analysed, and a few of them are presented in the following paragraphs.

5.3.5.1 Limit of the comparison between flow based and ATC

The following charts show the difference in social welfare between ATC and FB mode as well as the price volatility per market, obtained under the abovementioned assumption ("ATC new" and "FB new" refer to the simulations where the order books have been altered according to the described assumption).



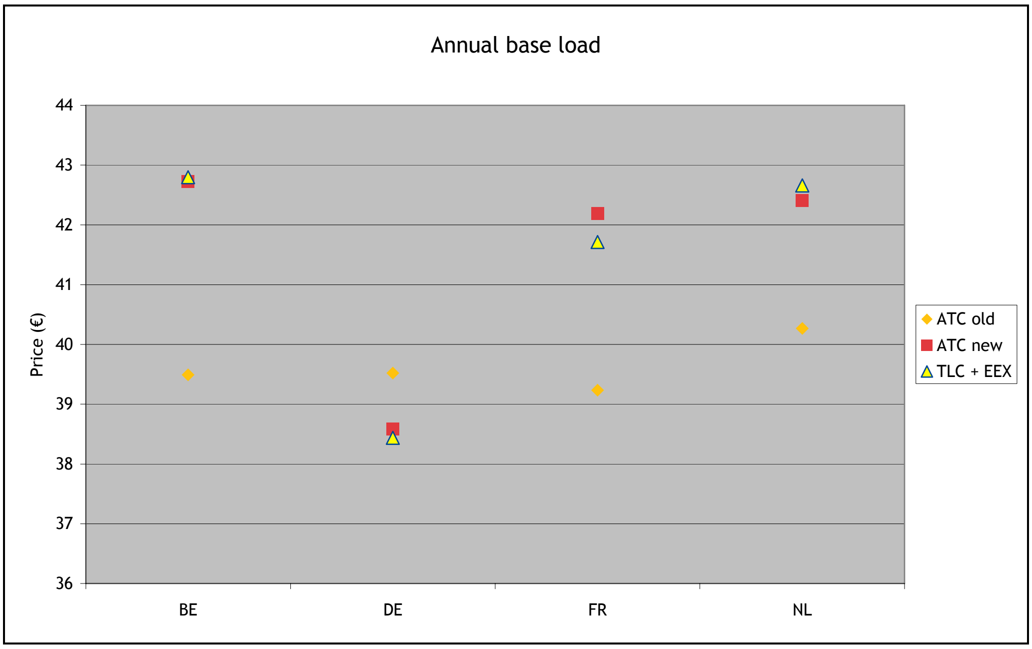
Under this assumption, it can be observed that the total social welfare difference is -49.91M€, i.e. larger as previously mentioned.



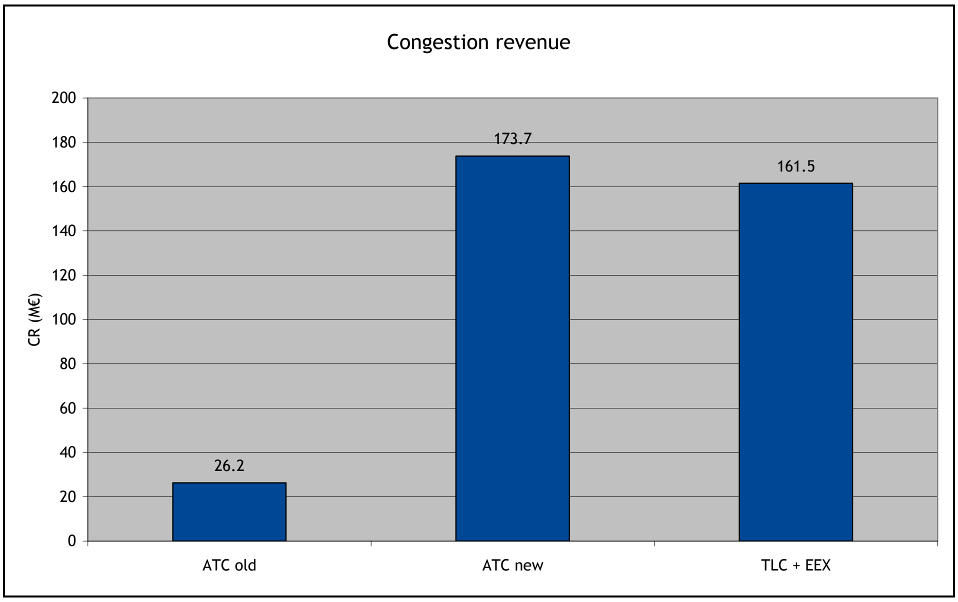
Under this assumption, it can be observed that the price volatility difference between FB new and ATC new is larger than previously.

5.3.5.2 Limit of the comparison between the historical situation and CWE MC under ATC

The following charts show the results obtained for the annual base load price as well as for the congestion revenue under this assumption ("ATC new"), compared to the results obtained with the previous simulation (i.e. without altering the order books) ("ATC old"), and the historical results ("TLC+EEX").



It can thus be noted that under this assumption, the observation on the very good price convergence between the prices on the different markets (all baseload prices between 39 and 40.5€) in CWE-MC under ATC would need to be revised. Also, under this assumption, the prices in CWE-MC under ATC would more or less be the same as under the TLC+EEX.



Under this assumption, the congestion revenue would also be strongly modified. By comparing the congestion revenue in the CWE-MC under ATC and in the TLC, the conclusion would no longer be a decrease of the congestion revenue of 135.3M€ (=161.5-26.2) but an increase of the congestion revenue of 9.6M€ (=173.7-161.5).

Therefore all abovementioned results are to be taken with care and appropriate reservation. Further investigations are foreseen to simulate different alterations of the order book to provide a more complete picture and a valid range for each market indicator.

6 Fallback arrangement

This chapter presents the high level description of the proposed CWE MC fallback arrangement. This arrangement came into the picture during the market parties consultation. Several other options have been examined, but are felt to be inferior. The alternative options are described in annex 4.

