Project Document

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

January 2010

Management summary

After signing the Memorandum of Understanding of the Pentalateral Energy Forum on market coupling and security of supply in the Central West European region, the TSOs and PXs of that region put in place a project that was tasked with the design and implementation of the market coupling solution.

At the moment, the TSOs of the project have sent, or will do so in short time, a dossier for formal approval of the solution according to the national regulatory framework. The purpose of the at hand report is to provide to all regulators of the CWE region a set of information regarding the final solution in order to facilitate their local approval procedure. Since formal approval is, or will be asked for the ATC based market coupling solution, this report covers the market coupling solution, as well as the coordinated ATC determination process.

The CWE Market Coupling Solution

During the daily operation of market coupling the available capacity will be published at 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 case results cannot be calculated by that time, the fall-back mechanism for capacity allocation will be applied and there will be a decoupling of the PXs. As a fall-back mechanism, the TSOs have implemented 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 and that the calculation of flows to adjacent regions takes a maximum of 20 minutes.

The solution is operated via a set of connected systems. These systems are operated by TSOs, jointly or individually, PXs, jointly or individually, CASC-CWE and clearing houses. Daily operations consists of 3 phases: provision of network data, calculation of results, and post publication processes.

Fall-back arrangement

In the CWE MC procedures, a fall-back situation occurs when the market coupling system operator declares that, for any reason, correct market coupling results cannot be published before the critical deadline.

The principle of the proposed fall-back 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.

Roll back

If an incident which has triggered the fall-back solution cannot be found or solved, the Steering Committee can decide to start the roll back procedure. This procedure will only be available for a maximum of two month after the launch of market coupling. However, if roll back must be applied, it will be in operation until the incident has been found and solved.

Roll back solution on German borders will be the explicit auctions operated by the shadow auction system. In roll back, a bank guarantee will be required from market parties. On the Belgium borders, capacity will be allocated by an implicit auction with a gate closure time of 12.00h**.**

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 future couplings.

Capacity determination

The TSOs have designed a coordinated procedure for the determination of capacity. This procedure consists of five steps that will be followed after each TSO has determined its capacity like today. The procedure is:

- NTCs are determined like today, independently by each TSO
- NTCs are shared among all CWE TSOs
- A common grid model is created
- Each TSO can then apply the common grid model in order to perform a decentralized grid security analysis
- In case potential security problems are detected, the NTCs are adjusted in a coordinated way.
- From NTC to ATC

This method has now been experimented for several months. During the experimentation of the method in July and August, the TSOs used minimum capacity values that are coherent with the values proposed by CREG on the Belgian borders (BE -> FR 600 MW; FR -> BE 1700 MW; BE -> NL and NL -> BE 830 MW), and by the Dutch Gridcode (Total NTC = 1800MW). These minimum values have not been hit during this experimentation period.

Economic Assessment

Extensive validation studies have been performed by the project parties, showing positive results. Among others, the studies show an increase in social welfare for the region of 43.2M Euro on an annual basis. Also price convergence in the whole region improves significantly.

These calculations were performed, using historical ATCs. In order to improve the validation, the project parties will do additional analysis using the capacities resulting from the coordinated ATC procedure. These results will be available by the end of February and will be sent to various stakeholders.

Transparency

The project parties will publish various operation data and documents related to ATC based market coupling, in compliancy with European regulations and the ERGEG report on transparency. These publications will support market parties in their behavior and facilitate en efficient functioning of the CWE wholesale market.

1 Introduction

After signing the Memorandum of Understanding of the Pentalateral Energy Forum on market coupling and security of supply in the Central West European region, the TSOs and PXs of that region put in place a project that was tasked with the design and implementation of the market coupling solution. Along the way, the Project Parties presented four reports to their stakeholders, in which they explained the flow based market coupling solution as it was known at that time. These reports are the Orientation Study, the Progress Report, the Implementation Study, and the Implementation Study Addendum.

Work has progressed and the market coupling solution has become clear in detail. At the moment, the TSOs of the project have sent, or will do so in short time, a dossier for formal approval of the solution according to the national regulatory framework. The purpose of the at hand report is to provide to all regulators of the CWE region a set of information regarding the final solution in order to facilitate their local approval procedure. Since formal approval is, or will be asked for the ATC based market coupling solution, this report covers the market coupling solution, as well as the coordinated ATC determination process. It is further explained in the following chapters:

- The general principles of market coupling
- The CWE market coupling solution
- The fall-back solution
- The roll back solution
- The functioning of the algorithm
- The network models
- The economic validation
- The publication of data
- The contractual scheme
- The congestion rent sharing key
- The calculation of bilateral exchanges

Obviously these chapters are based on the documents that were previously published. They were updated where necessary.

The project parties wish to emphasize that the final goal still is the implementation of flow based market coupling. Work in that field is being carried out and discussions with the regulators on related topics will continue. For the approval of the flow based solution, the TSOs of the project will file in due time a second dossier to their regulators for formal approval of the flow based solution. For information purposes these files will also be accompanied by a document explaining the flow based solution, and presenting the final results of the parallel run.

2 General principles of market coupling

2.1 General principle of market coupling

Market coupling is both a mechanism for matching orders on power exchanges (PXs) and an implicit cross-border capacity allocation mechanism. Market coupling optimizes the economic efficiency of the coupled markets: all profitable deals resulting from the matching of bids and offers in the coupled hubs of the PXs are executed; matching results are however subject to capacity constraints calculated by Transmission System Operators (TSOs) which may limit the flows between the coupled markets.

Market prices and schedules of the connected markets are simultaneously determined with the use of the available capacity defined by the TSOs. The transmission capacity is thereby implicitly auctioned and the implicit cost of the transmission capacity is settled by the price differences between the markets. In particular, if no transmission capacity constraint is active, then there is no price difference between the markets and the implicit cost of the transmission capacity is null.

2.2 ATC market coupling

Under ATC, Market coupling relies on the principle that the markets with the lowest prices export electricity to the markets with the highest prices. Between two markets, two situations are possible: both the ATC is large enough and the prices of both markets are equalized (price convergence), or the ATC is not sufficient and the prices cannot be equalized. These two cases are described in the following examples.

Suppose that, initially, the price of market A is lower than the price of market B. Market A will therefore export to market B, the price of market A will increase whereas the price of market B decreases. If the ATC from market A to market B is sufficiently large, a common price in the market may be reached (PA* = PB*). This case is illustrated in Figure 1.

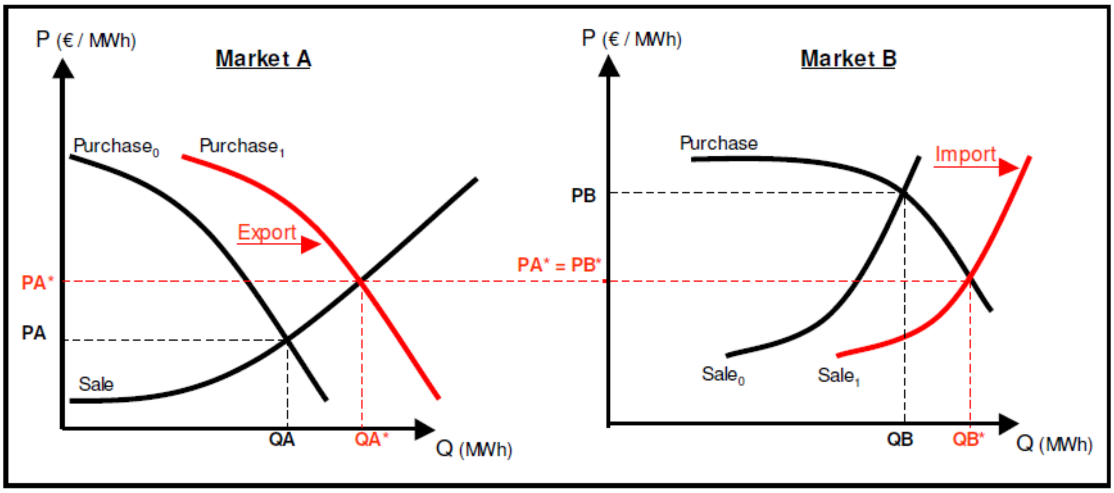

Figure 1: Representation of market coupling for two markets, no congestion

Another situation illustrated in Figure 2 happens when the ATC is not sufficient to ensure price harmonization between the two markets. The amount of electricity exchanged between the two countries is then equal to the ATC and the prices PA* and PB* are given by the intersection of the purchase and sale curves. Exported electricity is bought in the export area at a price of PA* and is sold in the import area at a price of PB*. The difference between the two prices multiplied by the exchanged volume – i.e. the ATC – is called congestion revenue, and is collected and used pursuant to article 6.6 of the Regulation (EC) N° 1228/2003 of the European Parliament and of the Council of 26 June 2003 on condition for access to the network for cross-border exchanges in electricity.

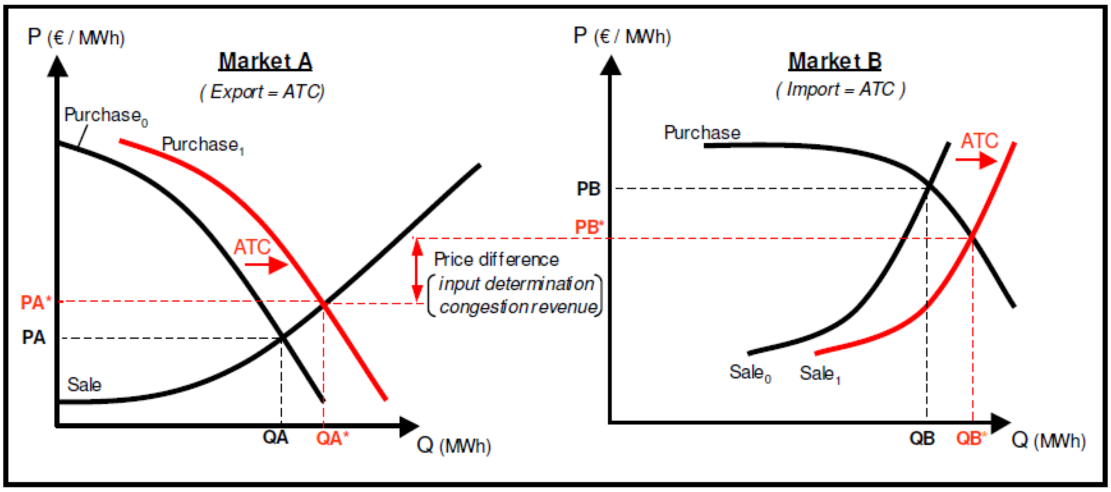

Figure 2: Representation of market coupling for two markets, congestion case

3 The CWE Market Coupling Solution

This chapter describes the CWE market coupling solution by the high level architecture, the daily schedule and its procedures.

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 2008. 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 1.

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] and the results will be included in the German order books. This implies a volume coupling between the two regions. However, the solution is still under discussion. 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 is further explained. They are devoted to:

- Terminology
- The high level functional architecture
- Daily schedule
- The operational procedures and the roles of the Parties

3.1 Terminology

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 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 fails before critical deadline, or if it is known that this will not happen before the critical deadline.

Other procedures: procedure describing actions to be taken by an agent in certain specific situations, which are not directly associated to normal procedures.

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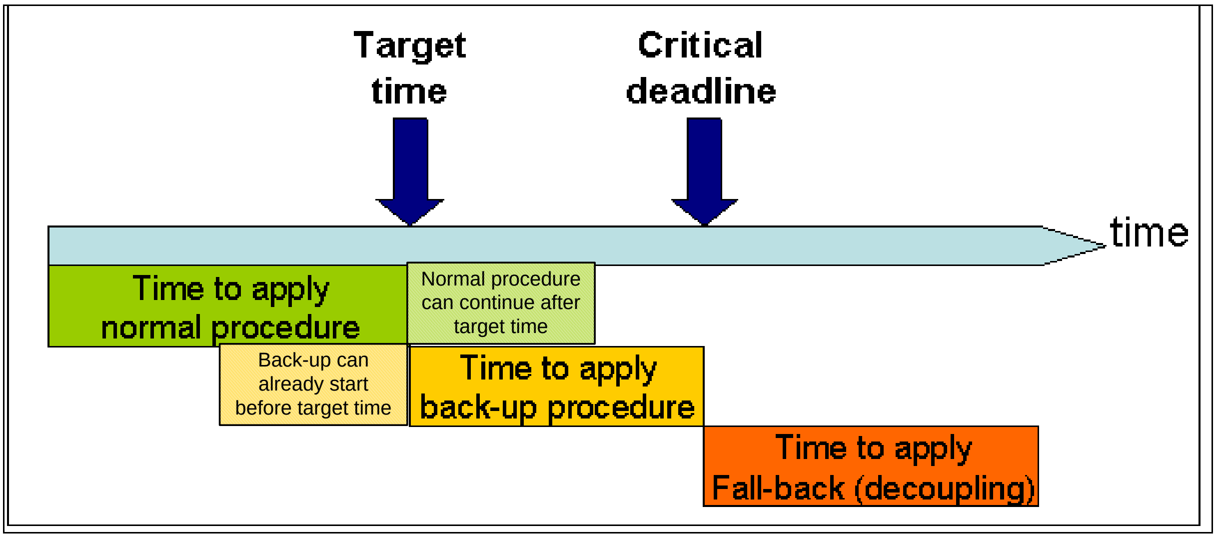
[1] These 20 additional minutes must still be confirmed by the operational experience of EMCC, whose contractual arrangements were designed for 30 minutes prior to the CWE request.

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



3.2 High level architecture

The main purpose of this section is to describe the High Level Architecture. We define the CWE Market Coupling as the set of MC system components and arrangements created or adapted with the explicit aim of establishing in a first stage the ATC and in a second stage the flow based coupling of the day-ahead electricity markets covering the five countries of the CWE zone, Germany, France, Belgium, the Netherlands and Luxembourg.

Among the many perspectives possible, this section adopts one particular perspective on the MC: that of information flows. This perspective can be labeled the information perspective. At a high level of abstraction, this section tries to clarify the issues below:

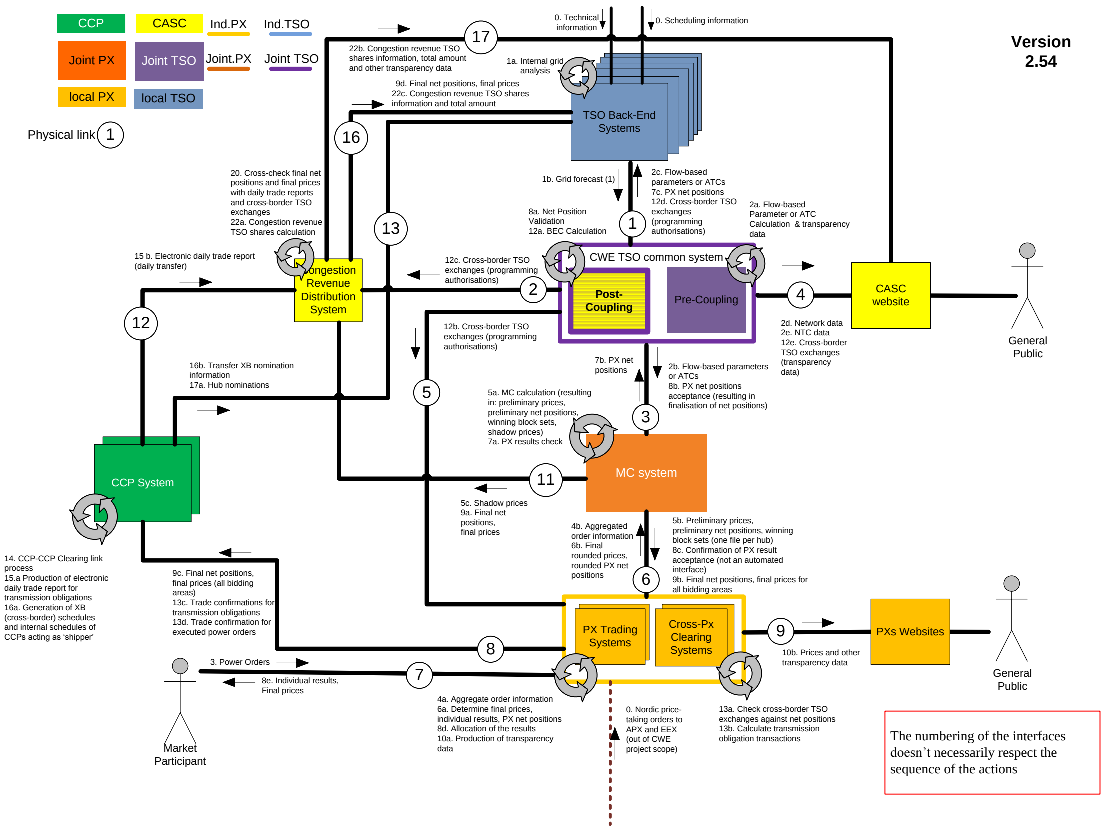
- Which automated system components play a role in the MC
- Which human agents (the 'Agents') play a role in the MC
- What information is produced by any of the MC components and Agents in the MC(only information relevant to the MC is taken into consideration)
- What information is exchanged between any of the MC components and Agents in the MC (applying the same restriction as item 3)
- In what sequence is the information produced by and exchanged between the MC components and the Agents

3.2.1 Architecture overview

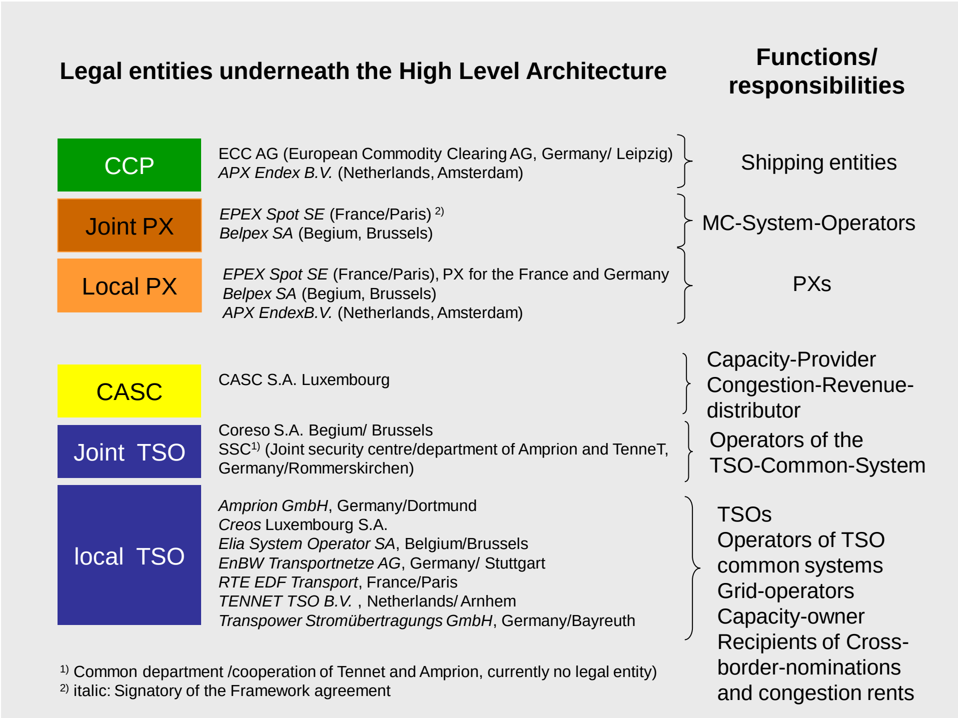
The architecture overview below is explained in the following sections of this chapter, which are devoted to:

- The system components shown
- The Agents shown
- The information produced and exchanged
- The indicative sequence in which the information is produced and exchanged

For better readability of the high level architecture, we refer to annex 2.



