



# CWE Enhanced FB

Report presentation

March 22<sup>nd</sup>, 2011

# Background

- ▶ The **Memorandum of Understanding** of the Pentilateral Energy Forum on market coupling and security of supply in Central Western Europe (CWE), was signed on the 6th of June 2007 and **sets as an objective** the analysis, design and implementation of a flow-based market coupling between the five countries of the CWE region.
- ▶ In **2008**, a market analysis on CWE FBMC was performed based on non-operational FB data and some **issues were detected which seemed to be linked to the data quality**.

At that time it was decided to **start with ATCMC** in CWE as an intermediate facilitation of the market and to **study a FBMC in parallel**.

- ▶ After that decision, the following major steps have been made and milestones accomplished:
  - **TSOs developed the CWE coordinated ATC mechanism** in order to facilitate the CWE ATCMC.
  - **TSOs and PXs successfully launched the CWE ATCMC** on November 9, 2010.
  - During 2009/2010 the **TSOs improved and fine-tuned the CWE FB**
  - **TSO & PXs started the FB parallel run**; so that the market impact of FBMC could be simulated, based on TSOs FB input data and PXs ATCMC order books, as soon as the ATCMC was live.



# Contents

- ▶ CWE Flow-Based capacity calculation feasibility report
- ▶ Flow-Based market coupling market impact analysis
- ▶ Interactions with coupling to other initiatives



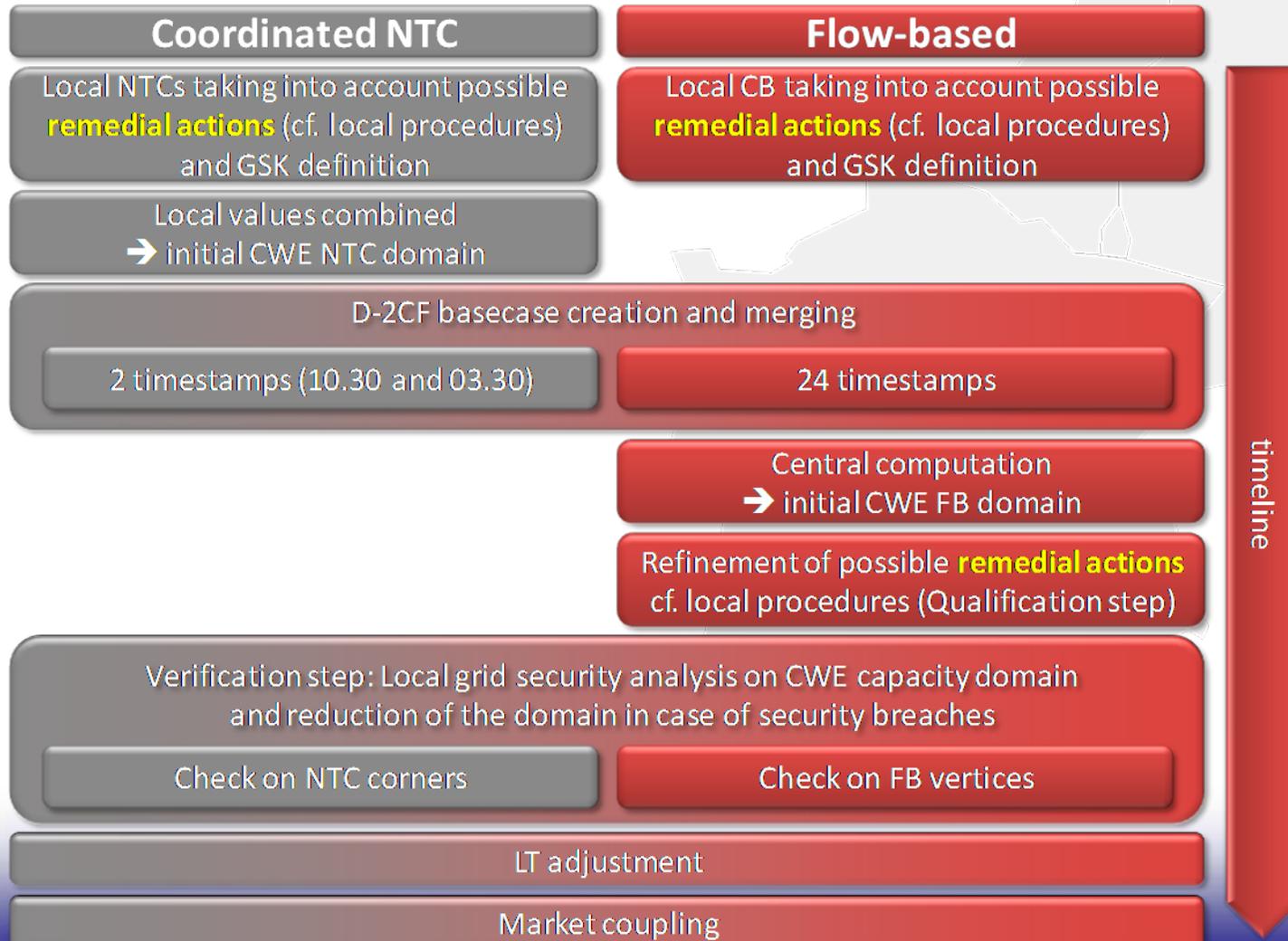


# 1 – CWE Flow-Based capacity calculation feasibility report

- TSOs deliverable -

# CWE enhanced FB operational process (1/3)

- ▶ The **2008 CWE FB “classical” method** has been improved during the TSOs experimentation in 2010
- ▶ The development of the **CWE coordinated NTC/ATC** mechanism and the corresponding industrial tools/services to realize this, **greatly facilitated the work in this field**