The proposed fall back arrangement is described in following sections:

- Fall back situations
- Principle of the fallback arrangement
- Definitions
- Product to be purchased by market participants
- Bids
- Database tool
- Sequence of operations
- Matching and price determination rules

6.1 Fallback situations

In the CWE MC procedures, a fallback situation occurs when the market coupling system operator declares that, for any reason, correct market coupling results (i.e. MC results fulfilling the check conditions) cannot be published before the critical deadline. This triggers the fallback procedure.

The fallback is caused by the failure of one or more processes in the market coupling session[17], that affect the completion of the Business process phase 2. In other words, the fallback is pronounced if no market coupling result can be calculated and validated before the critical deadline of phase 2. For instance:

- some market data may not be received,
- the algorithm, or the system on which it runs may fail,
- some protocol checks may return a "non compliant" result.

6.2 Principle of the fallback arrangement

The principle of the proposed fallback arrangement is to allocate the ATCs via a "shadow explicit auction" and a full decoupling of the PXs. This means an isolated fixing by the 4 PXs, performed after having reopened their order books.

The shadow explicit auction consists in:

1. maintaining a permanent data base where all pre-registered market parties (fallback participants) may file, amend or withdraw, bids for capacity. During normal operation, these bids are not used;
2. should a fallback situation be declared on a particular day, the fall back operator performs a fallback auction to allocate the available transmission capacities according to the merit order determined by the filed bids; from the time of the announcement of fall back, the participants are not allowed to update their bids: the fallback operator immediately freezes the fallback database.

1.

[17] (most of these failures are to be identified in the operational normal and back-up procedures)

Note that this solution requires the provision of ATCs. In the ATC-based coupling, these ATCs will be the ATCs calculated by the TSOs for the MC System. After the switch to flow based market coupling, the calculation of ATCs will be replaced by a calculation of flow-based parameters. Therefore, the TSOs will have to establish a methodology for the calculation of ATCs for the fallbacks.

6.3 Description of the product to be purchased by market participants

The fallback auction allocates Physical Transmission Rights (PTRs) for each direction across country borders and for each hour of the day when the fallback situation is declared. From the ATCs, as provided by TSOs, and from the fallback database, the fallback operator determines (through the fallback auction) the PTRs and the corresponding programming authorizations. The PTRs resulting from the auction may not exceed the ATCs. The unused programming authorizations are lost by the fallback participants (UIOLI).

Since PTRs and programming authorizations are only options, the fallback arrangement can not take into account any netting of opposed capacities.

6.4 Bids

6.4.1 Content

A bid entered in the fallback database contains the following information:

- the country border for which the bid applies (Belgium-Netherlands, Netherlands-Germany, Germany-France or France-Belgium),
- the direction in which it applies (two directions for each country border),
- the hour of the day for which it applies,
- an upper limit of the cross-border capacity to be acquired,
- an upper limit of the price to be paid for the said capacity.

Moreover, in the implementation phase the Project Parties may determine that each participant is allowed to submit a number of such bids differing from each other in their volume or their price. Bids appearing in the fallback database are unconditional and irrevocable. Bids are subject to functional acknowledgement of receipt. If the fallback operator does not issue a functional acknowledgement of receipt for a bid, the bid in question is deemed not to have been submitted.

6.4.2 Ticks and currency

Bids contain whole MW units, and Bid Prices in Euros per MWh expressed to a maximum of two decimal places.

6.4.3 Format

The format of the bids will be designed during the implementation phase.

6.5 Fallback database tool and bid submitters

The fallback database tool enables participants to submit bids, according to the conditions set out in the documentation available on the fallback operator's website. In particular, bids must be submitted in accordance with the formats defined in the said documentation.

6.6 Sequence of operations

1. Before launch of the CWE MC and at any time later on, market parties are invited to register to the fallback arrangement by means of entering into an agreement with the fallback operator. From then on, they become "fallback participant".
2. Fallback participants are allowed to enter bids into the fallback database and amend or withdraw them anytime except in frozen periods (see below).
3. TSOs provide the fallback operator with ATCs according to a yet to be determined procedure and schedule. In any case, ATCs must be made available to the fallback operator at 10:30h at the latest.
4. Should a fallback situation be declared by the Parties, the fallback operator immediately freezes the fallback database (fallback participants' access is suspended), and market parties will be informed. The access of fallback participants to the fallback database will be restored only at a later time (for instance after the cross-border nominations - to be determined in the implementation phase)
5. The fallback operator then performs the fallback auction : it determines the PTRs allocated to each fallback participant and the corresponding programming authorizations.
6. The fallback operator provides each fallback participant with its programming authorizations and with the prices resulting from the auction.
7. The fallback operator provides each TSO with all programming authorizations.
8. The fallback operator publishes transparency data, as defined in chapter 7
9. PX participants are allowed to change their position in the PX order books in function of the fallback situation. The PXs then match and publish their results separately.
10. Fallback participants may submit their nominations to TSOs according to the existing processes.

If the fallback situation was to be declared for several consecutive days, then the fallback database would be reopened once a day and one auction would be operated each day for the following day.

6.7 Matching and price determination rules

The fallback auction is performed for each country border, each direction and each hour, by the following steps :

1. The bids are ranked according to the decreasing order of their price limit.
2. If the total capacity for which valid bids have been submitted is equal to or lower than available capacity for the auction in question, the marginal price is nil.
3. If the total capacity for which valid bids have been submitted exceeds the available capacity for the auction in question, the marginal price is equal to the lowest bid price selected in full or in part.
4. The highest bid(s) received for a capacity requested which does(do) not exceed the available capacity is (are) selected. The residual available capacity is then allocated to the participant(s) who has (have) submitted the next highest bids price, if the capacity requested does not exceed the residual capacity; this process is then repeated for the rest of the residual available capacity.
5. If the capacity requested under the next highest bid price is equal to or greater than the residual available capacity, the bid is selected either in

full, or partially up to the limit of the residual available capacity. The price of this bid constitutes the marginal price.

6. If two (2) or more participants have submitted valid bids with the same bid price, for a total requested capacity which exceeds the residual available capacity, the residual available capacity is allocated in proportion to the capacity requested in the bids by these participants, in units of at least one (1) MW. The capacities attributed are rounded down to the nearest megawatt. The price of these bids constitutes the marginal price.