The high level architecture above shows the systems and the functional roles in the market coupling process. In the picture below, we listed all entities operating a task within these functional roles.



3.2.2 Systems

In the architecture diagram, the automated system components that are expected to play a role in the Market Coupling are indicated with rectangles. These systems may either be existing systems adapted to the Market Coupling or systems that were newly built. The systems distinguished are logical or virtual systems. This means, they do not necessarily correspond to single software applications or to dedicated computer hardware. In the information perspective, a system can be thought of as a set of information manipulation functions for which it is convenient to consider as a separate entity. The following Systems are distinguished:

- The back-end systems of the 6 TSOs involved are grouped together as the 'TSO Back-End Systems'. (For information: Creos is not connected to the Market Coupling yet). This grouping is made on the assumption that these systems each manipulate essentially similar information.
- The 2 Trading Systems used by the PXs involved are represented together as the PX Trading Systems'. The 2 trading systems (EPEX Trading System (ETS) and EuroLight) will be adapted to the Market Coupling. Each trading system will moreover be complemented with a new module called the 'Cross-PX Clearing System' dedicated to the Cross PX Clearing Process. The connection between the PX Trading System and its Cross PX Clearing System is considered internal. Therefore both are presented as one box.
- The TSO Pre-Coupling is consisting of the ATC system for the ATC launch and will be replaced by the Flow Based system for the Flow Based Launch. This Pre-Coupling produces the aggregated cross border grid capacity data.
- The TSO Post-Coupling consists of 2 modules:
    - The NPV Module or the Net Position Validation Module which validates the preliminary net positions
    - The BEC Module or Bilateral Exchange Calculation Module which calculates the bilateral Cross Border Exchanges out of the net positions

Physically the pre- and post-coupling systems are hosted in the CWE TSO common system; therefore they are represented together in one box. However the operators of the pre- and post-coupling systems are different.

- The Congestion Revenue Distribution System (CRDS) calculates the congestion revenue to be collected, and calculates the share of each TSO of the congestion revenue. This information is the basis for the determination and verification of the amounts of the bank transfers for the collection and redistribution of the Congestion Revenues which happen in parallel.
- The 2 CCP systems are the systems of the 2 Clearing Houses. These systems are existing and have to be adapted to perform the physical and financial settlement of the Cross Border Bilateral Exchanges
- The system to be built that will calculate the market coupling result is called the 'MC System'.

Systems are interconnected via Interfaces. Each Interface serves one or more information flows. The different information flows are defined in 3.2.4 with an indicative sequence

3.2.3 Agents

The Agents are represented in the diagram as abstract human figures.
Just like the MC components are abstract systems, the Agents distinguished are logical or virtual agents. 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. 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 published data due to transparency requirements.

3.2.4 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 in the table below. The numbering of the information flows doesn't always respect the sequence of the actions. The real frequency, timing and sequences are being defined in the procedures. It should be stressed that only flows of information are shown in the diagram. Other flows, like electricity and money flows, are not taken into account.

Flow Nb	Info	Produced by	From	To	Prede-cessor
1a	Produce internal grid analysis	TSO Back-End System	-	-	

1b	Grid forecast		TSO Back-End System	Pre-Coupling	1a
2a	Flow-based Parameter or ATC Calculation & transparency data	Pre-Coupling	-	-	1b
2b	Flow-based parameters or ATCs		Pre-Coupling	MC System	2a
2c	Flow-based parameters or ATCs		Pre-Coupling	TSO Back-End System	2a
2d	Flow-based parameters or ATCs (Transparency data)		Pre-Coupling	CASC website	2a
2e	NTCs (Transparency data)		Pre-coupling	CASC website	2a
3	Power orders		Market Participant	PX Trading Systems	
4a	Aggregate order information	PX Trading System			3
4b	Aggregated order information		PX Trading Systems	MC System	4a
5a	MC calculation	MC System	-	-	2b, 4b
5b	Preliminary prices, preliminary net positions, winning block sets		MC System	PX Trading Systems	5a
5c	Shadow prices (must be stored by CASC, usage to be defined). Will not be used in ATC-based coupling.		MC System	Congestion Revenue Distribution System	5a, 8b
6a	Determine final prices, individual results, PX net positions	PX Trading Systems	-	-	5b
6b	Final rounded prices, rounded PX net positions		PX Trading Systems	MC System	6a
7a	PX results check (if what was received in 6b is identical to what was sent in 5b)	MC System	-	-	6b
7b	PX net positions		MC System	Post-Coupling	7a
7c	PX net positions		Post-Coupling	TSO Back-End System	7b
8a	Net position validation (check compatibility of net positions with network parameters)	Post-Coupling	-	-	7b

8b	PX net positions acceptance		Post-Coupling	MC System	8a
8c	Confirmation of PX result acceptance* (not an automated interface)		MC System	PX Trading Systems	8b
8d	Allocation of the results (also known as execution of power orders). All hourly orders that match the prices received in 5b are matched. Some may be curtailed if they are at market price. Block orders are matched insofar as selected by the coupling algorithm. An imbalance equal to the net position received in 5b remains.	PX Trading Systems			8c
8e	Individual results, final prices (timing will be aligned). Results cannot be rejected by participants.		PX Trading Systems	Market Participant	8d
9a	Final net positions, final prices		MC System	Congestion Revenue Distribution System	6b, 8b
9b	Final net positions, Final prices for all bidding areas		MC System	Cross-PX Clearing Systems	6b, 8b
9c	Final Net positions, Final prices for all bidding areas (optional, only to be Implemented when needed)		Cross-PX Clearing Systems	CCP Systems	9b
9d	Final net positions, final prices		Congestion Revenue Distribution System	TSO Back-End System	9b
10a	Production of transparency data	PX Trading System	-	-	6a
10b	Prices and other transparency data		PX Trading Systems	General Public (PXs websites)	10a, 8c
12a	BEC calculation	Post-Coupling System	-	-	8b
12b	Cross-border TSO exchanges (programming authorisations) – note that the recipient of the authorization as identified in the message content is the relevant CCP, see overview below. Assumption is the full set of cross-border TSO exchanges is sent to both Cross-PX Clearing Systems. Each one can discard whichever information they do not need.		Post-Coupling System	Cross-PX Clearing Systems	12a

12c	Cross-border TSO exchanges (programming authorisations)		Post-Coupling System	Congestion Revenue Distribution System	12a
12d	Cross-border TSO exchanges (programming authorisations)		Post-Coupling System	TSO Back-End System	12a
12e	Cross-border TSO exchanges (programming authorisations)		Post-Coupling System	CASC website	12a
13a	Check that the cross-border TSO exchanges are compatible with the net positions. This is done for all cross-border TSO exchanges, flows in both directions (congested and non-congested).	Cross-PX clearing Systems	-	-	9b, 12c
13b	Calculate transmission obligation transactions (based on cross-border TSO exchanges and final prices). This is done for all cross-border TSO exchanges, flows in both directions (congested and non-congested). A price is put to each cross-border TSO exchange, the price is identical to the price difference between the Hubs concerned.	Cross-PX clearing Systems	-	-	13a
13c	Trade confirmations for transmission obligations (only implemented where needed). Note that this information is not sent to CASC, as CASC confirmed not needing it.		Cross-PX clearing Systems	CCP Systems	13b
13d	Trade confirmations for executed power orders (only implemented were needed)		PX Trading Systems	CCP Systems	8e
14	CCP-CCP Clearing link process, in which the imbalance between the CCPs is settled (refer to description of the details in a document to be written by ECC and APX)	CCP System (actually, between the two CCP systems)	-	-	9c, 13d
15a	Production of electronic, daily trade report for transmission obligations, two different formats (ECC and APX), containing: date, hour, price, quantity, TSO oriented border, payment amount.	CCP System	-	-	9c, 13c

15b	Daily transfer of electronic daily trade report		CCP System	Congestion Revenue Distribution System	15a
16a	Generate XB schedules based on BEC information (24 hours schedule). Compute internal schedules of the CPPs acting as 'shipper'. (This means the party that exports in the case of cross-border TSO exchanges, for each TSO involved). For each given TSO and each connected active CCP acting as 'shipper' there will be one internal schedule. For instance, one could speak of the RWE-APX internal schedule and the RWE-ECC internal schedule). Refer to Internal Schedule diagram below.	CCP Systems	-	-	9c, 13c
16b	Transfer Cross border Schedules. The schedules (24 hours schedule) each are in the native format and follow nomination rules (for instance clock change) of the receiving TSO. One message per TSO border and direction. Note that in case any related information transfer fails, the existing TSO backup nomination procedure will be used.		CCP System	TSO Back-End Systems	16a
17a	Hub nominations		CCP System	TSO Back-End Systems	9a
20	Cross check final net positions and final prices with daily trade reports and cross-border TSO exchanges	Congestion Revenue Distribution System	-	-	9a, 12c, 15b
22a	Congestion revenue TSO shares calculation	Congestion Revenue Distribution System	-	-	5c, 20
22b	Congestion revenue TSO shares information, total amount		Congestion Revenue Distribution System	CASC website	22a
22c	Congestion revenue TSO shares information and total amount. Invoice on monthly basis.		Congestion Revenue Distribution System	TSO Back-End Systems	22a

3.3 Daily schedule

The table below clarifies the daily operational schedule that will be applicable during the operation of market coupling under normal conditions. The opening time of PXs is not shown, since the trading platforms are accessible continuously. The procedures that will be operated in this daily schedule are explained in section 3.4.

Business process step	Target timing	Critical deadline
Long term nomination deadline (Yearly and monthly) by market parties	Between 08:00 and 09:00h depending on the country	NA
ATC values publication time	10.30	11.15
PX's Gate Closure Time	12.00	NA
Market Coupling Results publication	12.43	13.05 (+2min of Tolerance interval cf. FAL_01)
RTE Nomination (Cross Border and Hub)	14.00 (Cut off time at 14.30)	NA
Tennet Nomination (Cross Border and Hub)	14.00 (Cut off time at 14.30)	NA
Amprion Nomination (Cross Border and Hub)	14.00 (Cut off time at 14.30)	NA
Transpower Nomination (Cross Border and Hub)	14.00 (Cut off time at 14.30)	NA
EnBW Nomination (Cross Border and Hub)	14.00 (Cut off time at 14.30)	NA
Elia Hub Nomination	14.00 (Cut off time at 14.30)	NA
Elia Cross Border Nomination	14.30	NA

3.4 Operational procedures

The Market Coupling process is divided into 3 different phases. During each phase, a number of common procedures will be operated under normal conditions. These procedures are called Normal Procedures and Back Up Procedures. In addition there is a number of common procedures which are not associated to a specific phase. The procedures that belong to this category are Other Procedures and fall-back Procedures. For all detailed description of all procedures we refer to annex 3. In this paragraph we describe them on a high level.

3.4.1 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 pre coupling system. It ends with the integration of transmission constraints into the database of the algorithm. The procedures during this phase are:

- Normal procedure 1 (NOR 1).
- Back-up procedures associated to NOR 1 (BUP 1)

NOR_1: Reception and integration of the network model	This procedure describes the first phase of the business process dedicated to upload the ATC values in a normal mode
• BUP_1: Provision of network model data by the TSOs	Description of the actions to be performed by the functional service operator (hereafter: FSO) in case the regular process described in NOR_1 does not work.

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.

3.4.2 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 procedure 2 (NOR 2)
- Back-up procedures associated to NOR 2 (BUP 2, BUP 3, BUP 4, BUP 5, BUP 6)

NOR_2: Results calculation and validation	This procedure describes the second phase of the business process dedicated to calculate and validate the results in a normal mode
• BUP_2: Reception of the data from PXs	Description of the actions to be performed by the FSO in case reception of the order books is not successful.
• BUP_3: MC calculation	Description of the actions to be performed by the FSO in case calculation isn't performed correctly, as well as the transfer of preliminary results to the PXs
• BUP_4: Rounded price check	Description of the actions to be performed by the FSO in case the rounding of the prices is not done correctly, as well as the transfer of final prices to the PXs
• BUP_5: Results validation by TSOs	Description of the actions to be performed by the FSO in case validation by the TSO's CS can't be performed
• BUP_6: Display results in GUI	Description of the actions to be performed by the FSO in case the connection with the MC system GUI is lost

Target time of publication of the results to market participants is at 12:43h. 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.

3.4.3 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. The procedures applied during this phase are:

- Normal procedure 3 (NOR 3)
- Back-up procedures associated to NOR 3 (BUP 7, BUP 10, BUP 11, BUP 13)

NOR_3: Post publication processes	This procedure describes the third phase of the business process regarding the steps that have to be performed by the FSO in a normal mode
• BUP_7: Transfer final results from MC system to CRDS	Description of the actions to be performed by the FSO in case the transfer of the final results isn't performed correctly
• BUP_10: incident validation	This procedure gives the practical guidelines to be followed by the FSO in case of an operational incident.
• BUP_11: Cross PX clearing systems	Description of the actions to be performed by the FSO in case the transfer of the final prices to the cross PX clearing systems isn't performed correctly
• BUP_13: Cross border TSO exchanges (Programming Authorizations)	Description of the actions to be performed by the CSO and PX SO in case the transfer of Programming Authorizations isn't performed correctly

3.4.4 Other Procedures

Other Procedures are not associated to a specific phase. They relate to certain situations which need to be managed by a formalised procedure.

Other Procedures	Documents describing various actions to be performed by the FSO under certain conditions which are not back up or fall-back actions
• OTH_1: request for quote	Still under construction depending on the results of PX market consultation
• OTH_2: communication to the market participants	Description of the communication messages that has to be sent by the FSO depending on the market coupling process situation
• OTH_4: Change control procedure	Description of the process to follow by all parties in case of change in one of the systems

• OTH_5: Long clock change	Description of the actions to be performed by the FSO on the day of switch between summer and winter time
• OTH_6: Switch of the MC system	Description of the actions to be performed by the FSO in case of MC system switch in emergency and regular mode
• OTH_7: Reset of the system	Description of the actions to be performed if the MC Session needs to be restarted to solve an incident

3.4.5 Fall-back procedures

Fall-back Procedures	Documents describing the actions that should be performed by the FSO under fall-back conditions
• FAL_1: Incident Committee	Description of the initiation of the Incident Committee and the way discussions should be handled
• FAL_2: Full Decoupling	Description of the action to be initiated by the FSO in order to organise the fall-back activities

4 Fall-back arrangement

This chapter presents the description of the proposed CWE MC fall-back arrangement. This arrangement came into the picture during the market parties consultation held from 5 to 8 May 2008. 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 fall-back arrangement
- High Level Architecture
- Definitions
- Product to be purchased by market participants
- Bids
- Database tool
- Sequence of operations
- Matching and price determination rules

4.1 Fall-back situations

In the CWE MC procedures, a fall-back 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 fall-back procedure.

The fall-back is caused by the failure of one or more processes in the market coupling session, that affect the completion of the Business process phase 2. In other words, the fall-back 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 checks may return a "non compliant" result.

4.2 Principle of the fall-back arrangement

The principle of the proposed fall-back 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 of:

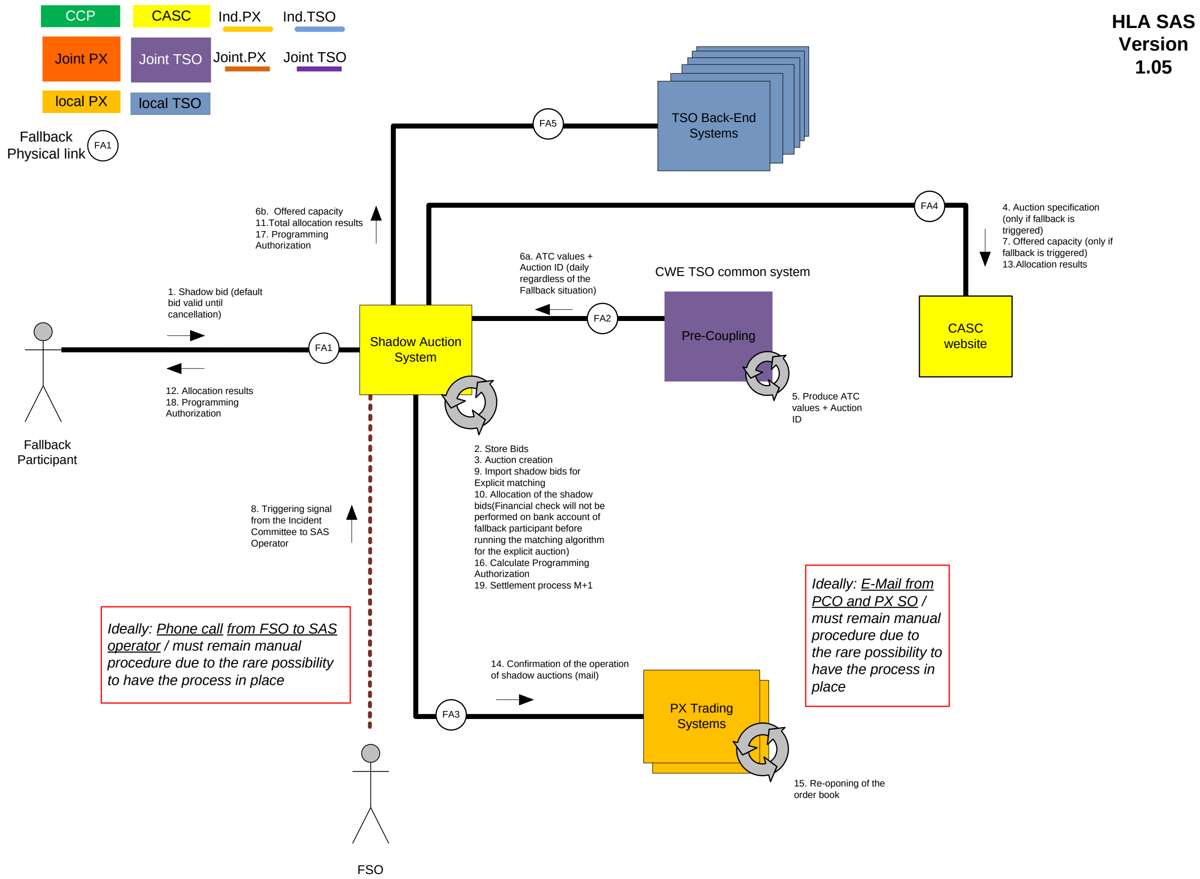
- maintaining a permanent data base where all pre-registered market parties (fall-back participants) may file, amend or withdraw, bids for capacity. During normal operation, these bids are not used;
- should a fall-back situation be declared on a particular day in case of an incident during the daily session, the fall-back operator performs a fall-back 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 for the upcoming shadow auction: the fall-back operator immediately takes a snapshot of the fall-back database.
- should a fall-back situation be declared in advance for the next sessions of CWE MC in case of any foreseen unavailability, the participants are allowed

to update their bids according to the time schedule communicated by the fall-back operator; the fall-back operator performs a fall-back auction to allocate the available transmission capacities according to the merit order.

4.3 High level architecture

This paragraph contains the high-level functional architecture and business process of the fall-back solution. It is explained in the following sections, which are devoted to:

- The System components shown,
- The Agents shown,
- The information produced and exchanged,



4.3.1 Systems

The following Shadow Auction Systems are distinguished.

- The back-end systems of the 6 TSOs involved are grouped together as the 'TSO Back-End Systems'. (For information: Creos is not connected to the Shadow Auction). This grouping is made on the assumption that these systems each manipulate essentially similar information.
- The 2 Trading Systems used by the PXs involved are represented together as the PX Trading Systems. No representation of the Cross PX Clearing System is given since this specific PX system is not involved in the process.

- The common TSO Pre-Coupling ATC system that is used for the ATC launch to be maintained even after the Flow Based Launch. This Pre-Coupling produces the aggregated cross border grid capacity data.
- CASC Website is the web based platform onto which all relevant information concerning the Shadow Auction procedure has to be published.
- The Shadow Auction System is the EXAU platform, owned by CASC and used to perform Explicit Auctions on all CWE borders. A subset of these borders can be presently selected and, if needed, explicit auctions can be performed only on these borders.

Systems are interconnected via Interfaces. Each Interface serves one or more information flows. The different information flows are defined in 4.3.3 with an indicative sequence.

4.3.2 External Agents

The Agents are represented in the diagram as abstract human figures. Just like the MC components are abstract systems, the Agents distinguished are logical or virtual agents. 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. In the HLA Shadow Auction the identified External Agents are the "Fall-back participant", i.e. the entity submitting shadow bids to the Shadow Auction System, and the fall-back service operator.

4.3.3 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 numbering of the information flows doesn't always respect the sequence of the actions.

The real frequency, timing and sequences are being defined in the procedures and in the business process. It should be stressed that only flows of information are shown in the diagram. Other flows, like energy and money flows, are not taken into account.

Flow Nb*	Info	Produced by	From	To	Prede-cessor
1	Shadow bid (default bid valid until cancellation /modification, and 20 will be the limited number of bids	--	Fall-back Participant (whenever they want except when the DB is frozen (=when SA is run)	Shadow Auction system (SAS)	-
2	Store bids	Shadow Auction System (SAS)	-	-	1
3	Auction creation	Shadow Auction System (SAS) (Daily operation)	-	-	-
4	Auction specifications (only triggered in fall-back mode)	-	Shadow Auction System (SAS)	Casc Website	3, 6, 8

5	Produce ATC values & auction ID	TSO Pre-Coupling (ATC system)	-	-	-
6a	ATC values + Auction ID (daily operation regardless the fall-back situation declared or not)	-	TSO Pre-Coupling (ATC system)	Shadow Auction System (SAS)	5
6b	Offered capacity (=ATC with Auction ID) (only if fall-back situation declared)	-	Shadow Auction System (SAS)	TSO Back-end Systems	6a, 8
7	Offered capacity (Only if fall-back is triggered)	-	Shadow Auction System (SAS)	Casc Website	6a, 8
8	Triggering signal from the Incident Committee to SAS Operator. (Casc will participate to the IC allowing it to be informed of the decoupling situation)	-	FSO	Shadow Auction System Operator	-
9	Import shadow bids for Explicit auction	Shadow Auction System (SAS)	-	-	8
10	Allocation of the shadow bids (Financial check will not be performed on bank account of fall-back participant before running the matching algorithm for the explicit auction)	Shadow Auction System (SAS)	-	-	9
11	Total allocation results	-	Shadow Auction System (SAS)	TSO Back-end Systems	10
12	Allocation results	-	Shadow Auction System (SAS)	Fall-back participant	10
13	Total Allocation results	-	Shadow Auction System (SAS)	Casc Website	10
14	Confirmation of the operation of shadow auctions (mail)	-	Shadow Auction System Operator	PXs Trading System Operator	10
15	Re-opening of the order book	PXs Trading System	-	-	
16	Calculate Programming Authorization	Shadow Auction System (SAS)	-	-	10
17	Programming Authorization (max 15 min after Auction result)	-	Shadow Auction System (SAS)	Fall-back participant	16

18	Programming Authorization (max 5 min after Auction result)	-	Shadow Auction System (SAS)	TSO Back-end Systems	16
19	Settlement process M+1	Shadow Auction System (SAS)	-	-	18

*The numbering of the interfaces doesn't necessarily respect the sequence of the actions.

4.4 Description of the product to be purchased by market participants

The fall-back auction allocates Physical Transmission Rights (PTRs) for each oriented country border and for each hour of the day concerned by the fall-back allocation. Using the ATC, provided by TSOs, and the auction bids from the fall-back database, the fall-back operator calculates (through the fall-back auction) the PTRs allocated to the participants and the corresponding programming authorizations. The PTRs resulting from the auction may not exceed the ATCs. The unused PTRs are lost by the fall-back participants (UIOLI) if they are not nominated according to the programming authorizations.

Since PTRs and programming authorizations are only options, the fall-back arrangement cannot take into account any netting of opposed capacities.

4.5 Bids

4.5.1 Content

A bid entered in the fall-back database contains the following information:

- the country border for which the bid applies (Belgium-Netherlands, Netherlands-Germany, Germany-France or France-Belgium),
- the direction for which it applies (two directions for each country border),
- the hourly period for which it applies,
- a price to be paid for the said capacity.

Bids inserted by the participants in the fall-back database are unconditional and irrevocable once the fall-back mode has been declared in case of an unforeseen unavailability of the CWE MC or according to the new time schedule communicated in advance if an unavailability of the CWE MC is forecasted for the next daily sessions.

Bid(s) submitted by the participant to a Shadow Auction are submitted in a priority order according to their Bid Identification. Lowest ID number being the highest priority. When a Shadow Auction is run, bids are created according to the priority order until the Bids meet the available capacity. The last created bid that exceeds the Available Capacity is reduced so the total of Bids does not exceed the Available Capacity.

4.5.2 Ticks and currency

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

4.6 Fall-back database tool and bid submitters

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

4.7 Sequence of operations

The sequence of operations is applicable after a decision to resort to fall-back after the critical deadline (13:05h) or in case a fall-back situation is announced in advance.

1. Before launch of the CWE MC and at any time later on, market parties are invited to register by means of entering into an agreement with the fall-back operator through the CWE Auction rules. From then on, they become "fall-back participant".
2. Before the launch of CWE MC and at anytime later, market parties are invited to register by means of entering into an agreement with the TSOs for the nomination part (it being understood that the market parties should sign a nomination contract or designate their nomination responsible according to each country's regulation).
3. Fall-back participants are allowed to enter bids into the fall-back database and amend or withdraw them anytime.
4. TSOs provide the fall-back operator with ATCs at 10:30h.
5. Should a fall-back situation be declared by the Parties, the fall-back operator immediately takes a snapshot of the fall-back database, and market parties will be informed
   Or:
6. Should a fall-back situation be announced in advance by the Parties, the fall-back participants can update their bids according to the new time schedule communicated by the Parties.
7. The fall-back operator then performs the fall-back auction : it determines the PTRs allocated to each fall-back participant and the corresponding programming authorizations.
8. The fall-back operator provides each fall-back participant with the results and prices resulting from the auction.
9. The fall-back operator provides each TSO/fall-back participant with all programming authorizations.
10. The fall-back operator publishes transparency data, as defined in chapter 9.
11. PX participants are allowed to change their position in the PX order books in function of the fall-back situation. The PXs then match and publish their results separately.
12. Fall-back participants may submit their nominations to TSOs according to the existing processes.

4.8 Matching and price determination rules

The fall-back 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.

4.9 <u>Daily schedule</u>

A fall-back situation may be declared at any time before publication of MC results. 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 fall-back is triggered at the MC results' publication deadline.
In the worst case, i.e. when the fall-back 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[2] 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 [3]	14h	14h	14h	14h
Market results publication [4]	14h10	14h10	14h10	14h10

1.

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

Cross border nominations	15h30	15h30	15h30	15h30

4.10 Opening hours

The access to the fall-back database is open 24h a day and 365 days a year, except for system maintenance periods, announced by the fall-back operator 15 days in advance.

5 Roll back

The launch of CWE market coupling is a major change including the introduction of new and/or adapted systems and new operational procedures. Even when tested thoroughly, there is always a risk of failure when switching from the current systems to CWE market coupling on the launch day itself as well as during the first period after the launch. In order to mitigate this risk, the Project Parties will keep possible roll back options as a backup available for one to two months after launch of the market coupling. The next paragraphs describe the roll back solutions. They are devoted to:

- Roll back situations
- Roll back solution for German borders
- Roll back solution for TLC region

5.1 Roll back situations

The decision to roll back to the roll back solutions for TLC and for the German borders will be a Steering Committee decision. The rare situation in which roll back will be applied:

- The Incident Committee has decided for full decoupling due to an incident regarding the Market Coupling System or due to nonfunctioning or malfunctioning of the Market Coupling Algorithm (e.g. no market results or unacceptable market results) and the capacity is auctioned via the Shadow Auction.
- During the investigation it becomes apparent:
  - that the incident is found but cannot be resolved instantly or within an acceptable period of time or
  - that the incident is not found / cannot be reproduced and therefore the period to solve the issue is unknown and
  - that the risk to continue with the Market Coupling algorithm with the possibility to regularly having to decouple is estimated too high
- The Steering Committee decides based on the above arguments to resort to roll back.

After such a decision of the Steering Committee, the Parties need at least 3 to 5 working days for the technical aspects of the roll back, i.e. reinstall the roll back systems, test the connections and run a couple of test scenarios. Parties have prepared procedures and checklists for such a roll back situation before the launch and will make sure that the procedures are known internally.

Regarding the regulatory framework, all countries are busy to establish a framework which is compliant both with CWE Market Coupling as well as with the roll-back situation. For the Netherlands this will be handled in the grid code and also the Auction Rules and the Service Level between CASC and the TSOs will already describe the disposition applicable to the roll back. The contractual framework to roll back will be established with an amendment of the TLC Umbrella Agreement which organizes the suspension/re-activation of the TLC agreements including the necessary changes in procedures, e.g. the GCT at 12.00 and a different fall-back procedure.

The new CWE Auction Rules and the Service Level between CASC and the TSOs will however already describe the disposition applicable to the roll back.

During the interim period necessary to install the roll back the daily explicit auctions will be held with the Shadow Auction system.

All necessary information will be given to the market parties regarding the practical modalities of the roll back, in particular, its potential duration, the time schedule of the explicit auctions etc.

After this interim period where the Shadow auction system is used, the TLC system will take over for the NL-BE border and BE-FR border. The Shadow Auction system will remain for the German borders.

The roll back systems will continue to function until the re-launch of CWE Market Coupling, which is decided by the Steering Committee.

5.2 Roll back solution for German borders

The roll back solution on the German border will be the explicit auctions operated via the Shadow Auction Tool. For risk management reasons a bank guarantee will be required to take part in the roll back solution. Both fall-back and roll back solutions will be regulated by the CWE Auction Rules. These rules will be filed to the CRE and CREG for formal approval and to the EK and BNetzA for review.

5.3 Roll back solution for TLC region

For the TLC region an implicit auction of capacity according to current TLC rules is proposed. The reason is that it is not desired to operate an explicit auction in roll back situations, since such a mechanism is inferior compared to implicit auctions. So the purpose is to reinstall in roll back situation the TLC rules. However, a few modifications will be made compared to the original TLC solution:

- GCT PX 12:00h instead of 11:00h
- Fall-back will be explicit auction operated with the shadow auction tool, instead of separated explicit auctions on Dutch Belgium and French Belgium borders operated by TenneT respectively RTE.

6 The algorithm

6.1 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[5] 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

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. 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 and implementation study for details about the selection procedure).

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 provides additional information related to the functionalities and behaviors of the algorithm.

6.2 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

1.

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

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.

6.2.1 Order types currently in use at CWE PXs

6.2.1.1 Hourly orders

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

6.2.1.2 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[6], 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.

6.2.2 Order types supported by COSMOS, but not currently in use at CWE PXs

6.2.2.1 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 has no been possible to submit such profile block orders in the current trading systems of the CWE exchanges.

6.2.2.2 Flexible Hourly Orders

Flexible hourly orders – currently only available at NordPool Spot (NPS) - are defined as hourly fill or kill sell orders which are accepted "at the hour with highest price during calculation" (which thus supposes that their acceptance is dependent of the chosen algorithm). Similarly, in a welfare optimization approach such as COSMOS, they are defined to be accepted such that the total welfare is maximized.

1.

[6] 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.

6.2.2.3 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 is able to deal with such orders, which are nonetheless not available for the moment at any exchange.

6.2.2.4 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.

6.2.2.5 Exclusive Block Order

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). Again, this feature is not currently in use in CWE Exchanges.

6.3 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.

6.3.1 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. The CWE launch will also be based on such a model.

6.3.2 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, but would also support more simplified network models.

6.3.3 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,

- Losses may be taken into account on some particular network elements as a fixed proportion of the flows over these network elements[7]
- Charges may be applied for the utilization of some network elements. As a result, usage of this network element is subject to a price difference threshold between the two adjacent market areas.

6.4 <u>Functioning of COSMOS</u>

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.

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.

1.

[7] In which case the sum of the area net positions equals the total of all losses (instead of zero)

[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.

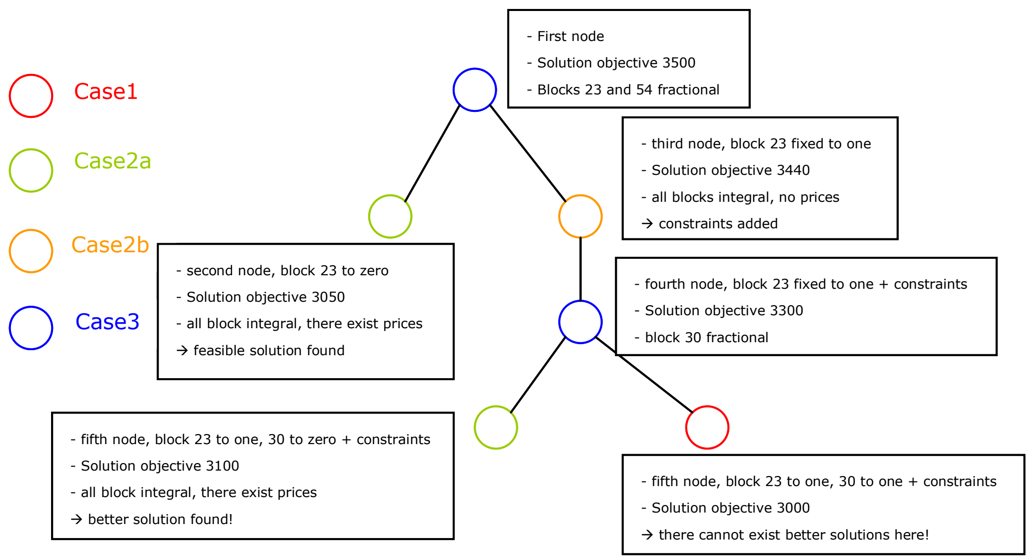
Secondly, it might happen, by chance, that all blocks are actually fully accepted or fully rejected in the optimal solution of the Quadratic Program (even those that were not fixed by the partial selection). In this case, we must still test if there exists acceptable prices associated with this solution.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



6.5 Additional requirements and features

6.5.1 Extendibility

During the design and implementation of Cosmos, great care has been taken to ensure that 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, IFA etc, were also implemented without any technical difficulties as they can be modeled through linear constraints.

6.5.2 Price boundaries

Since the introduction of negative prices might not occur at the same moment at all exchanges, algorithmic requirements had to integrate the fact to deal with negative prices and with different price boundaries.

6.5.2.1 Price boundaries and network constraints

Generally speaking, different price boundaries can 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). 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[11].

In order to accommodate technical price boundaries and to compute coherent prices (in the sense that they respect exchange and network constraints), COSMOS guarantees on the one hand that exchange and network constraints are satisfied with respect to unrounded prices. On the other hand, COSMOS also ensures that exchange properties are satisfied using rounded and within bound prices. Hence some network constrained are not checked against rounded and within bound prices, but only against unrounded and possibly out of bounds prices. This allows computing coherent prices while respecting the local price boundaries.

6.5.2.2 Non-harmonized price boundaries and curtailment

Different price boundaries might trigger unfair in some cases. Indeed, it might be that some participants in markets where negative prices are not allowed are

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

actually facing negative marginal costs which they can not express in the platform. These orders might then be overruled by negatively priced order in other markets, possibly against the real economical optimum.

In order to limit these perverse market effects, COSMOS enforces price taking orders in markets with the most restrictive bounds – i.e. sell orders at 0.01 €/MWh in the CWE case – to be accepted prior to the coupling calculations.
More precisely, COSMOS enforces local matching of price taking hourly orders using hourly orders in the opposite direction and in the same market as counterpart. Hence, whenever curtailment of price taking orders can be avoided locally on an hourly basis – i.e. the curves cross each other - then it is also avoided in the final results. Otherwise, in case the local matching does not allow to fulfill all the price taking orders, then this curtailment can be improved or remain as is, but can not be degraded because of the coupling with negatively priced markets.