6.8 Schedule

A fallback situation may be declared at any time before publication of MC results. The fallback procedure will be unique, whatever its cause and whenever it is triggered. However, the timing of procedures may depend on the moment it is triggered: if known sufficiently in advance the timing will be adapted to the prevailing conditions, this will be communicated to the market as early as possible. The timings presented in this document correspond to the worst case, which is when fallback is triggered at the MC results' publication deadline.
In the worst case, i.e. when the fallback situation is declared at 13:05h, the table below shows the daily schedules in each concerned country. The underlying hypothesis are:

- The deadline for cross-border nominations (in France) is 15h30,
- The delay between publication of the market results and cross-border nominations[18] is 1 hour.
- 30 minutes are reserved to publish market results after the matching,
- 30 minutes are reserved for market parties to amend their orders on the PXs after the allocation of capacity.
- Sufficient time must remain for the TSOs to respect critical deadlines of the day ahead processes (e.g. UCTE, Intra day capacity calculation, margins calculation)

Process	Belgium	The Netherlands	Germany	France
Decoupling decision	13h05	13h05	13h05	13h05
Allocation results publication	13h30	13h30	13h30	13h30
PXs gate closure – Market results [19]	14h	14h	14h	14h
Market results publication [20]	14h30	14h30	14h30	14h30
Cross border nominations	16h30	16h30	15h30	15h30

6.9 Opening hours

The access to the fallback database is open 24h a day and 365 days a year, except for system maintenance periods, announced by the fallback operator 15 days in advance and for frozen periods, as introduced in §6.6.

1.

[18] as required by market parties during the consultation in May 2008
[19] Regarding GCT and publication of market results, the PXs make their best effort to coordinate the timings
[20] idem

7 Publication of data

This chapter describes the way in which the Project aims to provide the necessary level of transparency towards market participants of market coupling. The issue of transparency has been discussed with market participants during the consultations, organized in the beginning of May 2008. The results of those consultations have been taken into consideration by the Project. Where relevant, the results are presented on a high level in this chapter. For the full overview of all comments expressed in the consultation we refer to Annex 2

The transparency is explained in the next sections which are devoted to:

- Relation with Regulation 2003/1228
- Transparency under ATC based network constraints
- Transparency after migration to flow based network constraints

7.1 Relation with EU regulations

Transparency aspects are currently being regulated by the annex to the EC Regulation 1228/2003 (also known as Congestion Management Guidelines). These Guidelines put the obligation on TSOs to publish on their website a broad variety of data related to congestion management. The CWE regulators have published a report in which they further clarify how the requirements from the Guidelines should be interpreted. To the opinion of the Project Parties, it is the responsibility of the individual TSO to fulfill the requirements of EU regulations and the regulators report on transparency concerning the obligations imposed on TSOs. In this chapter we present the data which facilitate the market parties in their bidding behavior, as far as these data are being produced by the common MC systems (CCU and flow based systems). Since these additional data differ in the various countries, they will also differ in the CWE environment.

Having this said, it is clear that the individual TSOs may benefit from the market coupling publications by using these publications for their own responsibility to meet the transparency requirements as set out in EU regulations and in the Regulators transparency report. In any case, the publication of data by the MC Project is compliant to the relevant requirements of all regulations.

7.2 General information to be published

- A description of the working method of the implicit auction
- The high level description of principles governing the algorithm
- Fallback arrangements in case of decoupling

These documents will be published by the Project Parties.

7.3 Publication of data under ATC based market coupling

7.3.1 Publication of data before GCT

The relevant requirement from the regulator's transparency report is to publish for each hour of the day the day-ahead available capacity for the market. For the ATC market coupling, the project proposes to continue with the same publications regarding capacity as for the present time: ATC values on each border and for each direction.

7.3.2 Publication of data after market coupling calculation

The relevant requirements from the regulator's transparency report are the following:

- Capacity allocated (being defined by the commercial flow in implicit allocation schemes)
- Indication of the capacity value, given by the price difference between two hubs in implicit allocation schemes
- The total congestion income in CWE area and the sharing of congestion income of each TSO

These data will be published after allocation for each hour of the day and will be available for 2 years. This is a regulatory requirement, expressed in the regulator's transparency report.

In addition to the above data, it is the purpose of the MC Project to implement the publication of following data also in the CWE environment:

- Market prices: the market prices for each hour of the day will be published by the individual PXs for their hub.
- Aggregated supply and demand curves for each hour of the day will be published by the individual PX for their hub

7.4 Publication of data after the switch to flow based market coupling

7.4.1 Publication of data before GCT

In a flow based environment, the available capacity is not described by a single ATC value for each direction, hour and border. Instead, the available capacity is described for each hour by the network representation in terms of a list of critical branches, the margins (Fmax- Fref – FRM[21]) and the PTDF matrix. Since this presentation of the network may be difficult to understand, the Project aims to provide the level of available capacity in such way that it is understandable and useful for market participants. The way the capacity will be published is not yet decided upon. During the transition period, the Project Parties will discuss this together with market participants and with regulators, in order to reach agreement on the right publications. This parallel running will enable the market participants to better understand the implications of the flow based model and may result in changes to data that is published. However, at this stage the Project Parties consider the following publications, which were endorsed by the market parties during the consultations:

1. The list of constraints including critical branches, PTDF matrix and margins.

1.

[21] The FRM is the Flow Reliability Margin, i.e. the appropriate specific margin on each equipment necessary for the Security of Supply (SoS).

- The critical branches shall be anonymous, since the names of the branches, as well as the contingency cases, are confidential data and could be advantageous for dominant participants.
- On each critical branch, the physical margin (Fmax-FRM-F'ref) should be published to the market. It should be noted that this margin is the flow-based equivalent of the ATC, which means that the Project proposes at least the same level of transparency as nowadays.