6.5.3 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[12].

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 (DeltaP[13]) 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

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[12] It is important to note that the objective function in this context is to be understood as a way to select block orders with "fill or kill" conditions. In other words, when there are no orders with fill or kill a constraints, only prices and volumes have to be lifted at the margin, but the total welfare is constant for all feasible solutions.
[13] 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.

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 during its computation the solutions with paradoxically rejected blocks that are very deep in the money.

6.5.4 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 30 seconds on all our CWE instances..

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 instances were solved at optimality in less than 10 minutes, the remaining showing quite small distances to optimality after this time limit.

6.5.5 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.

6.5.6 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).
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.

6.5.7 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 cannot 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 NorNed, charges and losses of BritNed and IFA) 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.

7 Capacity determination

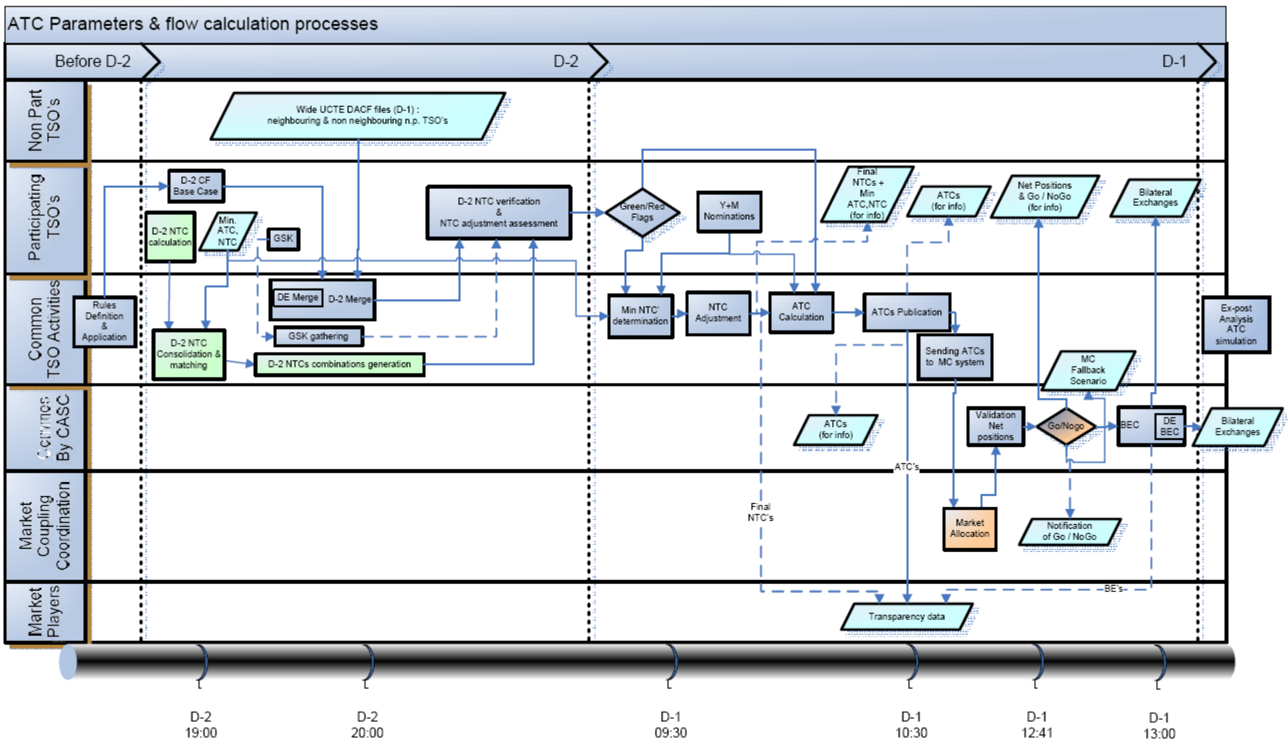
This chapter describes the way capacity, that will be allocated via the market coupling solution, is being determined. It has been proposed that the CWE market coupling will start using ATC values for cross border capacities, representing the transmission grid. The process to obtain the ATCs and a methodology to adjust ATCs in case of potential security problems has been developed, and some insight in this methodology has been given at the Pentalateral Energy Forum of 15 September 2008. A more profound description of the NTC process and methodology is the subject of this chapter.

7.1 Coordinated NTC process and methodology

The design of the coordinated NTC process and methodology that are proposed to be used in the CWE market coupling is driven by the following objectives:

- to enhance the way in which TSOs facilitate the market and safeguard the grid by striving for an increased level of coordination (at this moment the NTC values are coordinated in a bilateral way between neighbouring TSOs) thereby making a step towards the flow based methodology
- to have an allocation methodology as close as possible to what we have today, both for the market and for TSOs
    - not to confront the market with too many changes in mechanisms in a short period of time, so that the well-known ATCs are the values to be published to the market
    - the implementation of the methodology should be feasible given the tight schedule of the ATC MC.

The coordinated ATC process, as defined by the CWE TSOs, is the following:



This TSO process comprises different kind of activities: the aim of the pre-coupling activities is to compute the capacities that will be sent to the MC system. The aim of the post-coupling activities is to check the MC result and to transform the Net Positions, computed as a result of the market coupling, into Bilateral Exchanges for further processes. Some activities are local activities (i.e. each TSO is responsible of performing its share of the activity), and others are Common activities (i.e. a single calculation is performed by a single entity).

In short, the coordinated NTC process is:

- In a first step, NTCs are determined like today, independently by each TSO
- NTCs are then shared among all CWE TSOs
- A common grid model is created
- Each TSO can then apply the common grid model in order to perform a decentralized grid security analysis
- In case potential security problems are detected, the NTCs are adjusted in a coordinated way.

The steps of this process are elaborated in the following sections.

7.1.1 Step 1: NTCs are determined like today

Every TSO will continue to apply its own NTC determination procedure in D-2 in order to provide the twenty-four NTC values for its own borders. Existing procedures include a bilateral/multilateral coordination between the neighbouring TSOs of a given border, in order to have agreed values.

7.1.2 Step 2: NTCs are shared among all CWE TSOs

For the CWE market coupling, NTCs are shared by all TSOs of the region in order to determine the area where the Y/M/D-trade should be possible without violating the grid security: this area (or “NTC domain”) is defined by all possible combinations of NTC values, which represents simultaneous NTC usage situations. As an illustration: in case of two borders, there are four possible simultaneous NTC usage situations and the NTC domain is a 2-dimensional space, as represented in the figure 1:

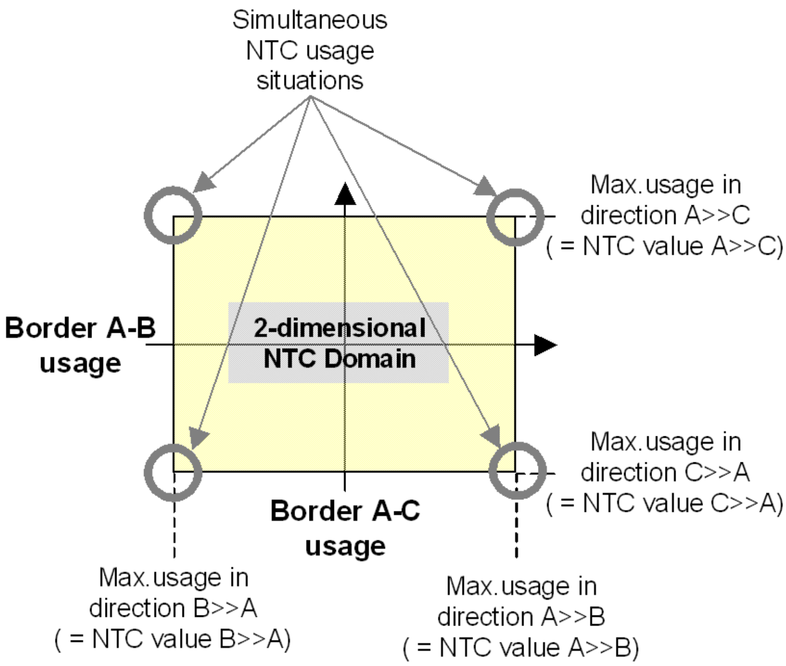


Figure 1: Example of ATC domain with 2 borders

Since the CWE region counts four electrical borders, the NTC domain is a 4-dimensional space defined by 16 corners.

7.1.3 Step 3: Creation of a common grid model

For the purpose of verification of the regional NTC values that are proposed, two base cases per day D are created on day D-2: one base case for peak hours and one for off-peak hours.

The procedure is identical to the D-2CF procedure for the Flow Based procedure as explained in the Orientation Study.

The CWE TSOs started the experimentation of this process in January 2009 and the experience gathered since then allowed the CWE TSOs to successfully transfer this activity to a merging service provider, Coreso, in order to prepare for the Market Coupling launch.

A short review of how these common base cases are established is described hereunder.

The D-2CF-procedure is the daily creation of a representative load flow model of the grid for the region of the participating TSOs (BE-NL-FR-DE) for a specific hour, but already two days ahead. The following information is incorporated in the dataset:

- Best estimation for:
  - the planned grid outages
  - the outages of generators
  - representative load pattern
  - wind generation
  - load-forecast

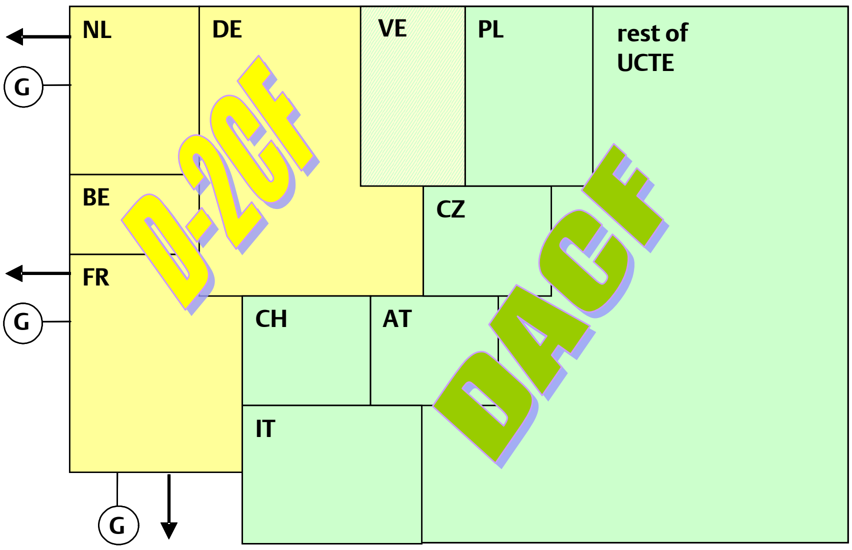
- As the best estimation for the exchange programs (as they are unknown at the time of the file-creation), the programs of a representative reference day are chosen

Usually, as an assumption for the exchange program of day D, the exchange program of D-1 is used. The table below shows the default reference days.

Day D-2 (day of file creation)	Estimated Topology	Estimated Load Prog.	Estimated Gen. Prog.	Estimated Wind Prog.	Exch. Prog.	D D D

For bank holidays/special days, individual reference days have been identified and fixed in a separate calendar.

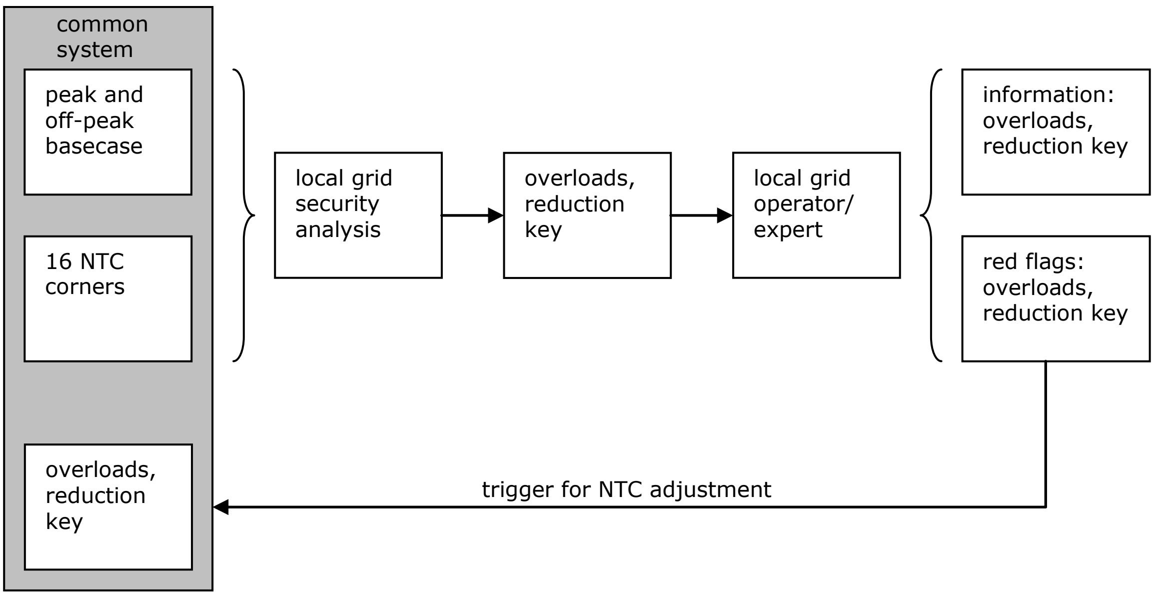
Every participating TSO creates, within its own responsibility, a D-2CF-file, thereby incorporating the before-mentioned information. For the rest of the UCTE grid, needed to represent the physical influences of these grids, the DACF-files of the reference day are used. The individual files (D-2CF respectively DACF) are merged together in order to obtain a UCTE-wide grid model for the capacity assessment purposes. This is shown in the picture below.



In the coordinated NTC methodology, and this is in contrast with the FB methodology, the base case is not used for capacity calculation, but only for verification.

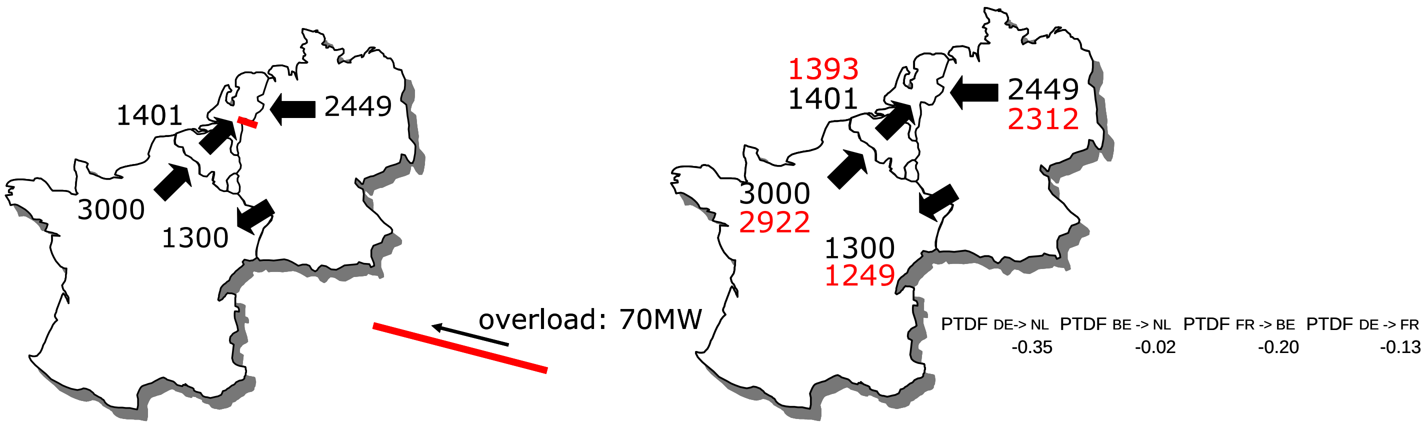
7.1.4 Step 4: Decentralized grid security analysis

Each TSO may use the two base cases to check the security of its grid at each 'corner' of the NTC domain. Basically this means checking that the grid is secure in case of simultaneous full use of NTCs. The coordinated NTC adjustment methodology is triggered if one or multiple red flags are raised by one or multiple TSOs. This indicates that there is a step in between the local NTC verification (where the common grid model, in combination with the 16 NTC corners, is subjected to a local grid security analysis by a TSO) and the sending out of red flags. The outcome of the local grid security analysis by a TSO provides valuable information on possible hot spots in his grid in the case of certain 'extreme' market conditions. Given this output it is up to the TSO operator/expert to decide if one or multiple red flags need to be triggered or that the output is for information only as he can have measures at hand to counter/deal with the foreseen grid security violations on day D (this could for example be the case if a small-to-medium overload is predicted on a tie-line that is equipped with a phase shifter). This is schematically illustrated in the following graph.



7.1.5 Step 5: Coordinated adjustment of NTCs

When a TSO foresees potential grid security problems, an adjustment of the NTC values for the concerned hours is triggered. Possible overloads should be alleviated by adjusting, in principle, all NTC values. The adjustment will be based on an efficiency key: the borders with the highest impact (in terms of flow-sensitivity) on the overloaded branch will have their NTC be adjusted most. This is illustrated in the example in the two following graphs.



In the left graph, one of the sixteen combinations of the NTC values is used for a grid security analysis. This combination leads to an overload on a tie-line between NL and DE; the overload amounts 70 MW in the direction DE to NL. With the PTDF factors (the power transfer distribution factors for country-to-country exchanges) showing the impact of the various bilateral exchanges on the overloaded branch, we have an efficiency key at hand to use for the NTC adjustment. The PTDF factors of the overloaded branch are shown in the graph on the right; we can see that all exchanges contribute to the overload and will be adjusted in accordance to their contribution. The impact of the exchange from DE to NL on the overloaded branch is the highest (the largest PTDF factor) and will be adjusted most. The impact of the exchange from BE to NL is very small, leading to a minor adjustment of the NTC value on this border. The adjusted values are shown in red in the figure.