2. A downloadable worksheet or web interface to simulate the impact of the flow based constraints on the market. This provides the opportunity to market players to enter a number of trades, and the worksheet will tell them if these trades are simultaneously admissible. Following trades shall be possible to fill in
   - By entering hub-to-hub exchanges[22]
   - And by entering net hub positions[23]

3. Simple indicators to easily visualise the network limitations. The Project proposes following indicators:
   - Maximum value on each hub-to-hub exchange in each direction, all other hub-to-hub exchanges being set to zero
   - Maximum net hub positions (+ and -) that is possible, given the set of grid constraints
   - Another example of a set of values (hub-to-hub exchanges and/or net hub positions) that are compatible with the Flow Based constraints. This set of values can be chosen automatically using a pre-determined key, e. g. the set of values that maximises the sum of all hub-to-hub exchange values (or of all net hub positions). The interest of this indicator is to make clear to the market players that the values given by indicators "a" and "b" are non-simultaneously admissible values.

When decided, these data will be published by the TSOs. The data will be accessible for two years.

7.4.2 Publication of data after market coupling calculation

Regarding the data that will be published after market coupling in the flow based mechanism we refer to section 7.3.2, since these data will be the same.

On top of that the Project considers to implement the publication, after the daily allocation, of following flow based data:

- the encoded name of the critical branch that has been constraining the allocation, if there is an active constraint, and the associated shadow price,
- The remaining available margin on each critical branch after the daily allocation

1.

[22] This means 2*6 values for each hour, since all virtual links between the 4 PXs will be represented, even if there is no physical link between the corresponding grids.
As an example, nowadays the grid constraints in CWE are represented by 2*4 ATCs for each hour.
[23] This means 2*4 values for each hour.

Before deciding, security matters, amongst others, need to be assessed.

7.5 Publication of data in fall back mode

The fallback operator should publish and update when necessary the following information on its website:

- auction rules
- names, phone and fax numbers and e-mail addresses of persons to be contacted at the fallback operator;
- the forms to be sent by participants;
- the ATCs for each auction;
- the data resulting from auctions, including the anonymous complete Bid curves;
- the number of participants having obtained capacity and the total number of participants having taken part in the auction;

8 Governance structure

The governance framework refers to a set of arrangements to ensure that the CWE market coupling is built and operated to the required standards and that the solution is able to support extensions to new countries. The high level objectives are amongst others:

- Market design standards able to facilitate European electricity market integration
- Efficient utilisation of the transmission network, consistent with network security
- Efficient price formation and development of robust wholesale markets
- Responsiveness to stakeholder requirements
- Transparency
- Extendibility

One can distinguish several levels in the governance framework ranging from agreements on the ownership of assets, to handbooks, containing very detailed daily operational procedures. The governance framework is usually established through a combination of regulations, agreements, contracts, procedures, handbooks and licenses, each describing a relevant piece of the framework.

In the next sections we describe the high level CWE market coupling governance framework according to the principles the Project Parties have agreed upon. The CWE Parties have decided to establish a set of collaboration agreements between different existing legal entities of the 4 PXs[24,] 7 TSOs and some external service providers. The main governing agreement will be the Framework Agreement. The signatory Parties to this framework agreement will be the 11[25] CWE Parties, 4 PXs and 7 TSOs. This framework agreement will establish the main tasks and responsibilities of the respective legal entities in the setup of the market coupling system and running its process on a daily basis. Subsidiary agreement necessary to implement the FA will also be needed. During the implementation phase, all necessary agreements, as well as procedures and handbooks will be drafted and agreed upon by which the governance structure will become clear in all its details.

The next sections are devoted to:

- The roles and responsibilities of the Parties
- The decision making
- Ownership of assets
- Switch to flow based

8.1 Roles and responsibilities of the Parties

In order to operate market coupling to the required standards, the Parties have agreed to allocate the involved tasks and actions to certain individual Parties or a subset of Parties. By doing so, it is ensured that all tasks and actions are performed by the most competent body, and are executed in an efficient way. One can distinguish the following actors:

1.

[24] The number of legal entities on the PX side is likely to be 3
[25] The number of legal entities will decrease to 10, once the merger between EEX and Powernext has been established.

- Individual TSOs
- Joint TSOs
- Individual PXs
- Joint PXs
- Joint Parties
- External service providers

In the next sections we will explain the roles of these involved actors.

8.1.1 Roles of the individual TSOs

The individual TSOs are responsible to define on a daily basis the day ahead capacity that is available on its borders for the operation of market coupling. This capacity can either be presented by an ATC value, or by the flow based parameters. The TSOs who will perform this are Elia, EnBW TNG, E.ON Netz, RTE, RWE TSO and TenneT TSO. Cegedel has no connection to the joint TSO system, and does not have a task in this daily process managed by each of the individual TSOs, since part of its grid is integrated in the control zone of Elia and the other part is integrated in the control zone of RWE TSO.

8.1.2 Roles of the joint TSOs

The joint TSOs are responsible to send the available capacity to the market coupling system. To do so, the joint TSOs will build a system that aggregates the individual grid constraint data and sends the aggregated file to the CCU.

The joint TSOs are also responsible for the calculation of cross border exchanges that result from the net positions. These cross border exchanges are necessary for the nomination of the cross border flows at each TSO.

At this moment it is under discussion whether or not the TSOs will establish a legal entity holding these systems.

8.1.3 Roles of the individual PXs

The individual PXs are responsible to collect all bids and offers from their participants, and to submit their aggregated and anonymous order books to the CCU. The 4 PX order books are transferred and injected directly into the CCU database. The order books contain all the bids of the market parties in an aggregated and anonymous format.

After the market coupling has been performed and the price has been set, the individual PXs are responsible for executing all orders placed by their participants that are within the calculated price, and to form the contracts with them.

8.1.4 Roles of the joint PXs

The joint PXs are responsible for building, operation and maintenance of the Central Calculation Unit (CCU). The CCU is the central computer on which the market coupling algorithm will run on a daily basis to calculate the net positions, market prices and accepted block bids on the different hubs. This is an all in service of the joint PXs delivered to the market coupling Project Parties.

8.1.5 Roles of joint Parties

The PXs and TSOs are together responsible for the management of the market coupling solution. Decisions regarding the solution will have involvement of all Parties in some way. In order to perform this task, the Parties will set up several committees, among which a joint steering committee and an incident committee. During the implementation phase, it may be decided to implement other committees as well.