7.1.6 Step 6: From NTC to ATC

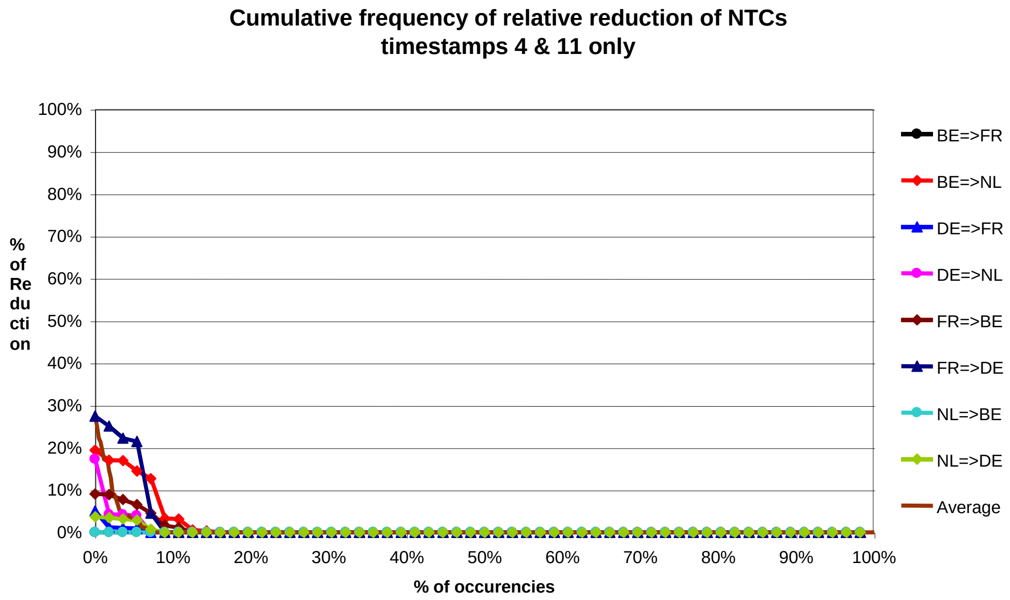
The long-term (LT) nominations are used to obtain the coordinated ATC values from the coordinated NTC values by using the existing formula (today, this formula is used with non-coordinated NTC values):
Coordinated ATC = Coordinated NTC – Netted LT nominations
The coordinated ATC values are the input for the market coupling system.

7.2 Experimentation and results

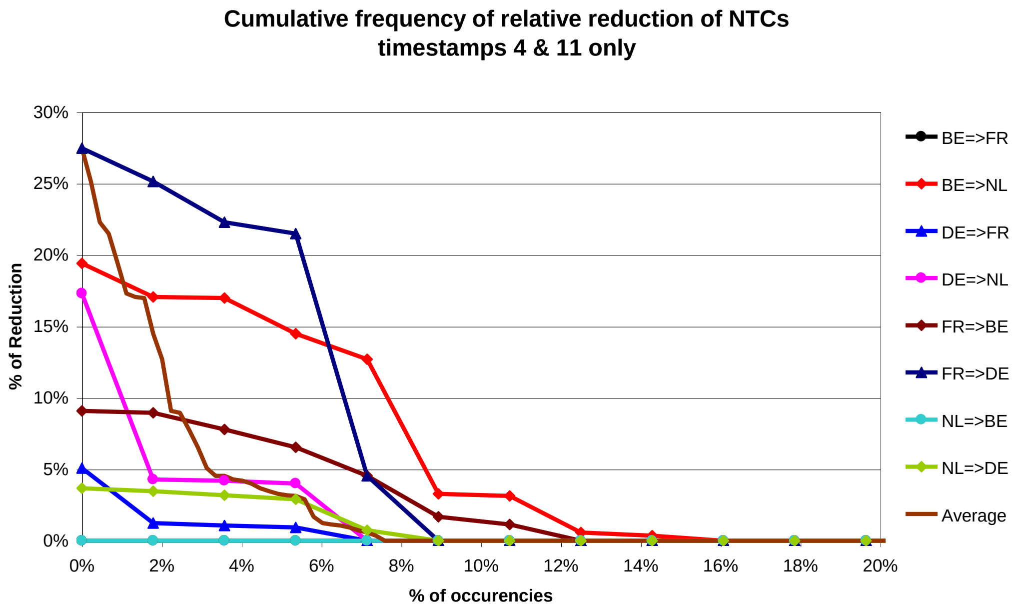
During the implementation phase, the CWE MC TSOs tested and fine-tuned the chosen methodology. In this section the results of the testing in weeks 21-24 and weeks 30-33 in which 2 timestamps a day (03:30 (timestamp 4), and 10:30 (timestamp 11)) are described. As the coordinated NTC methodology is a regional approach, leading to an adjustment of all NTC values contributing to foreseen grid security problems, any adjustment impacts all electrical borders. During the second time period (weeks 30-33, 56 timestamps) the coordinated set of NTCs has been created successfully. The comparison of the final coordinated NTCs with the matched NTCs determined like today shows that:

- In about 84% of the timestamps, the TSOs didn’t trigger any reduction of the matched NTCs
- In about 96% of the timestamps, an average reduction of less than 5% of the capacity is triggered
- The maximum reduction observed, is less than 30% (in one case).

In annex 5 we included a table containing the absolute NTC and ATC figures resulting from the experimentation. This table was provided to regulators before.



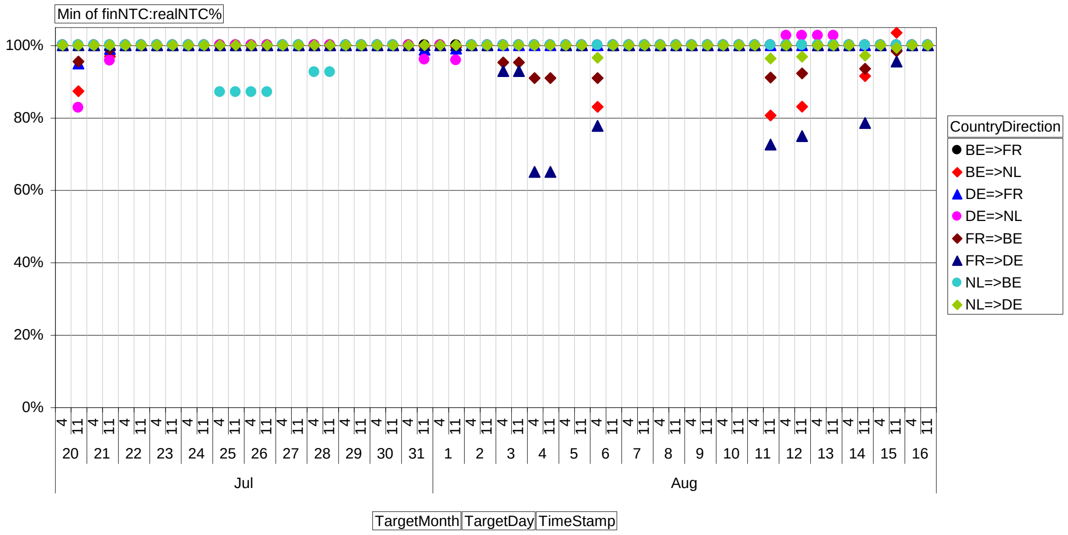
Next graph is the zoom of the preceding one.



The following figure shows the comparison between the final coordinated NTC and the capacities given to the market (value given before the TLC clearing or the explicit auctions on F-D and D-NL borders). During the experimentation, the TSOs jointly analyzed in-depth each grid adjustment as shown in this graph : as a result they are now aware whether each adjustment reflects a potential constrained grid situation, human errors made during the experimentation, or whether improvements of the coordination between TSOs could lead to minimize or suppress the adjustment. For instance:

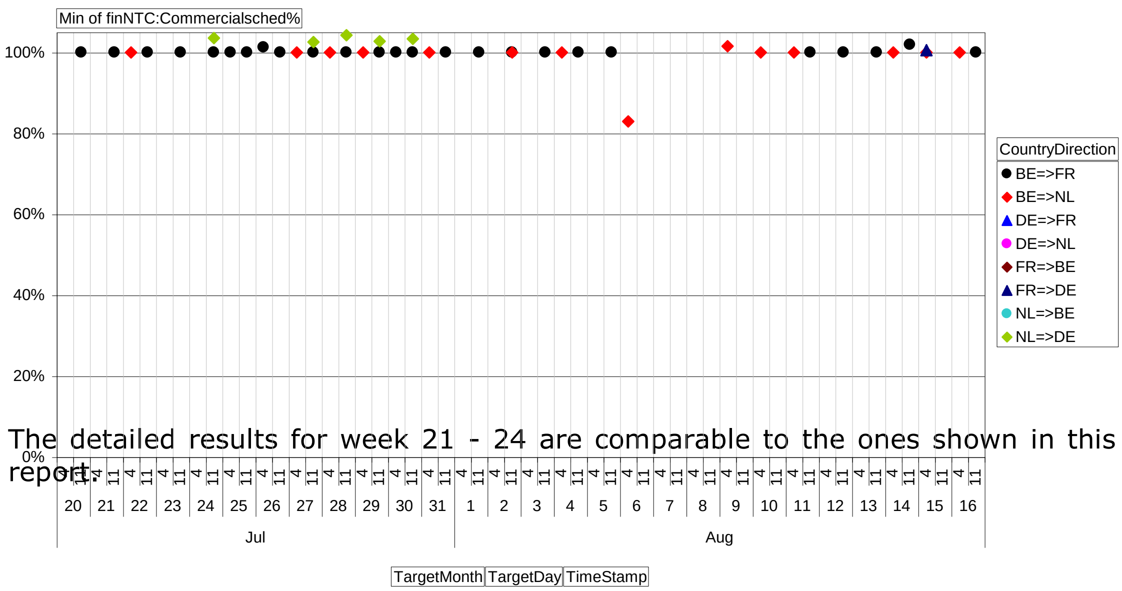
- the peak under 100% observed on 4Th August is due to a human error during the experimentation (a too low input NTC-value has been specified in the process).
- on 25th, 26th and 28th of July the NTC values were impacted by two incidents on the Belgian grid which lead to differences in the NTC's estimated in D-2 evening or in D-1 (measures were found during the night).

Final NTC, relative to NTC given to the market
timestamps 4 & 11 only



The comparison of the coordinated NTCs with the capacity nominated in D-1 by the market parties (after the TLC market clearing and the explicit auctions on F-D and D-NL borders) shows that the capacity provided by the TSOs using the coordinated NTC methodology would cover quite well the needs of the market, except for one day (6th August).

Final NTC relative to D-1 nominations



The detailed results for week 21 - 24 are comparable to the ones shown in this report.

The CWE TSOs would like to underline that the results obtained and presented here are real experimentation results. The human error, as mentioned above, should also be seen from that perspective. Both the results and the experience gained by running the process are a learning process in itself, leading to improvements and/or refinements where possible.

Furthermore, we would like to remind that the coordinated NTC methodology has been developed for the CWE MC, as an intermediate step towards Flow-based. The main trigger is that an implicit coupling of the German market will further increase the risk of unexpected flow patterns, since flows will then be directly forced by market price differences (based on experience with the capacity usage within TLC). The check on the '16 corners' is therefore a check on the grid security in the extreme corners of the NTC domain where the market could clear. Indeed, this does not mean that during the market coupling the market will actually clear in a (specific) corner of the NTC domain.

7.3 Minimum capacities

The TSOs designed the coordinated adjustment method in order to allow specifying and respecting some minimum capacities[14]. The NTC adjustment respects minimum capacities (if they are specified) in the following way: in the exceptional case that such a large adjustment is required that during the NTC adjustment a minimum capacity value is hit, this minimum value is respected and the reduction continues on the other NTC values involved in the adjustment until the overload(s) is/are alleviated.

This method has now been experimented for several months. During the experimentation of the method in July and August as in this chapter, the TSOs used minimum capacity values that are coherent with the values proposed by CREG on the Belgian borders (BE -> FR 600 MW; FR -> BE 1700 MW; BE -> NL and NL -> BE 830 MW), and by the Dutch Gridcode (Total NTC = 1800MW). These minimum values have not been hit during this experimentation period.

7.4 Example of application of the method

The CWE TSOs are preparing a detailed example in order to illustrate the coordinated capacity calculation method.

The date mentioned at first for this example was August 3rd at 11.00 when the capacity from Belgium to France was equal to the minimum of 600 MW. But the 3rd of August does not correspond to a day with reduction (the difference between D-2 NTC and the published NTC was not due to a reduction but was due to a modification of the capacity during the night and the capacity Belgium-France was 800 MW since the beginning of the process and was therefore not representative of a minimum capacity being reached during the reduction process).
So, in order to replace this example, The TSOs have decided to prepare the case of the 3rd of December 2009 at 11:00 which is a representative case of a 'normal' reduction.

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14 These minimum capacities can be expressed in terms of minimum ATC or in terms of minimum NTC.

8 Economic Assessment

The Project Parties have performed an extensive economic validation of the solution, both for flow based as well as for ATC based market coupling. The results were presented first in the Implementation Study. As set out in the Implementation Study, reservations were made regarding the TSO and PX data used in the validation analysis. With regard to the PX data, it was explained that the historical order books were not representative since they were not corrected for cross border flows due to explicit auctions. In a second step, this correction was made and new analyses were carried out. The updated results were presented in the Implementation Study Addendum.

At this stage, the updated results are the best possible indications of the economic consequences of the launch of ATC based market coupling in the CWE region. Therefore they are repeated in this chapter. It explains specifically:

- Why the historical order books are not representative for a CWE MC situation, and how they have been adapted for this second series of simulations. Note that these changes were not made in the Implementation study.
- The benefits of replacing an explicit auction mechanism (current situation between DE-FR and DE-NL) by an implicit auction mechanism, that is, a comparison of the results of the CWE market coupling under ATC and the historical[15] results (TLC + German hub isolated) on relevant indicators, hence the comparison using the same network model with the same capacities, but a different allocation method (explicit and implicit).

The study simulates a shift from an explicit to implicit auction of the capacity of the German borders, with the assumption that everything else remains unchanged. Due to limitations of this assumption, appropriate reservations are still to be taken regarding the validity of the obtained results.

It has to be noted that the Project Parties will perform an additional validation study in which the ATC resulting from the ATC experimentation phase will be used. The results of the additional study will provide a better indication of the quality and the value of ATC based market coupling. At the moment the study is being carried out and results are expected by end of February. Section 8.6 however, describes the set up of the study and gives an overview of indicators that are being investigated.

The Project Parties wish to emphasize that reliable validation results of the flow based market coupling, will only become available during the parallel run. Results will be reported to regulators in the second half of 2010.

8.1 Objective of the validation

The objective of the validation was to determine the increment in quality and value of the coupling of the German- and the TLC-markets based on implicit auctioning of ATCs. To determine these increments a number of quantitative and qualitative indicators have been established which are presented below.

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[15] These results were in fact obtained by simulation with COSMOS using historical data (historical order books of APX, Belpex, EPEX Spot DE and EPEX Spot FR and historical TLC ATC) and zero capacity between the TLC and Germany

8.2 Simulation data used

The simulations have been conducted with the following input data:

- Power Exchanges : 318 days historical order book data of 2007 (modified as described in the subsections below)
- TSOs: 318 days[16] historical ATC for 2007. (The same capacities were used for the two scenarios –implicit/explicit-, whereas it might be that capacity calculation would be different under CWE-MC (i.e. coordinated ATCs)).

8.2.1 Limitation of the order books

In general, in the CWE-MC, since the market situation will differ from the historical one, it is questionable whether the order books will be the same, and so whether historical order books should be used for the simulations. The simulation results presented in this document are intended to compare two coupling mechanisms: an explicit and an implicit auctioning of the daily cross-border capacity available between the TLC region and Germany, i.e. on the DE-NL and DE-FR borders (the NL-BE and FR-BE borders were already implicitly auctioned through the TLC mechanism in 2007, and there is no electrical BE-DE border).

However, currently, the transmission capacities on the DE-NL and DE-FR borders are auctioned via an explicit auctioning mechanism; which mechanism has a potentially large impact on the Exchanges' order books. Indeed, with both implicit and explicit auctioning mechanisms, energy is bought in some markets and sold in other markets, and these transactions have impacts on prices. For example, shipping energy from Germany to France – whether via an explicit or an implicit allocation principle - will tend to increase prices in Germany and to decrease prices in France.

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). This trading strategy is defined as cross border arbitrage.
With implicit auctions, this daily cross border arbitrage is performed via a centralized system, and no longer via the participants' orders.

In Figure 2 such a daily cross border arbitrage is illustrated: arbitrageurs anticipated the market to be high-priced, hence they bought and nominated import capacity, and sold all the imported volume locally. This is reflected by the "explicit import" price taking order in the Supply curve in the figure to the left. Under the assumptions taken (see the following section), the size of this "explicit import" is equal to the nominated imported volume in this market.

The right hand side of Figure 2 illustrates the situation without the explicit import: the price is higher. This is the situation we wish to recreate before simulating the implicit coupling between TLC and the EPEX Spot German order book: it is from this high isolated price that the coupling (either explicit or implicit) schedules a trade to lower the price (and increase welfare) for the importing market.

Analogously one could create an example where the demand curve of an exporting market contains the exported volume that is bought locally. Removing the explicit export will recreate the isolated situation.

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[16] Complete set of input data were only available for 318 days.

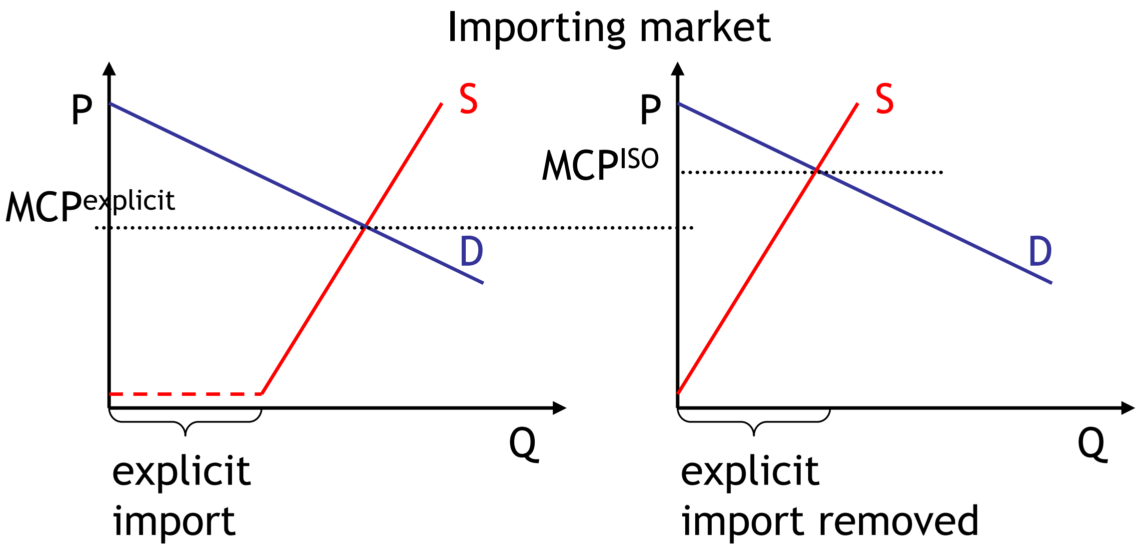

Figure 8.1: Effect of explicit (import) order in order book

8.2.2 Adaptation made on the order books

The historical CWE order books used for the simulations presented in the implementation study are those collected just after the exchanges gate closure time.

For the reasons explained above, French, Dutch and German order books take into account the effects of explicit auctions on the DE-NL and DE-FR borders as held in 2007, and thus show prices as reflected in the left hand side of Figure 8.1. In contrast to the TLC-DE borders, the order books do not contain any daily capacity allocation between the TLC markets.

To simulate an implicit auction the daily cross border arbitrage volume must be removed from the French, Dutch and German order books. It is very difficult to know the proportion of daily cross border arbitrage in the TLC order book and the EPEX Spot German order book situation, and even more difficult to anticipate the participants' behaviour when moving to implicit auctions. Therefore four assumptions of the reality are made for the simulations:

- All the orders resulting from the daily cross border arbitrages are price-taking hourly orders, but some arbitrageurs can as well submit blocks or price-dependent hourly orders.
- 100% of the daily explicit nominations are used for daily cross border arbitrage in the Power Exchanges (and not in the OTC), meaning that we assume that all the day-ahead capacity is used for daily cross-border arbitrage. If this is not the case, the volume to remove from the order books would then be lower. This approximation is however expected not to be too far from reality, since the Power Exchanges' price in the end is still influenced by the OTC cross-border volume;
- The volume in the order books of long term explicit nominations used for daily cross border arbitrage is not impacted by a change from explicit to implicit mechanism, meaning that we assume that no long term capacity is used for daily cross-border arbitrage. If this is not the case, the volume to remove from the order books would then be higher;

- The overall market participants' behaviour will remain the same under an implicit auction mechanism.

Note that the combinations of these four approximations potentially introduce biases in the results. Therefore removing the daily explicit nominations from the simulation data is equivalent to removing supply (respectively demand) volume up to the daily explicit import (respectively export) volume from the Power Exchanges' order books.

8.3 CWE-MC under ATC vs current situation (implicit vs explicit auction)

This section shows the impacts of moving from explicitly auctioning to implicitly auctioning the TLC region and Germany, under the same ATC constraints.

8.3.1 Benefits of implicit auctions

One can summarize the differences between implicit and explicit auctions by the fact that all the information is available at a central level in implicit auctions, which avoids the step of estimating market conditions and prices. This indeed allows a central entity to compute the best (=optimal) cross-border exchanges by using all the necessary information to do so. Consequently, the final price differences between the coupled markets are optimal, and this is directly observable from the results (i.e. no price differences if no congestion).

In contrast, under explicit auctions, individual market parties must estimate part of the necessary information in order to perform cross-border transactions: because there is no central computation, some information has to be estimated before the price computations. This lack of exact information causes some inefficiency in the cross-border exchanges: the amount of energy bought in some markets and sold in other markets might be too large or too small compared to optimal bilateral exchanges. Consequently, price differences are not necessarily optimal (e.g. price differences but capacities not fully nominated). The first inefficiency of explicit auction is thus the suboptimal usage of the available capacity.

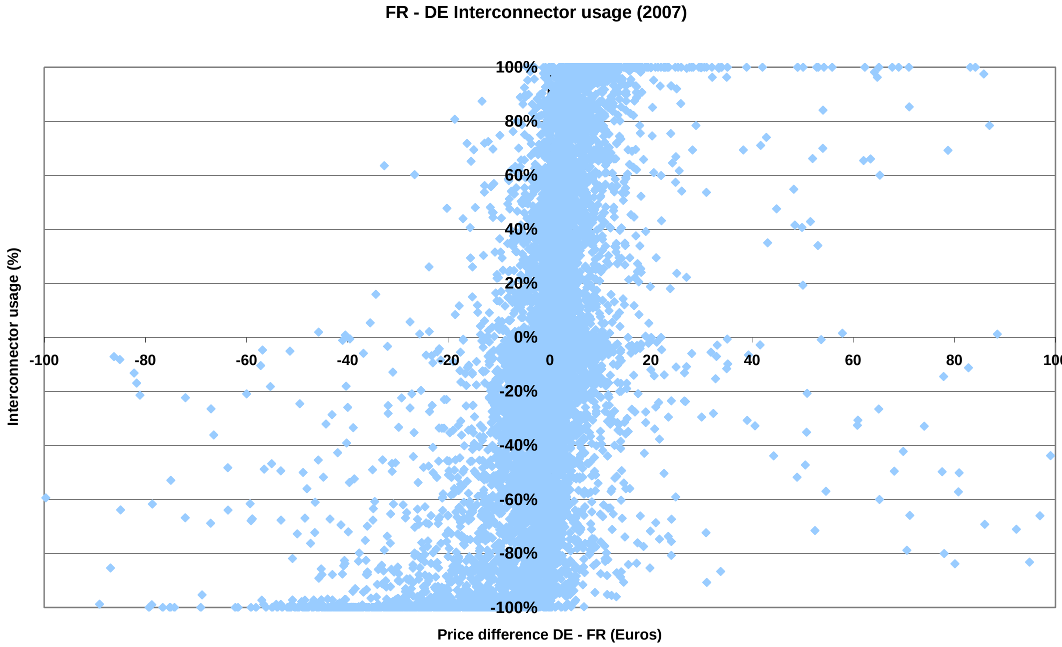

Figure 8.2: FR DE interconnector usage

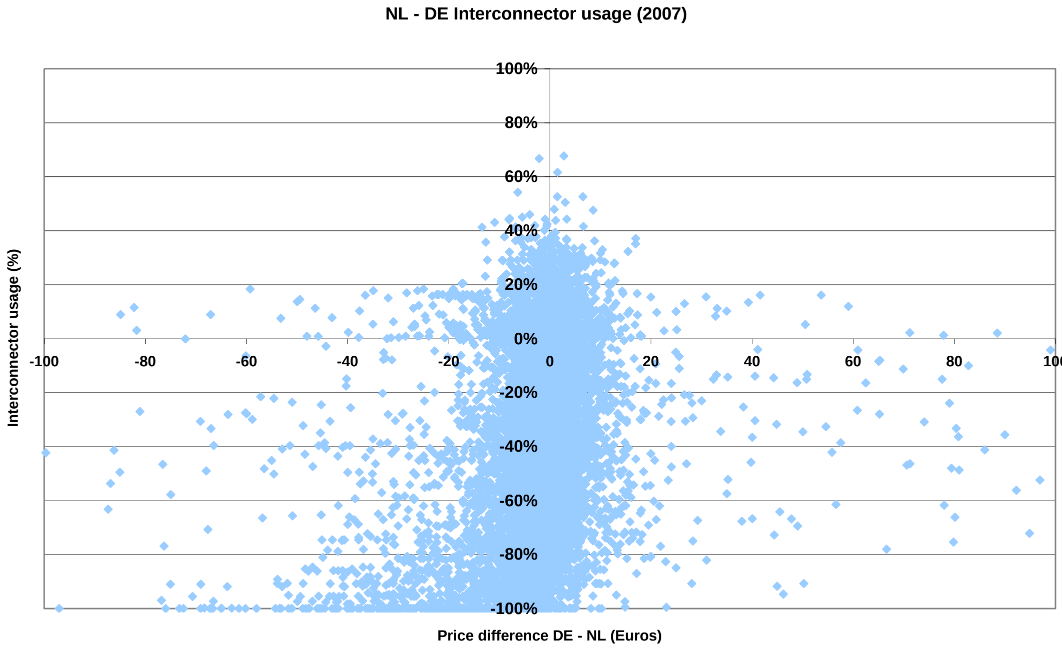

Figure 8.3: NL DE interconnector usage

In addition, the price of transmission rights auctioned explicitly might differ from the Exchanges price difference. This is where explicit auctions show their second inefficiencies, which is the source of the daily cross border arbitrageurs' revenues.

8.3.2 Results of the simulations

This section explores the impact that the transition from explicitly to implicitly auctioning FR-DE and NL-DE capacities brings on a number of market indicators.

The explicit auction is represented by historical results[17], since these represent the situation where FR-DE and NL-DE capacity was explicitly auctioned.Note again that the order books used in the simulations of the historical situation are the historical order books, whereas the ones used in the simulations of the implicit auctions in CWE under ATC are the "modified order books by removing the cross-border trades nominated on the German borders".

4.3.2.1 Indicator: social welfare

Total welfare change

Figure 5 illustrates the difference in welfare between explicitly and implicitly coupling Germany to the TLC markets (FR, BE and NL). The welfare is the sum of buyer surplus, seller surplus and revenue due to price difference between two adjacent markets (mentioned as price spread revenue[18] in the rest of the document) –this revenue is collected by the market participants under an explicit mechanism, and by the TSOs under an implicit mechanism. Note that the large numbers on the vertical axis (337.5 billion euros) mainly represent buyer surplus. This number is somewhat arbitrary, since it mainly reflects price taking demand, which is submitted at the € 3000 maximum price. Instead, more relevant is the price spread revenue: under the implicit auction this revenue decreases from € 158M to € 134M (compared to the explicit current situation). Nonetheless overall welfare increases under the implicit allocation by **36.4** millions euros (over 318 days).

In Figure 6 the change in welfare between implicit and explicit is subdivided in surplus (buyer +seller surplus), auction income and arbitrageurs' revenue and is presented in a cumulative view. An increase corresponds to higher results for implicit auction; a decrease corresponds to higher results for explicit auction.

Auction income versus price spread revenue

Note that in the explicit case, price spread revenue, defined in this text as the cross border price-spread multiplied by the cross border volume, is not equivalent to auction income, since TSO income follows from the auctioning of explicit nomination rights (equals to "capacity price x sold capacity[19]").

For the explicit case the difference between price spread revenue and the TSO income can be considered to be arbitrage revenue: an arbitrageur can buy cross-border capacity for a price different than the price spread between the markets. Executing his right allows the arbitrageur to make an income of "(mcpto – mcpfrom) x cross-border volume – explicit right x obtained capacity".

For the implicit case, price spread revenue is equivalent to auction income and is commonly called "congestion revenue". For the sake of clarity, this document uses "price spread revenue" and "auction income" without referring to "congestion revenue" as this term does not allow this specific distinction.

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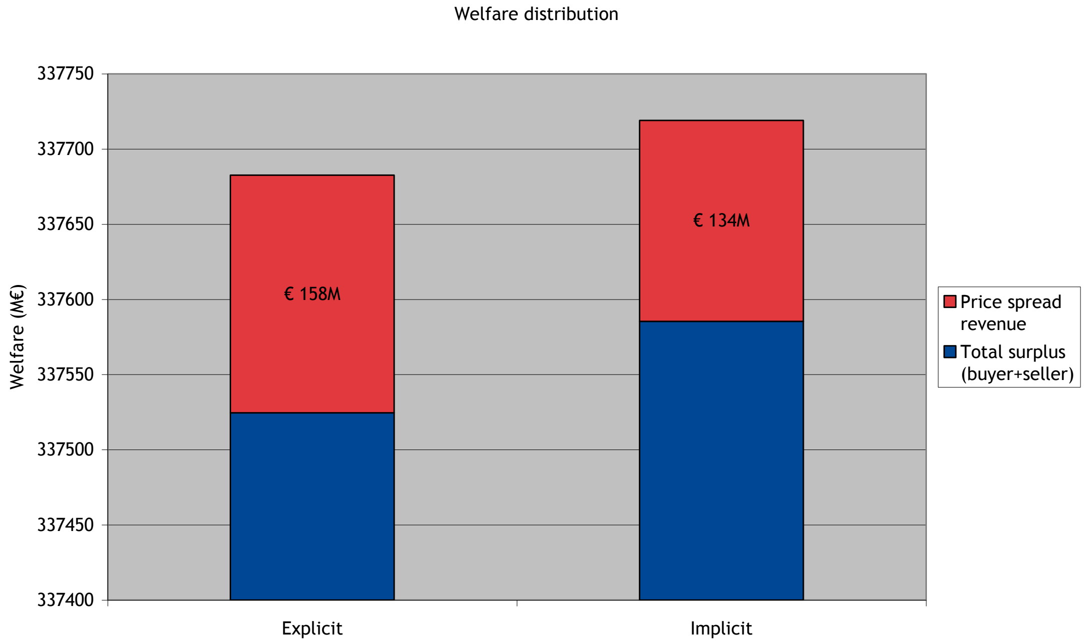
[17] In the absence of some important indicators (e.g. welfare) for the historical case, this case has been recreated by simulating the TLC with COSMOS using the same historical TLC ATCs and order books, and setting the TLC-DE capacities to zero. Since different algorithms were used, the simulated historical results differ from the real historical results. However, these differences happen on a limited number of hours, and the impact on the total social welfare is expected to be negligible.

[18] Price spread revenue is computed as sum over all borders and hours of the price differences multiplied by the cross border volume (Auction income plus arbitrage revenue).

[19] Consequently, in the explicit case, the CWE TSO income amounts to the sum on internal TLC borders of the cross border price-spread multiplied by the nominated commercial trade, plus the sum on both directions of the FR-DE and NL-DE borders of the capacity price multiplied by the sold capacity.



Figuur 2: welfare under implicitly coupling TLC and DE

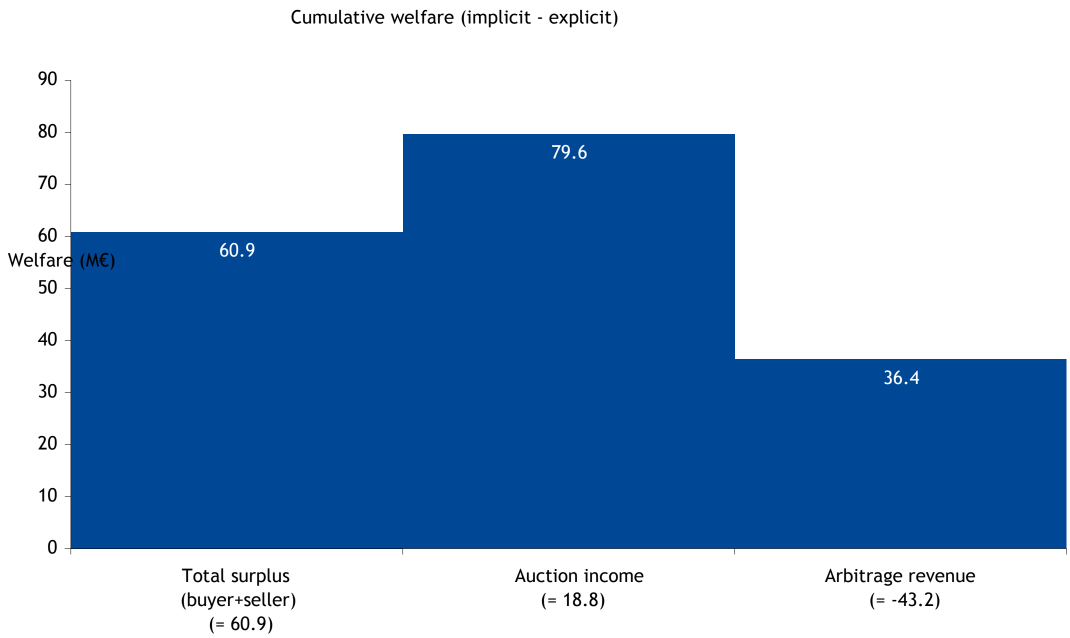


Figure 6 Changes in welfare distribution between implicitly and explicitly coupling TLC and DE

RESULTS

The results in 6 suggest that the total surplus and auction income increase (by 60.9M€ and 18.8M€ respectively) whereas the market participants cross border arbitrage revenue decrease (by 43.2M€) when moving to implicitly auctioning the FR-DE and NL-DE capacity. Overall social welfare increases by **€ 36.4M** (over 318 days).

Price spread revenue: arbitrage revenue and Auction income

The repartition of the revenues induced by the price differences is different under explicit and implicit auctions.

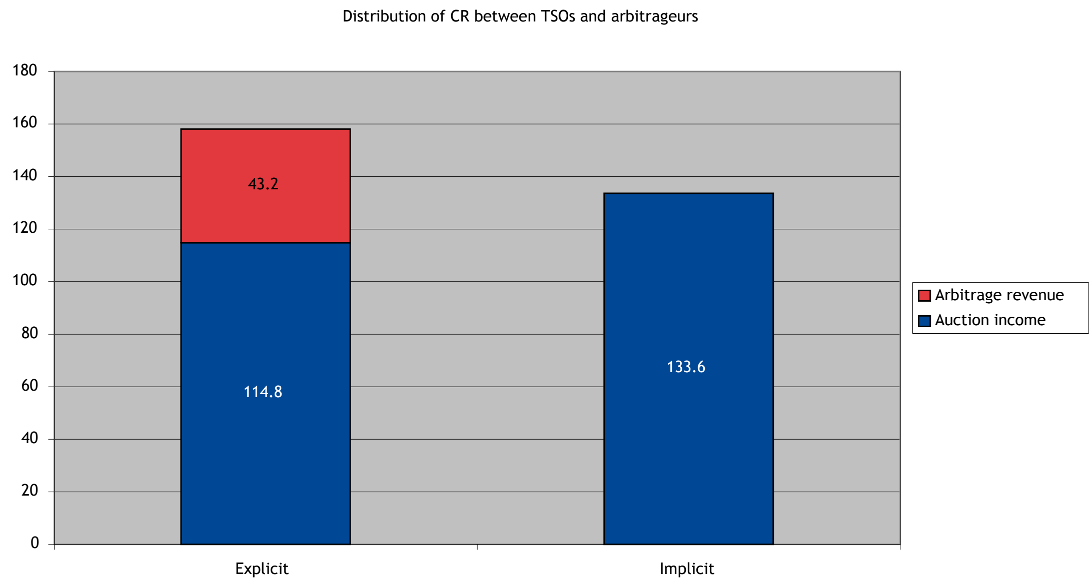


Figure 7 Distribution of price spread revenue between TSOs and market parties

RESULTS

Figure 2 illustrates that under implicit coupling price spread revenue decreases by 24.5M€ (over 318 days). Figure 7 shows the breakdown of price spread revenue between TSOs and market parties for both the implicit and explicit scenarios: the increase in auction income is of 18.8M€ (over 318 days) from 114.8M€ to 133.6M€, i.e. a 16% increase. This amount does not take into account any additional cost of resale of long term capacity. Hence the implicit allocation has two consequences. Firstly it reduces the price spread revenue, that is, the revenue due to cross border arbitrages and somehow paid by the community because of scarce cross border capacity. Secondly, this lower price spread revenue is collected by the TSOs.