8.1.6 Roles of external service providers

In order to operate an efficient market coupling, the Project Parties have decided to outsource a number of tasks to external service providers. The tasks involved are:

- Shipping agent activities (electricity purchase, physical delivery, financial settlement/congestion revenue collection). At the moment it has not been decided yet to whom these tasks will be outsourced. The option currently being evaluated is that these activities would be performed by the clearing entities of the PXs.
- Reception of congestion rents and distribution to the individual TSOs. The option currently being evaluated is that this service would be rendered by CASC.

8.2 Decision making

In order to manage the market coupling process, decisions need to be taken each day. To do this efficiently, the Project Parties have decided to authorize certain individual Parties or a subset of Parties to take certain decisions. By doing so, it is ensured that the decision making process is efficient and effective.

One can distinguish the following decision makers[26]:

- Joint decision by the eleven Parties
- Joint TSO decision
- Joint PX decision
- Joint TSO decision with PX approval
- Joint PX decision with TSO approval

The decisions to be taken are grouped in 4 categories. These categories are:

- Decisions regarding the MC systems (assets)
- Decisions regarding MC procedures (assets)
- Decisions regarding the MC operations
- Decisions regarding the extension of the region

In the subsections below, the joint decisions, being the most important ones, are further explained, as well as decisions regarding the CCU (joint PX decision) and regarding the extension of the region (joint TSO decision)

8.2.1 Joint decisions by the Parties

The most important decisions regarding the market coupling are taken by the eleven Parties together. For that purpose the Parties will implement a Steering Committee that will be active during operational phase. It may be that the Parties

1.

[26] For the full picture it must be stated that that there are also decisions to be taken at the local level. In this case, the individual PX or TSO is the decision maker, or the decision is taken together by those Parties. However, in this overview, these decisions are left out

will implement additional joint committees, such as an operational and an incident committee, in order to manage the market coupling efficiently and effectively.

The Steering Committee will have the powers to decide on following subjects:

- MC system requirements (including algorithm requirements, overall requirements,…)
- MC interface specifications
- MC solution functional architecture
- MC operational procedures
- Yearly budget to operate and maintain the MC system
- Joint change control process
- Share of costs between Parties
- Manage operational performance of the MC solution
- List of key activities that cannot be outsourced
- Incident management

Basically, these decision making powers enable the Steering Committee to decide on the design, construction and future modifications to the market coupling system and the necessary budget for that. It must be noted that a change to any system (individual PX, individual TSO, joint TSO, MC system) with a potential impact on the functioning of the CWE market coupling will be handled through the change control procedure. According to this procedure, changes must be transparent and upfront mutual consultation is mandatory. The implementation of the change is subject to compliance with the market coupling requirements. The change control procedure allows a party to refuse the change if "reasonable ground" for objection exists. A change implying adaptation of other Parties' assets will oblige those Parties to undertake reasonable effort to make such changes.

8.2.2 Decisions regarding the CCU

Since all operational tasks regarding the CCU (building, operation and maintenance) are outsourced to the joint PXs, the joint PXs have the powers to take the necessary decisions in order to perform their task. In that perspective the PXs can decide on the specifications of the CCU, on the appointment and removal of CCU service providers, the acceptance criteria of the CCU delivered, the CCU working instructions and so on. It must be noted however, that the CCU that will be in place and be operated by the PXs, need to meet the quality standards as set by joint Parties.

8.2.3 Decisions regarding extension of the region

The extension of the region is primarily a joint regulatory and TSO decision. By doing so, it is ensured that potential regulatory and legal frameworks regarding market integration can be discussed and agreed upon between the Parties to whom such frameworks are applicable: the TSOs. However, it has to be acknowledged that a decision to extend the region to another country, will have an impact on the MC systems and contracts between the eleven Parties. Therefore, the execution of a TSO decision to extend the region is a matter of the eleven Parties together, and decisions regarding that execution are taken jointly. All Parties are obliged to undertake reasonable efforts to make the extension happen. Nonetheless Parties have the ultimate right to exit.

8.3 Ownership of assets related to the algorithm

Being its producer, Belpex is the original owner of the COSMOS algorithm. It has been agreed that the algorithm assets will be co-owned by the PXs. For this purpose, a specific agreement is being negotiated. In the capacity of co-owners, the PXs can decide about the future strategy of the algorithm (in terms of future development, future application). However, potential changes to the algorithm that is used in CWE market coupling will follow the change control procedure, managed by the Parties jointly.

The TSOs will not own the algorithm assets, but they will individually receive the necessary rights through a licence, according to their own requirements. For instance, such license will enable them to fulfil potential regulatory requirements (transparency). Specific terms have been negotiated between PXs and TSOs and will be translated into contracts between the individual TSOs and the co-owners of the algorithm assets.

8.4 Required modifications due to switch to Flow Based Model

In terms of governance, all agreements will foresee the switchover at a certain moment in time from the ATC based model to the flow based model, without having to renegotiate aspects of the contracts. The governance principles foresee that the TSOS can jointly decide to switch model, but that PXs and TSOs shall study the effects together in order to come to a proper solution to avoid unexpected effects on markets.

9 Cost recovery

This project aims at improvement of the functioning of the electricity markets and the facilitation of cross border exchanges in the CWE Region, while maximizing social welfare. The CWE Project Parties, contributing to the realization of regional CWE Market Coupling, are pre-financing financial and other resources in the setup of the necessary systems and processes. The project design phase is currently reaching completion, and implementation phase will soon start. It is therefore important that the model for pre-financing and cost recovery is outlaid.

During the implementation phase, not only new joint systems but also adaptation of existing local systems and processes have to be performed in order to be able to run the CWE Market Coupling. During the operational phase, some CWE Project Parties will perform tasks in the daily operations of CWE Market Coupling and its necessary maintenance processes.

This chapter outlines a proposal for the principles of such a cost recovery model to the regulators of the CWE countries, covering both the implementation phase and the operational phase of the CWE Market Coupling. Complementary to the principles of the model, the CWE Market Coupling Project Parties will inform the regulators of a cost budget.

9.1 Main assumptions underlying the cost recovery model

9.1.1 The CWE Community is the main beneficiary of CWE Market Coupling

The CWE Market Coupling Project Parties consider the CWE Market Coupling project as a service rendered to the CWE community in order to achieve the best possible use of grid infrastructure and reach the highest possible electricity market efficiency in the CWE region.