4.3.2.2 Indicator: base load prices

Annual Base-load prices

The chart below shows the (annual) base-load prices obtained under implicit (CWE-MC UNDER ATC) and explicit TLC-the EPEX Spot German order book (Historical) auctioning.

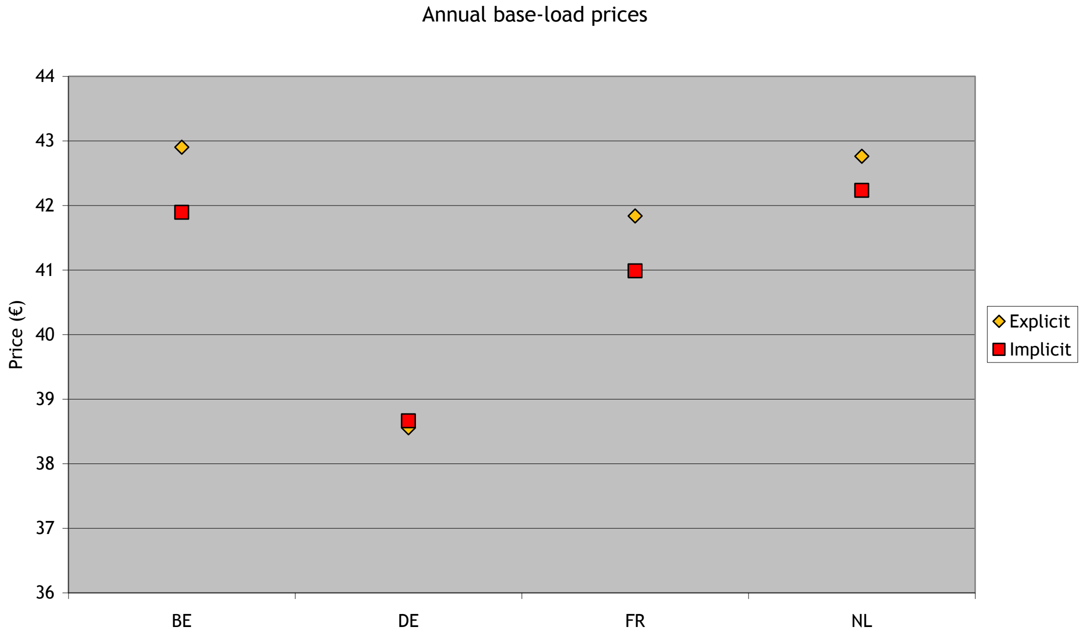


Figure 8 Annual base-load prices

RESULTS
Historically some level of convergence between the markets existed: the spread in annual base-load was mcpBE – mcpDE = € 4.35. Under implicit coupling this spread tightens to mcpNL – mcpDE = € 3.57: on average, more convergence is obtained.

Price convergence

Figure 9 considers the possible price convergence scenarios (i.e. which markets have identical prices). Results are presented as a histogram, with frequencies expressed as number of hours. Prices are considered identical if their difference is less than € 0.01.

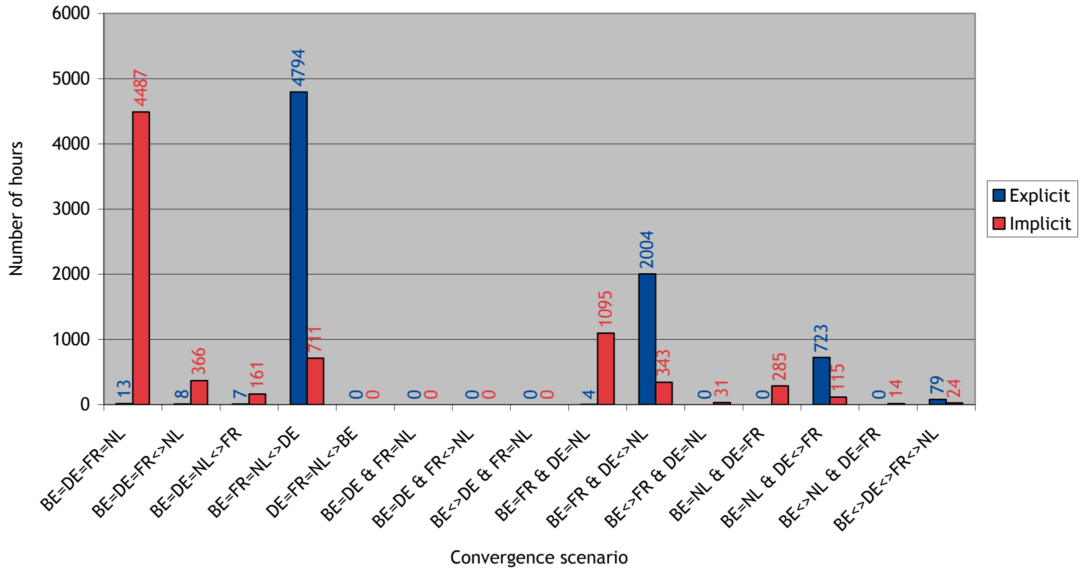


Figure 9 Convergence for historical and CWE-MC UNDER ATC cases. A tolerance of € 0.01 was applied.

RESULTS

The historical result already contains the implicit coupling within the TLC region. This is expressed by the blue spike for the scenario BE=FR=NL<>DE. Implicitly coupling the TLC and DE moves this spike to the full convergence of all four markets. For those cases for which full convergence is not possible the implicit coupling typically results in either a TLC & DE price or a BE+FR and a DE+NL price. Under explicit coupling this latter case typically resulted in a BE+FR and DE and NL price, i.e. no convergence between DE and NL. In terms of price convergence, the results showed the following:

- There is full convergence (4 Market Clearing Prices equal) in CWE-MC UNDER ATC in 58.8% of the hours.
- There is full convergence (4 Market Clearing Prices equal) in Historical in 0.2% of the hours.
- There is partial convergence (at least 2 Market Clearing Prices equal) in CWE-MC UNDER ATC in 99.7% of the hours.
- There is partial convergence (at least 2 Market Clearing Prices equal) in Historical in 99.0% of the hours.
-

These results illustrate the superiority of implicit auction over explicit auction: both the historical and CWE-MC under ATC coupled results show good TLC convergence. For the TLC-DE convergence (with a tolerance of € 0.01), the CWE-MC under ATC results are superior.

Price divergence

The figure below illustrates price divergence: the price difference per hour between the most expensive and the least expensive markets. The differences have been sorted in descending order. Results for both the Historical and the CWE-MC under ATC case are presented.

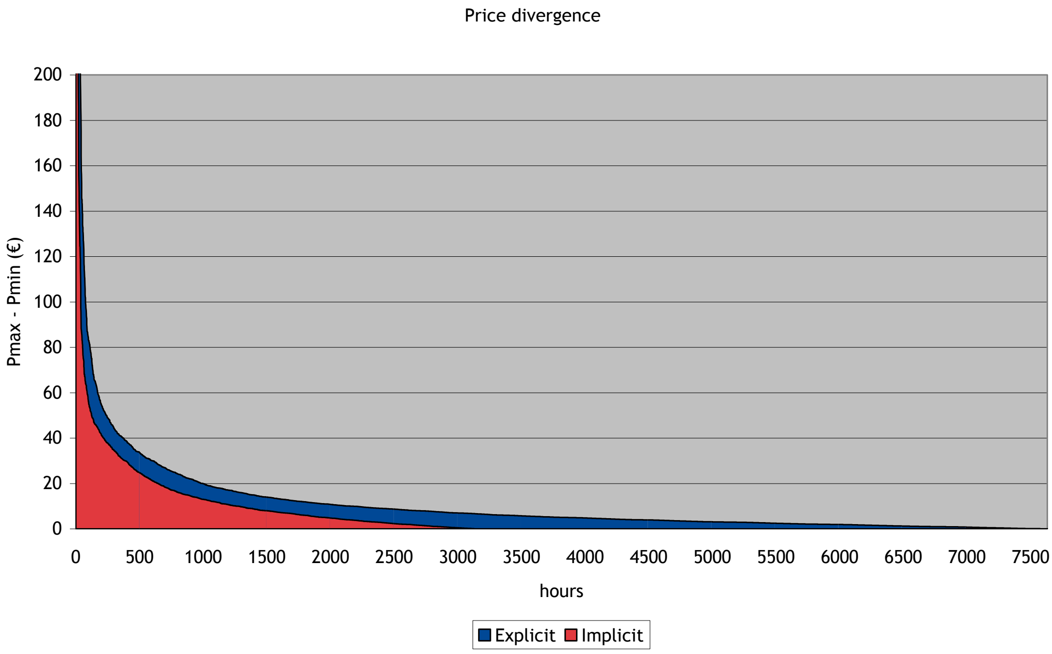


Figure 10 Price divergence

RESULTS
This indicator illustrates that under implicit auctions prices tend to converge more than under explicit auctions.

4.3.2.3 Indicator: volatility

Impact on daily price volatility

A proxy for the price volatility of a market is the standard deviation of the price. Base-load price standard deviations are illustrated in figure 11.

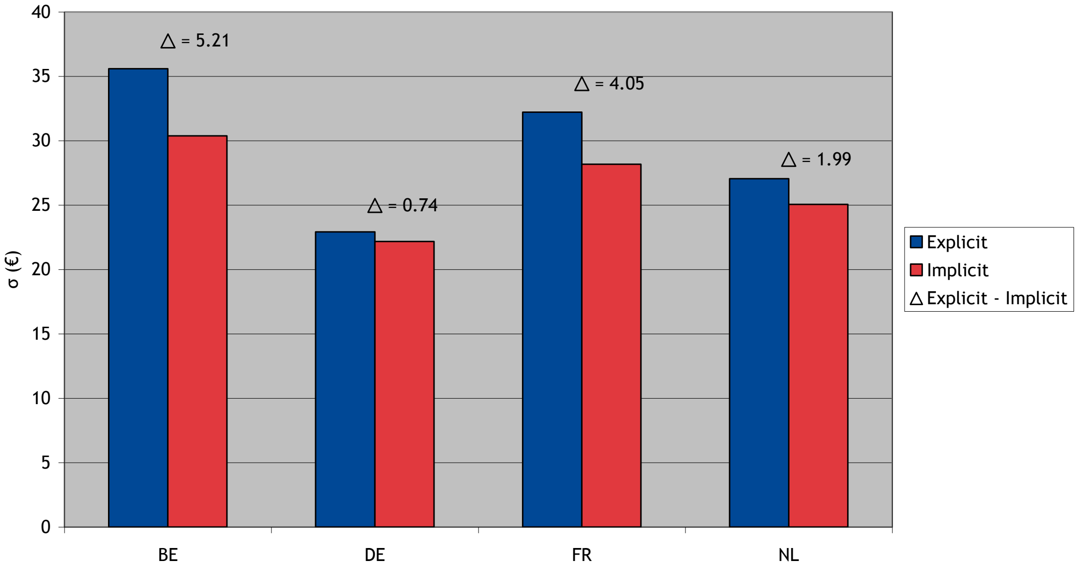


Figure 11 Standard deviation of weekday base-load prices as a proxy for volatility

RESULTS

Comparing the volatility between historical and CWE-MC under ATC shows a decrease for all markets when moving to implicit auction under ATC. In the previous and subsequent section we observed a better price convergence: indeed less extreme values are observed under an implicit coupling mechanism, and the standard deviation is smaller.

4.3.2.4 Indicator: market clearing volume

The graph below shows the market clearing volume for all markets under the historical and CWE-MC under ATC scenarios. Note that market clearing volume is defined to be the largest of either the total demand volume or the total supply volume. The difference between the two is the net position.

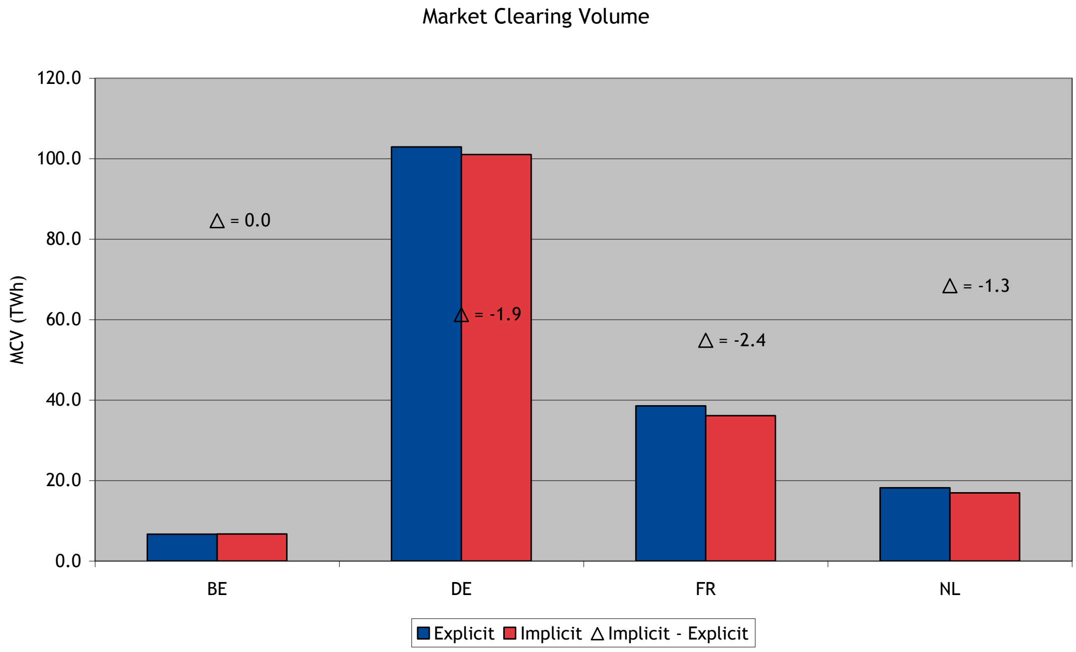


Figure 12 Market clearing volume under the historical situation (explicit) and the CWE-MC UNDER ATC situation (implicit)

RESULTS
Simulation results show that CWE-MC under ATC market clearing volumes never change by more than 7% (NL market). For all markets but BE the change is negative, i.e. the CWE-MC under ATC scenario less cleared volume is achieved for the Power Exchanges compared to the historical situation.

8.4 Summation of main observations

Regarding the comparison between the results obtained under implicit and explicit ATC coupling of TLC and DE, the following observations have been made from the simulations[20]:

- Welfare increases by 41.8M€ annually[21];
- Buyer surplus increases under implicit auction;
- Supplier surplus decreases under implicit auction;
- Auction income increases under implicit auction by 21.6 M€[22] annually;
- Price spread revenue decreases under implicit auction by 28.1 M€[23] annually;
- Price convergence improves under implicit auction;
- Price volatility reduces (improves) under implicit auction.

8.5 General conclusion

Before drawing any conclusion from the abovementioned observations, some reservations need to be made regarding the data that is used in the simulations. Indeed some effects of explicit auctions have been removed from the order books used for simulating implicit auctions, but additional effects (see the 4 approximations made) triggered by an implicit auction mechanism may have not

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20 Obviously, the real results during operation will differ from the simulated results
21 36.4M€ increase for 318 days extrapolated
22 18.8M€ increase for 318 days extrapolated
23 24.5M€ decrease for 318 days extrapolated

been taken into account and have not been reflected in the altered order books. In addition, the same capacities were used for the two scenarios, whereas it might be that capacity calculation would be different under CWE-MC (i.e. coordinated ATCs, or introduction of UIOSI).

First of all, the simulation of CWE-MC under ATC shows the efficiency of replacing cross border explicit auctions (historical situation) by implicit auctions. Almost all indicators are improved. The conclusion is that implicit auctions optimise cross border capacity usage and benefit to the community (the prices tend to converge, the welfare increase, the arbitrage revenue disappears). On the other hand, this analysis shows that the implicit auctions do not bring additional clearing volumes to the power exchanges.

8.6 Set up of additional validation Studies

The aim of the simulations is to provide insight on the impact of the coordinated ATC calculation on market results. The following indicators shall be analysed in order to assess the potential impact of the coordinated ATC method on the market results:

- Prices/Spreads
- Volatility
- Convergence/congestions
- Welfare
- Volumes

The analysis will be performed using data resulting from the coordinated ATC experimentation covering four the weeks 36, 37, 38 and 39 of 2009 with 24 hour ATCs. The results shall be reported to the regulators, once available.

9 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 1. In addition, the issue of transparency and monitoring has been discussed with regulators during several expert meetings. The conclusions of those meetings are included in this chapter. The Parties acknowledge that certain issues related to the flow based solution were not finalized and discussions with the regulators will continue in 2010. Transparency under flow based market coupling is not included and will be presented in 2010 before the launch of flow based market coupling.

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

- Relation with Regulation 2003/1228
- Transparency under ATC based network constraints

9.1 <u>Relation with EU regulations</u>

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. 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.

9.2 <u>General information to be published</u>

- A description of the CWE market coupling solution
- The high level description of principles of the algorithm
- Fall-back arrangements in case of decoupling
- Description of the coordinated ATC methodology and the flow based capacity calculation methodology, including calculation of bilateral exchanges
- A monthly report on the benefits of market coupling compared to isolated markets

These documents will be published by the Project Parties/TSOs.

9.3 Publication of data under ATC based market coupling

It is the obligation of individual TSOs to publish relevant data related to their cross border capacity. For the benefit of the market the TSOs of the CWE region have decided to present the information as set out in the next two subsections in a centralized way on the website of CASC.

9.3.1 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 will continue with the same publications regarding capacity as for the present time: NTC and ATC values on each border and for each direction.

9.3.2 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 Bilateral Exchange flow in implicit allocation schemes)
- Indication of the capacity value, given by the price difference between two hubs in implicit allocation schemes (information will not be available at launch, but will be added shortly after)
- 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

9.4 Publication of data in fall-back mode

The fall-back operator will 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 fall-back operator;
- the forms to be sent by participants;
- the ATCs for each auction;
- the information related to the time schedule of the shadow auctions when they are decided in advance;
- the information related to the time schedule of the roll back (only if applicable);
- 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;

10 Contractual scheme

In this chapter we explain a number of issues related to the contractual scheme of which we think may be important for regulators in respect to the approval procedures. We focus on:

- Principles of the Framework agreement
- Parties involved in the operation and their tasks
- Risk management
- Extension of the region

10.1 Principles of the Framework Agreement

The operation and maintenance of the market coupling solution is governed by a number of contracts between subsets of parties. These contracts are governed by the Framework Agreement: the overall contract between PXs and TSOs. The subsidiary agreements between subsets of parties must be compliant to the principles of the Framework Agreement. The principles of the Framework Agreement have been discussed with regulators during an expert meeting. For reminders, we have attached them in annex 6.