The CWE community is the main beneficiary from CWE Market Coupling. The community will thus be requested to cover the costs for setting up and operating the CWE Market Coupling systems to the extent these costs are accepted by the regulators in compliance with their local tariffs procedure and under the conditions described below.

9.1.2 Principles of efficient resource allocation

9.1.2.1 Efficient task allocation

In view of reaching maximal cost efficiency, the CWE Project Parties have divided the work for the different project phases between themselves. In the first place, efficiency originates from a task allocation that is building upon the core competences and existing tasks of PXs and TSOs. The PXs contribute by bringing in the use of their existing markets, and their daily activity of matching energy orders and price determination. The TSOs contribute by bringing in cross border capacity and their competence in grid constraints, transmission rights allocation for congested borders and grid security management.

The detailed description of the business processes, the tasks and functions can be found in this report. As a short summary we can state the following:

- The CWE Project Parties decided that the PXs will jointly build, operate and maintain the Central Calculation Unit (CCU) since the CCU activities are almost entirely tasks that are required by the PXs anyway (such as matching of energy orders and price formation); a few activities may, however, relate exclusively to the Market Coupling. The PXs will organise the setup and operational tasks between themselves.
- Transmission system operators (TSOs) will on the other hand build, operate and maintain joint TSO systems as a service to CWE Market Coupling:
    - The grid data aggregating system that will receive the individual TSOs grid data (ATC / Flow Based Data) and will deliver the aggregated grid constraints to the CCU. The party hosting this joint TSO system is under discussion and is still to be defined between TSOs.
    - A second joint TSO system, called bilateral exchange calculator, shall determine the bilateral cross border programs out of the net positions. It could potentially nominate the program to the individual TSOs on behalf of the shipping agent (see further). The party hosting this joint TSO system is under discussion and is still to be defined between TSOs.
- TSOs have to provide grid data on a daily basis to the CCU and therefore have to adapt their local processes and systems.
- TSOs have to implement a fallback mechanism for the allocation of capacity in case of decoupling
- PXs have to provide order book data on a daily basis to the CCU and therefore have to adapt their local processes and systems.
- The joint TSO company CASC will be the recipient of the congestion revenue in the name of the TSOs and will distribute the congestion revenue to the TSOs.
- The shipping agent(s) will ship the energy related to the net positions across the borders, collect the congestion revenue and payout this revenue to CASC, in exchange for transmission rights received on the implicit allocated cross border capacity. Expenditures related to the shipping agent role will be pre-financed by the Project Parties.
- Other service providers: For certain tasks, the CWE Market Coupling Project Parties decided to appoint service providers, both during project phase and during operational phase. External service providers have to be compensated for their tasks and thus pre-financed by a/some CWE party/ies.

9.1.2.2 Maximal use of existing systems, processes and remuneration mechanisms

Setup of system components for CWE Market coupling is in many cases incremental on existing systems of PXs and TSOs. This does however not exclude the obvious necessity to setup new building blocks of the system, such as the CCU and the joint TSO systems. The model presumes that for the newly built systems, costs will be entirely recovered; for changes to existing systems, only incremental costs will be recovered.

Each contributor to the setup of the CWE Market Coupling expects fair compensation for the services rendered for CWE Market Coupling. Parties pre-financing the setup shall be compensated by a reimbursement through the cost recovery mechanism.

Operations and maintenance are to the best possible extent integrated and aligned with existing activities, notwithstanding the fact that some new business processes and activities will have to be setup specifically for the CWE Market Coupling. Parties taking up tasks in the operations and maintenance of the Market Coupling system during operational phase, will get compensated through fees that will be recovered as much as possible from the cost recovery mechanism. For CWE MC specific tasks, the full cost will be presented for recovery.

9.1.2.3 Maximal use of internal resources

To the best possible extent, CWE Market Coupling Parties intend to use internal resources, for reasons of quality and cost efficiency. However, for some activities, external service providers have to be hired and pre-financed by one or more Parties.

9.1.3 Each PX recovers its costs via the local TSO(s)

The PXs propose to seek cost recovery via their related local TSO(s) through the cost recovery mechanism. The CWE Market Coupling Project Parties acknowledge that power exchanges can thereto be involved in cost recovery discussions with the energy regulators.

9.1.4 Cost recovery TSO through the local mechanism

The CWE Parties will inform the regulators of a reasonable cost budget for the implementation phase and operational phase. Local regulations and legal frameworks will determine the procedure and timing of budget discussions and cost acceptance. Thus, the mechanism by which the community will ultimately cover those costs (e.g. from congestion revenue versus grid tariff) in a particular country is a local regulatory decision, in the context of local regulations and legislation.

The CWE Parties highlight the fact that the cascading of costs outlaid in the recovery model in this paper implies the application of sharing keys between the CWE Market Coupling Parties. Those sharing keys will also be presented to each individual regulator, acknowledging that those sharing keys create interdependency between the individual regulator’s acceptance processes.
It is vital that CWE Market Coupling Project Parties have adequate assurance on endorsement of the cost recovery model ahead of the implementation phase. If this is not given, they will put the project on hold until such assurance is granted.

9.2 Main cost origins and cost cascading

9.2.1 Local cost recovery discussions PX / TSO(s) / regulator

The general principle of the proposed recovery scheme is that all costs rendered as a service or an investment for CWE Market Coupling are first pre-financed by one, some or all CWE Project Parties. The Parties seek then for cost recovery of their pre-financed sums, in a second stage.

If the service or the investment was made as a common cost (see definition below) the pre-financed sum is shared between the involved Parties via a settlement process. This settlement happens applying a sharing key defined in advance between the concerned Parties. Some examples are given below:

- The project management cost in the implementation phase is an all party cost. The pre-financing is started over one TSO in the country where the project management company is located. This TSO shares this pre-financed sum with the other CWE Project Parties according to a predefined sharing key, so that all Parties pre-finance this sum together

- The CCU building, operation and maintenance is a joint PX responsibility. 1 PX starts pre-financing the CCU building and shares the pre-financed sum with the other PXs according to a predefined sharing key, so that all PXs pre-finance this sum together
- The ATC or Flow Based system and Bilateral Exchange Computation system is a joint TSO responsibility. 1 TSO pre-finances the building of the systems and shares the pre-financed sum with the other TSOs according to a predefined sharing key, so that all TSOs pre-finance this sum together

The allocated share of the pre-financed common costs is invoiced to each of the concerned Parties, which pay their invoice accordingly. This common cost share is added to the local costs of that particular party. Through the local cost recovery mechanism, the Power exchanges invoice their costs to their respective TSO(s) so that at the end all CWE related costs accumulate at the level of the local TSO.