10.2 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:

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

In section 3.2.1 we listed the legal entities having an operational role in the market coupling. In the next sections we will further explain the roles of these involved actors.

10.2.1 Roles of the individual/joint 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. During the first step, this capacity will be presented by an ATC value, followed by the flow based parameters in the second step. The ATC values are determined in a two step approach: determination of ATC values by each individual TSO (except for CREOS), followed by the determination of coordinated capacities. The coordinated capacities are determined with the joint TSO pre coupling system using input from all TSOs (see dedicated section of this document). This system also sends the coordinated capacities to the Market Coupling System. The joint TSO pre coupling system is operated by all TSOs taking weekly shifts. SSC operates the system on behalf of Amprion and TenneT, and Coreso operates the system on behalf of RTE and Elia. Transpower and EnBW operate the joint TSO pre coupling system themselves.

The joint TSOs are also responsible for the final validation of the net positions and of the calculation of bilateral 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. The calculation of bilateral cross border exchanges is performed by the post coupling system. CASC is the operator of that system on behalf of the TSOs.

10.2.2 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 market coupling system, a joint PX system. The 4 PX order books are transferred and injected directly into the market coupling database. The order books contain all the bids of the market parties in an aggregated and anonymous format. The PXs involved are EPEX Spot for the French and German hub, Belpex for the Belgian hub and APXEndex for the Dutch hub.

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.

10.2.3 Roles of the joint PXs

The joint PXs are responsible for building, operation and maintenance of the market coupling system. The market coupling system 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. The involved PXs operate the market coupling system according to a rotation scheme.

10.2.4 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 a joint steering committee, an operational committee and an incident committee.

10.2.5 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. In section 10.2.1 the TSO service providers CASC, SSC and Coreso were introduced. Other tasks to be performed by service providers are:

- Shipping agent activities (nomination of cross border exchanges, financial clearing and settlement). These tasks will be performed by the clearing houses of EPEX Spot and APXEndex: ECC for the French and German hub and APXEndex for the Belgium and Dutch hub.
- Reception of congestion rents and distribution to the individual TSOs. This task will be operated by CASC.

10.2.6 Summary of operational roles

Entity	Role
TSOs	• Determine own ATC values • Operate the TSO pre coupling system (determination of coordinated ATC and sending to the market coupling system by taking weekly shifts
Coreso	• Operate the TSO pre coupling system on behalf of RTE and Elia
Amrion and TenneT staff organised in SSC[24]	• Operate the TSO pre coupling system on behalf of Amprion and TenneT
PXs	• Collection of bids and offers from their participants in their hub, and submission of their aggregated and anonymous order books to the CCU. • Operation of the CCU by taking turns
ECC	• financial clearing and settlement in the EPEX Spot French and German hub, nomination of cross border exchanges
APXEndex	• financial clearing and settlement in the Dutch and Belgium hub, nomination of cross border exchanges
CASC	• operation of the TSO post coupling system (calculation of bilateral exchanges • congestion revenue distribution among the TSOs

10.3 Risk management

In order to mitigate risks related to changes to all components that make the market coupling solution work as it is supposed to do, like systems, procedures and interfaces, the Project Parties have implemented a change control procedure. According to this procedure, potential changes are categorized. For each category there is a predefined procedure to be followed, before a change can be implemented. This procedure consists of, among others, the obligation to request for a change, a change log, testing procedure and a decision making process. The operational committee is tasked with the management of the change control procedure. For changes with highest impact on the market coupling solution, only the steering committee is allowed to approve such changes.

10.4 Future couplings

The Project Parties have expressed in the Framework Agreement a firm commitment to cooperate in the further integration of the European wholesale market. This can be achieved by an extension of the region under the Framework Agreement, or by an interregional market integration project. At the moment, several potential extensions are being discussed, like the interregional market coupling between the Nordic and the CWE region, extension to the UK via the BritNed cable and IFA and extensions towards German Swiss interconnector. In

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[24] In fact, SSC is not a legal entity. It is a cooperation between Amprion and TenneT.

addition all parties are involved in general discussions about market integration like in ENTSO-E, Europex, Florence Forum, and PCG.

11 Congestion rent sharing key

This chapter describes the congestion rent sharing key between the CWE TSOs. Basically the solution is to share the congestion rents on a 50/50 basis between the TSOs on both sides of the border

11.1 Reasoning

In an ATC based market coupling only those borders that are congested will see a price difference between the hubs on both sides of that border.
So there are normally only two cases:

- A non congested border with a capacity use less than the given ATC, and no price difference between the hubs on both sides;
- A congested border with a capacity use equal to the given ATC, and a price difference between the hubs on both sides, with the flow going from the lower price area towards the higher price area.

This means that if there is a price difference between two hubs, the ATC given on that border will be fully used; if there is no price difference, there is no congestion, and there should not be any income. Therefore the auction income which is generated in an ATC based market coupling can be individually determined on each border between hubs. Given the two cases which can occur, in each case could be given by the same simple formula of ATC multiplied by the price difference between the concerned hubs. In the case of an ATC based coupling, another way to formulate it is the additional market flow generated by the coupling (i.e. Bilateral exchanges calculated by TSOs on the basis of market coupling net positions), times the price difference between the hubs.

It is natural that the net-income (i.e. income minus direct related shipping-fees) generated on a particular border concerning particular hubs, would be assigned to the TSOs which are part of the concerned hubs. So the proposal is to allocate the auction income which has been generated on a border to the TSOs which share that border. And, in absence of any particular regulatory request for a different sharing, the usual 50/50 rule, which is currently used on all borders in the CWE area, should apply for the 2 sides of the border.

11.2 The chosen key: Hub Price Difference x Bilateral Exchanges

The idea of market based keys is that the auction income is shared depending on economic indicators, like clearing prices, or market value of congestions.
The overall auction income is thus distributed depending on economic indicators related to the clearing of the auction, that is to say on market price differences and not only on exchanged volumes.

The “clearing value” is assessed for each border by multiplying the assigned additional flow on the border by the hub clearing price difference. Then these clearing values are equally shared between the TSOs on both sides of the border.
With “Bilateral Exchange” it is meant the additional commercial exchanges resulting from Day Ahead Market Coupling.

11.2.1 Calculation

In case of a price difference, the Bilateral Exchange in a direction will be equal to the ATC in that direction. For any two TSOs A and B sharing a border

Assigned Income (A) = ½ x Bilateral Exchange (AB) x abs[Hub Price(B)-Hub Price(A)]

Where Bilateral Exchange is the exchange from the lowest price area to the highest price area. For three TSOs A, B1 and B2 sharing a border (A-B), with A on one side

Assigned Income (A) = ½ x Bilateral Exchange(AB) x abs[Hub Price(B)-Hub Price(A)]

Assigned Income (B1) + Assigned Income (B2) = Assigned Income (A)

where B1 and B2 determine between each other how to share the income.
where abs(x) is the absolute (positive) value of x.

11.2.2 Advantages of the proposed key

Working assumption for proposing these sharing keys is that possible disincentives to relieve congestions on borders arising from their usage have not been accounted.

- The key provides the most smooth transition with existing border-by-border schemes;
- The income is linked to arising congestions causing price differences, except for special cases described hereunder;
- It is transparent and non discriminatory;
- It is relatively easy to implement;
- There is consistency of auction income sharing between long term and short term allocations;
-

The short term volatility is only related to market price volatility, and ATC volatility.

12 Bilateral exchange computation

As a main result of the future MC process the net positions of all participating markets are determined and validated by the TSOs.
But since direct nomination of net positions is incompliant with UCTE scheduling rules, the net positions need to be transformed into bilateral cross-border schedules. This process is called "bilateral exchange computation" (BEC).

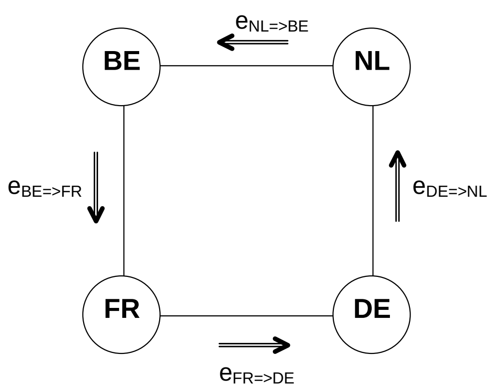
The Bilateral Exchange Computation method selected by the TSOs is the one that minimizes the (sum of the squares of the) Bilateral Exchanges, under the constraint of respecting ATCs. The advantage of this algorithm is that no 'commercial loops' are present in the results, making more "room" free for allocation processes at further timeframes, i.e. intraday.

It should be noted that in ATC mode, and under the constraint of respecting ATC, the choice of the BEC algorithm has no impact on the congestion rent sharing between TSOs. It should be also noted that it is not possible to define a BEC algorithm which is valid in both ATC and Flow Based context. Thus, the TSOs will need to define and agree on another Bilateral Exchange Computation algorithm in the Flow Based context.

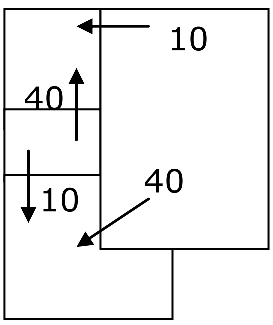
Further sections of this document detail the precise computation algorithm of the Bilateral Exchanges.

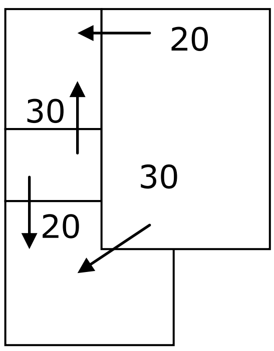
12.1 An infinity of possible BEC algorithms

Basically, a system of equations can be given that relates the regional NEx (Net Exports: B) to BEx (Bilateral Exchanges: e):
BBE = eBE→FR – eNL→BE
BDE = eDE→NL – eFR→DE
BFR = eFR→DE – eBE→FR
BNL = eNL→BE – eDE→NL



Due to the fact that in the MC the following equality constraint must be satisfied (ΣBx=0), the equations are linear dependent.
Therefore, without any additional constraint, the BEx are not uniquely defined. This can be illustrated in the following example, where two possible solutions of the infinite set of BEx is given that correspond to the following net export positions:
BBE = 50
BDE = 50
BFR = – 50
BNL = – 50





12.2 Requirements on the BEC in ATC

In an ATC MC, the available capacity to the market is expressed as ATC. As it has been decided to publish the capacity usage in terms of Bilateral Exchanges (although these values are arbitrary), it is legitimate to request from the BEC:

- to respect the ATCs,
- and to be intuitive (i.e. to show bilateral exchanges from the least expensive country to the most expensive country)

It can be proven that respecting ATCs implies being intuitive. Thus the second requirement is redundant to the first one.

It can also be proven that in case of congested situation (different hub prices), there is only one BEC respecting ATCs.

12.3 BEC 'extract loops' algorithm

In an ATC MC, with four market areas in the current situation, the relation between the net positions (B_{BE},B_{FR},B_{DE},B_{NL}) and the bilateral exchanges ($e_{BE=>FR}$,$e_{FR=>DE}$,$e_{DE=>NL}$,$e_{NL=>BE}$) is given by the following equations:
(Eq. 1)

$$
\begin{aligned}
&B_{BE} = e_{BE=>FR} - e_{NL=>BE} \\
&B_{FR} = e_{FR=>DE} - e_{BE=>FR} \\
&B_{DE} = e_{DE=>NL} - e_{FR=>DE} \\
&B_{NL} = e_{NL=>BE} - e_{DE=>NL} \\
&-ATC_{DE->FR} \le e_{FR=>DE} \le ATC_{FR=>DE} \\
&-ATC_{NL=>DE} \le e_{DE=>NL} \le ATC_{DE=>NL} \\
&-ATC_{BE=>NL} \le e_{NL=>BE} \le ATC_{NL=>BE} \\
&-ATC_{FR=>BE} \le e_{BE=>FR} \le ATC_{BE=>FR}
\end{aligned}
$$

The solution set of Eq. 1 in the Bex space can be easily determined:
(Eq. 2)
Let

$$
\begin{aligned}
e^{\min}_{BE=>FR} &= \max\left(-ATC_{FR=>BE},\ -ATC_{DE->FR} - B_{FR},\ -ATC_{NL=>DE} - B_{FR} - B_{DE},\ -ATC_{BE=>NL} + B_{BE}\right) \\
e^{\max}_{BE=>FR} &= \min\left(ATC_{BE=>FR},\ ATC_{FR=>DE} - B_{FR},\ ATC_{DE=>NL} - B_{FR} - B_{DE},\ ATC_{NL=>BE} + B_{BE}\right) \\
e^{\min}_{FR=>DE} &= \max\left(-ATC_{DE=>FR}, -ATC_{NL->DE} - B_{DE},\ -ATC_{BE=>NL} - B_{DE} - B_{NL},\ -ATC_{FR=>BE} + B_{FR}\right) \\
e^{\max}_{FR=>DE} &= \min\left(ATC_{FR=>DE},\ ATC_{DE=>NL} - B_{DE},\ ATC_{NL=>BE} - B_{DE} - B_{NL},\ ATC_{BE=>FR} + B_{FR}\right) \\
e^{\min}_{DE=>NL} &= \max\left(-ATC_{NL=>DE},\ -ATC_{BE->NL} - B_{NL},\ -ATC_{FR=>BE} - B_{NL} - B_{BE},\ -ATC_{DE=>FR} + B_{DE}\right) \\
e^{\max}_{DE=>NL} &= \min\left(ATC_{DE=>NL},\ ATC_{NL=>BE} - B_{NL},\ ATC_{BE=>FR} - B_{NL} - B_{BE},\ ATC_{FR=>DE} + B_{DE}\right) \\
e^{\min}_{NL=>BE} &= \max\left(-ATC_{BE=>NL}, -ATC_{FR->BE} - B_{BE},\ -ATC_{DE=>FR} - B_{BE} - B_{FR},\ -ATC_{NL=>DE} + B_{NL}\right) \\
e^{\max}_{NL=>BE} &= \min\left(ATC_{NL=>BE},\ ATC_{BE=>FR} - B_{BE},\ ATC_{FR=>DE} - B_{BE} - B_{FR},\ ATC_{DE=>NL} + B_{NL}\right)
\end{aligned}
$$

Then

$$
e^{\max}_{BE=>FR} - e^{\min}_{BE=>FR} = e^{\max}_{FR=>DE} - e^{\min}_{FR=>DE} = e^{\max}_{DE=>NL} - e^{\min}_{DE=>NL} = e^{\max}_{NL=>BE} - e^{\min}_{NL=>BE} \equiv \Delta
$$

And a Bex set e is solution of Eq. 1 if and only if it exists $\hat{\Delta}$, $0 \le \hat{\Delta} \le \Delta$
so that

$$
e = \begin{bmatrix} e_{BE=>FR} \\ e_{FR=>DE} \\ e_{DE=>NL} \\ e_{NL=>BE} \end{bmatrix} = \begin{bmatrix} e^{\min}_{BE=>FR} \\ e^{\min}_{FR=>DE} \\ e^{\min}_{DE=>NL} \\ e^{\min}_{NL=>BE} \end{bmatrix} + \hat{\Delta} \cdot \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}
$$

The BEC 'extract loops' algorithm selects e by minimizing the sum of squared

exchanges under the constraint of respecting the ATCs:
(Eq. 3)

$$\min(e_{FR=>DE}{}^2 + e_{DE=>NL}{}^2 + e_{NL=>BE}{}^2 + e_{BE=>FR}{}^2)$$

so that

$$-ATC_{FR=>BE} \leq e_{BE=>FR} \leq ATC_{BE=>FR}$$
$$-ATC_{DE=>FR} \leq e_{FR=>DE} \leq ATC_{FR=>DE}$$
$$-ATC_{NL=>DE} \leq e_{DE=>NL} \leq ATC_{DE=>NL}$$
$$-ATC_{BE=>NL} \leq e_{NL=>BE} \leq ATC_{NL=>BE}$$

Taking into account the sections above, this optimisation problem has the following solution:
(Eq. 4)
Let

$$\hat{e} = \begin{bmatrix} \hat{e}_{BE=>FR} \\ \hat{e}_{FR=>DE} \\ \hat{e}_{DE=>NL} \\ \hat{e}_{NL=>BE} \end{bmatrix} = -\frac{1}{4} \cdot \begin{bmatrix} 3B_{FR} + 2B_{DE} + B_{NL} \\ 3B_{DE} + 2B_{NL} + B_{BE} \\ 3B_{NL} + 2B_{BE} + B_{FR} \\ 3B_{BE} + 2B_{FR} + B_{DE} \end{bmatrix} \quad e^{\min} = \begin{bmatrix} e^{\min}_{BE=>FR} \\ e^{\min}_{FR=>DE} \\ e^{\min}_{DE=>NL} \\ e^{\min}_{NL=>BE} \end{bmatrix} \text{ and } e^{\max} = \begin{bmatrix} e^{\max}_{BE=>FR} \\ e^{\max}_{FR=>DE} \\ e^{\max}_{DE=>NL} \\ e^{\max}_{NL=>BE} \end{bmatrix}$$

Then

$$e^{\max}_{BE=>FR} - e^{\min}_{BE=>FR} = e^{\max}_{FR=>DE} - e^{\min}_{FR=>DE} = e^{\max}_{DE=>NL} - e^{\min}_{DE=>NL} = e^{\max}_{NL=>BE} - e^{\min}_{NL=>BE} \equiv \Delta$$
$$\hat{e}_{BE=>FR} - e^{\min}_{BE=>FR} = \hat{e}_{FR=>DE} - e^{\min}_{FR=>DE} = \hat{e}_{DE=>NL} - e^{\min}_{DE=>NL} = \hat{e}_{NL=>BE} - e^{\min}_{NL=>BE} \equiv \hat{\Delta}$$

And the solution e_{sol} is unique and defined as follows:

$$\text{if } \hat{\Delta} \leq 0, \qquad e_{sol} = e_{\min}$$
$$\text{if } 0 < \hat{\Delta} < \Delta, \qquad e_{sol} = \hat{e}$$
$$\text{if } \hat{\Delta} \geq \Delta, \qquad e_{sol} = e_{\max}$$