This model assures that the cost recovery discussion can happen always on a local level between the PXs and/or TSOs and the local regulator. For Germany, where the relationship PX-TSOs within the CWE Market Coupling Framework is 1 to 3, an extra sharing arrangement will be made between the relevant Parties for the German market.

9.2.2 Common costs originating from activities under multi-party responsibility

In the common costs we distinguish two categories:

1. Pre-financed costs originating from all party responsibility: the CWE Project Parties will share these costs equally between the CWE Project Parties.
2. Pre-financed costs originating from joint party responsibility. This concerns essentially joint PXs or joint TSOs responsibilities

    - PXs will share joint PX costs equally between market areas, i.e.
        - APX: 25%
        - Belpex: 25%
        - EEX and Powernext together: 50%
    - TSOs haven’t decided yet about the sharing rule they will apply to joint TSO costs

However, in some particular cases other combinations of Parties could engage in so called subprojects. Those subprojects generate costs are that supposed to be shared between the concerned Parties. In case of such other combinations of Parties, e.g. in the framework of subprojects, the sharing rule between the concerned Parties will be defined on an ad hoc basis.

Although multi-party in nature, common costs are in most cases paid at first by one party, which will request for sharing of the pre-financed sum via the agreed sharing rule. In some cases all participating Parties pay their share of the pre-financing directly.

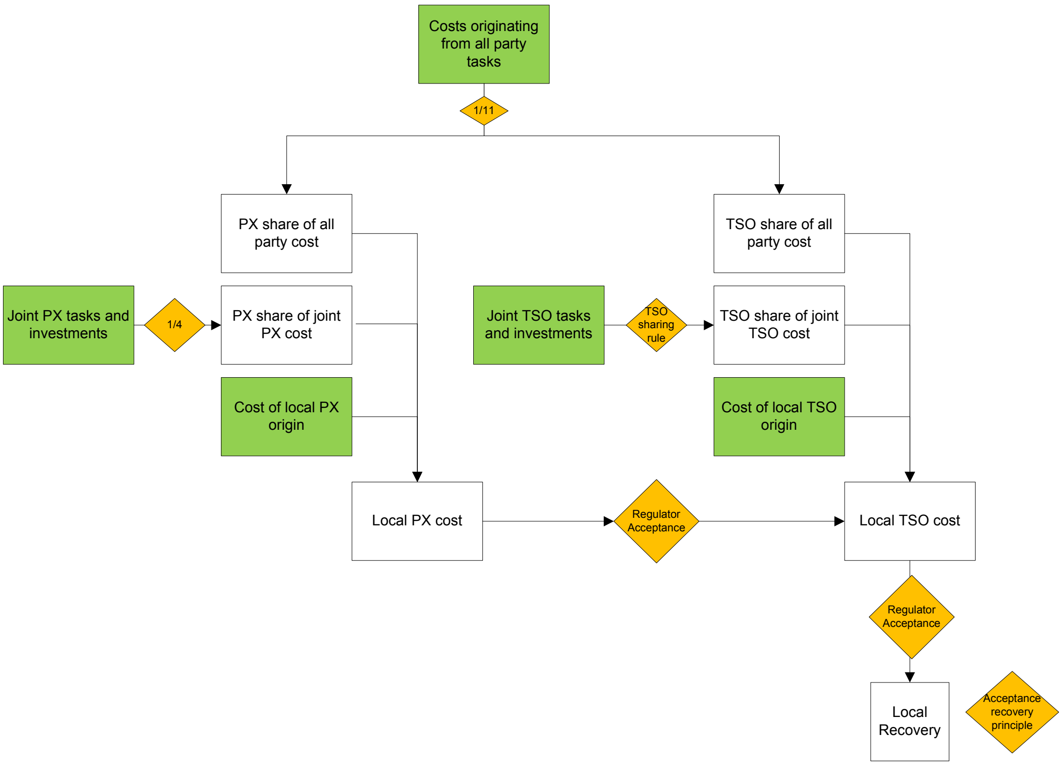
9.2.3 Costs originating from one party’s local activities

Non common costs originating from one party’s local activities, but necessary to perform CWE Market Coupling, are pre-financed by that party directly. Those local costs are entering the local recovery discussion with the local regulator directly.

The share of common costs borne by a party adds up with its locally incurred costs and forms the total amount to be recovered for that party.

9.2.4 Cost cascading down to local TSO level

The graph below shows the principles of cascading of pre-financed costs down to the local TSO level. The source of the costs is shown in the green boxes. The sharing rules where endorsement of each individual regulator is needed, and the instances where local regulator acceptance on costs is needed, are indicated in the orange boxes.



The CWE Market Coupling Parties acknowledge that in the case of subprojects, with other combinations of CWE Market Coupling Parties, the cost share pre-financed by each party involved in the subproject is a common decision and adds to the local costs of this party too.

9.2.5 Regulator Acceptance

CWE Market Coupling Parties request endorsement on the cost recovery mechanism outlined in this note ahead of the implementation phase by each regulator in compliance with the local regulation and legislation.

Local regulations and legal frameworks will determine the procedure and timing of budget discussions and cost acceptance.

9.3 Principles

The nature of the costs incurred is different in the different project phases. There are clearly identifiable, incremental costs associated with the initial setup of the CWE Market Coupling (and similar costs in the case of future investment).
The proposed principles are as follows::

1. Design phase: (almost finished)

    - Project organization costs
    - All party workstream costs : Costs for design and specification work, legal and governance principles, regulatory, …
    - Effort participating in the project process e.g. meetings, document review,…

2. Implementation phase - initial Market Coupling system setup:

    - Project organization costs
    - Subproject costs : Investments in systems, setup costs for processes
    - All party workstream costs: legal agreements, regulatory, …
    - Effort participating in the project process e.g. meetings, document review,…

3. Operational phase:

    - Daily operations and periodic maintenance cost.
    - The cost of firmness of transmission capacities and net positions resulting from market coupling with the exception of Force Majeure.

4. Future Investment/Substantial work during operational phase:

    - Future changes to the system, substantial work

In the operations of the CCU, there are broadly two types of costs:

1. Utilisation of existing services or investments, where the cost can be based on the fees charged for equivalent services, for example:

    - PX Matching
    - Clearing and settlement arrangements

2. New activities or services, specific to market coupling, for example:

    - Market coupling simulation tool
    - Shipping agent services

9.4 Future investment or substantial work

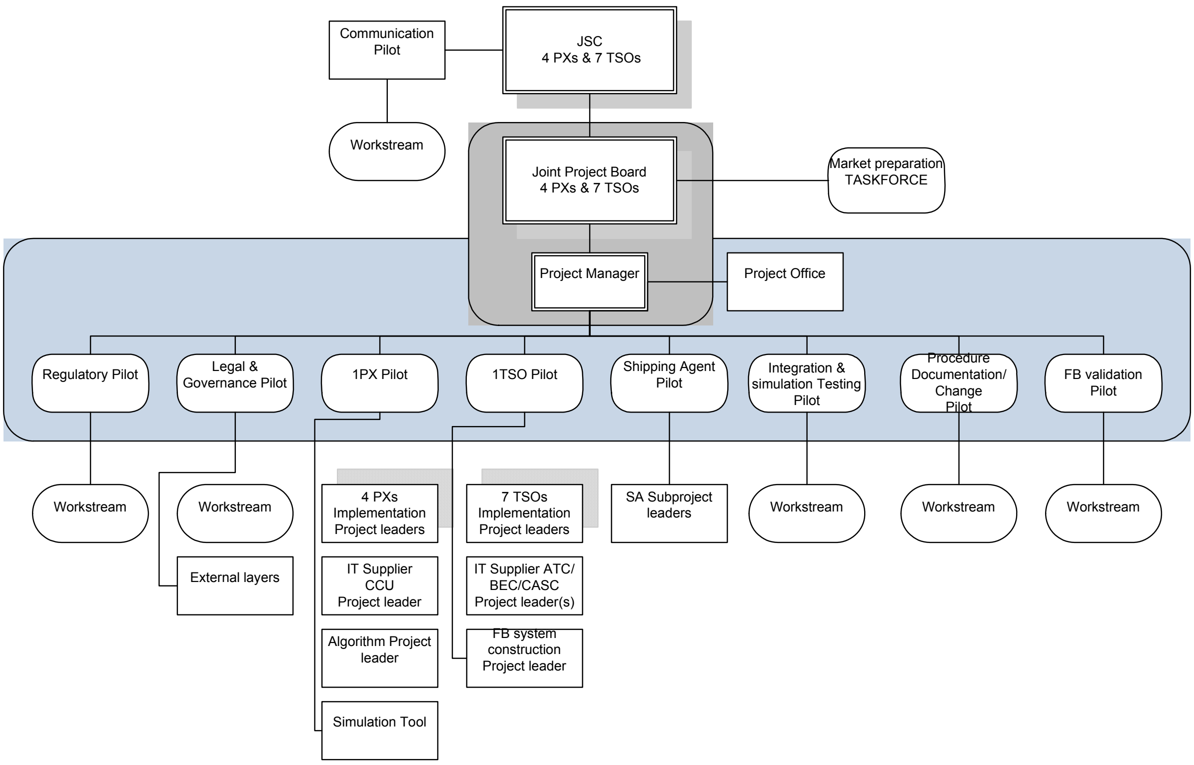
Future substantial work or investment in the CWE Market Coupling system (e.g. extension of the region), occurring during the operational phase, cannot be covered by the regular service fees of the operational phase and will need cost recovery discussions at the moment the decision for those works or investments is made.

10 Implementation plan

In this chapter we present the preliminary top down implementation approach for organization, planning and budget. During the pre-implementation phase the Project Parties will produce a more detailed bottom up planning and budget for the implementation phase. This information will be provided by the end of October 2008.

10.1 Project organization

The picture below presents the project organization the CWE Parties will setup during the entire implementation phase (pre-implementation and effective implementation).



10.2 Planning

The planning of implementation phase will exist in two different stages:

- **the pre-implementation**: from 1 September 2008 until 30 November 2008. This phase will contain the following works:
  - o selection and recommendation of the IT vendor for the CCU
  - o preparation of all the organizations for the implementation
  - o project organization setup
  - o bottom up planning and budgeting
  - o reaching regulatory endorsement on costs recovery principles, ATC based MC solution, and process to go to flow based market coupling
  - o design of the parallel Flow Based system

- **the effective implementation phase of ATC based solution**: from December 2008 until the launch of market coupling, which is in as much as possible foreseen towards the end of 2009. This phase will consist of the following works:
    - roll out of all the individual and joint systems
    - testing of all the systems on a local basis
    - integration testing of all the systems
    - writing the detailed operational procedures (normal, back up, fall back), and testing them and training operators
    - implementation of the parallel flow based system
    - information and education of market participants
    - drafting contracts

The transition period will start at the launch of the ATC based market coupling and will continue until the switch to flow based. During the transition period the flow based system will run in parallel and its behavior will be closely monitored. In addition, market participants will be informed and prepared for the introduction of flow based market coupling.

10.3 Budget

The best possible budget estimate from the CWE project at this stage looks as follows:

- Common Cost Design phase:
    - Design phase ends 1 September 2008
    - Common costs were initially budgeted at €3,5 Mio
    - The currently foreseen best estimate for the common cost of design phase is 2 Mio €
- Common Cost Implementation Phase:
    - The common project organization cost for implementation phase including pre-implementation is budgeted at €4.7 Mio
- The total cost for CWE design and implementation, including local costs is €26 Mio

A detailed bottom-up budget and plan will be provided at the end of October 2008, once the project organization is in place and once the price for the IT costs for the CCU will be known in detail, based on the offers of the vendor candidates.