# CWE enhanced FB operational process (2/3)

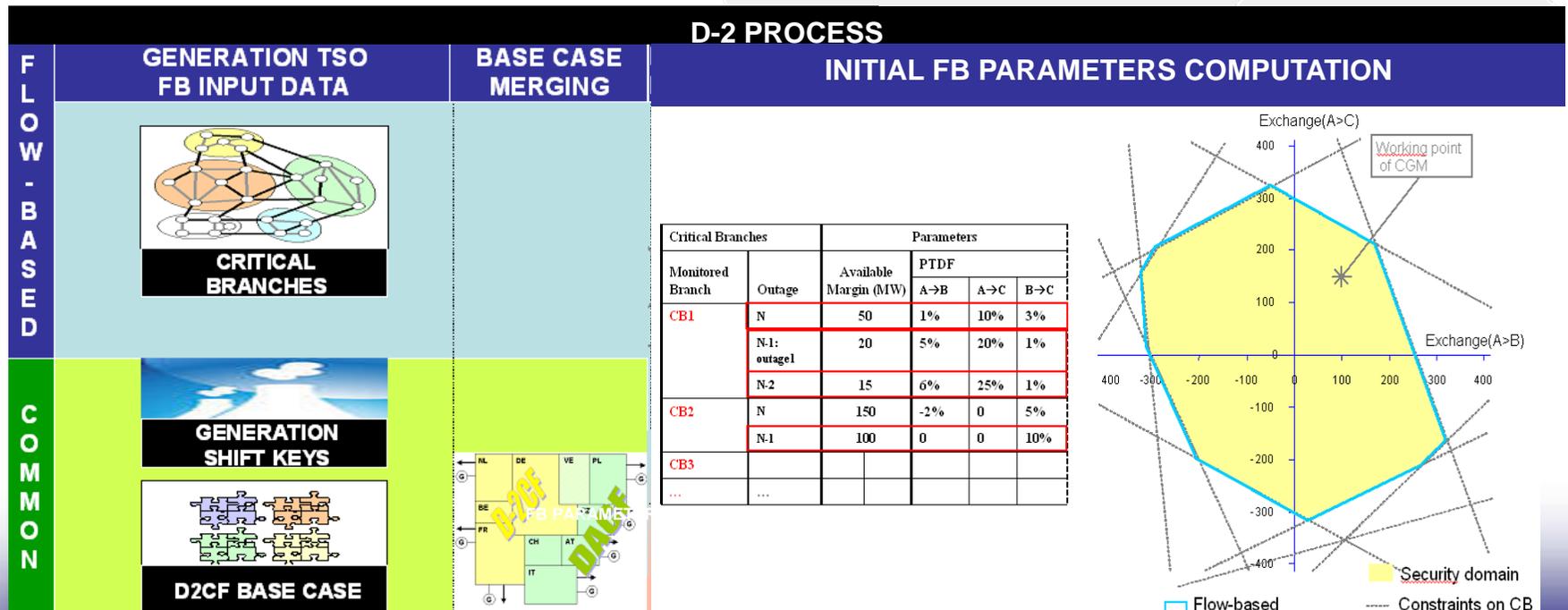
## -Initial FB parameters computation-

With the following input data:

- ▶ Network elements that may limit international trades (**critical branches**)
- ▶ European **D-2 common grid model** "also used in NTC process", (participating TSO D2CF merged with non participants TSO DACF)
- ▶ **Generation Shift Key** (GSK) that defines how a change in net position is mapped to the generating units in a bidding area

the following **initial FB parameters are computed**, based on a sensitivity calculation on the common base case by using the GSK:

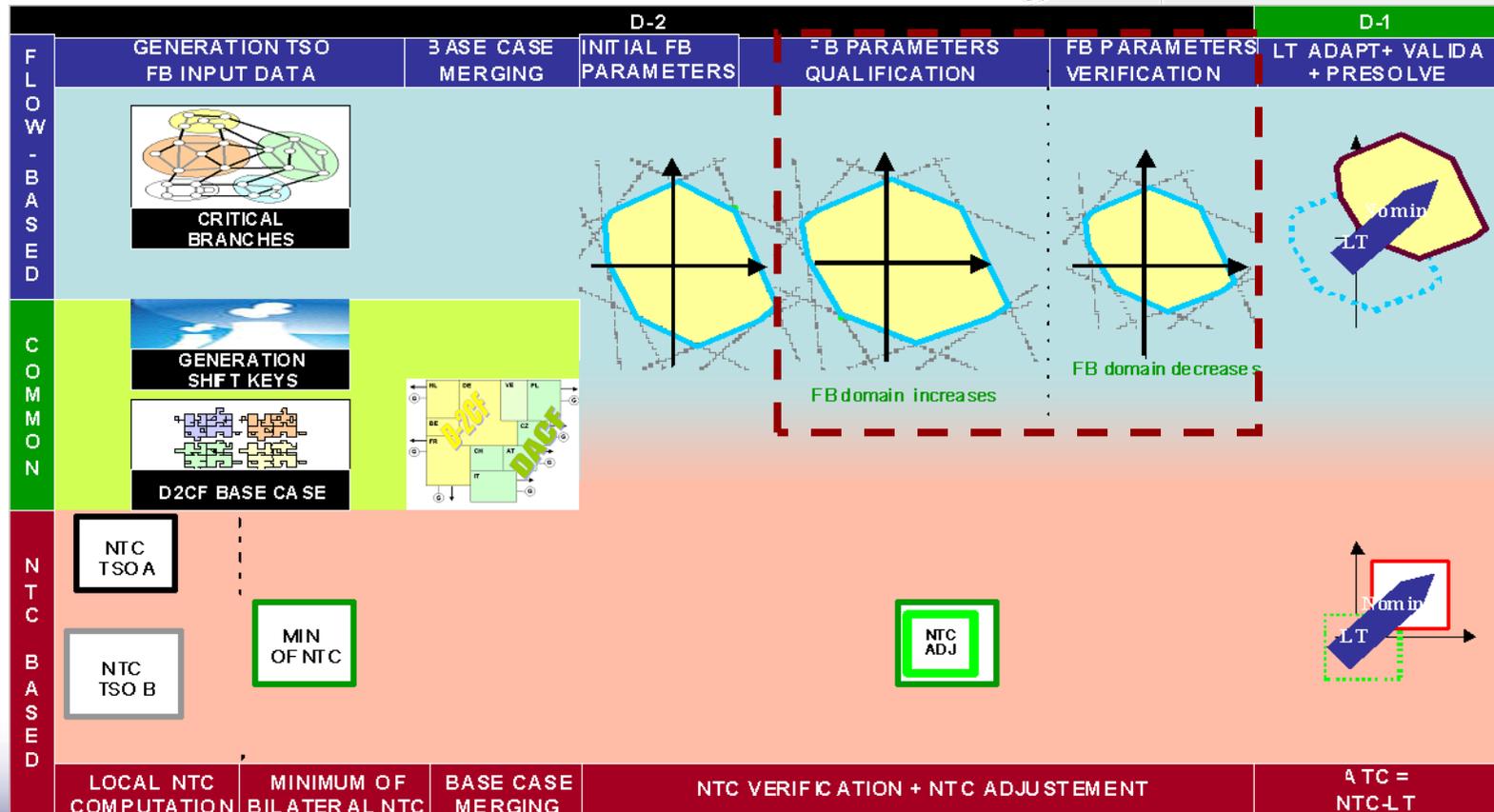
- ▶ **Available Margin** on a critical branch
- ▶ the **PTDF factors** (Power Transfer Distribution Factors) that represent the variation of the physical flow on a critical branch provoked by the variation of the net position of each hub.



# CWE enhanced FB operational process (3/3)

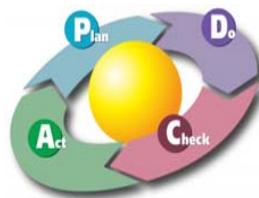
## - FB parameters qualification and verification -

- ▶ These two processes are the **main improvements** from the 2008 classical CWE FB capacity calculation method to the 2010 enhanced CWE FB capacity calculation method.
  - ▶ **FB qualification:** application of the **remedial actions** in FB parameters according to local capacity calculation procedures and risk policy leading to capacity optimization.
  - ▶ **FB verification:** verify that the FB domain is safe by **checking the relevant vertices of the FB domain** (possible to use **real merit orders instead of a linear GSK**, TSO can perform **full AC load flow** and check the **voltage limits**)



# Enhanced FB 2010 CWE TSO experimentation

- 2010 Enhanced FB experimentation cycles were performed, in the form of "PDCA" cycles on a monthly basis to ensure the progress towards a set of targets that is mentioned hereunder.



P	Adapt method to take into account validated improvements from previous cycle
D	Run FB MC precoupling business process
C	Compare the FB vs ATC results of the same days
A	Analyze results and propose improvements for the next cycle to approach target

- These cycles have been **executed** in ex-post mode (delay of about 3 weeks regarding the business dates) **by TSO key users (FB experts and grid experts** aware of the current operational process and situation of the grid) and grant the feasibility of the operational process

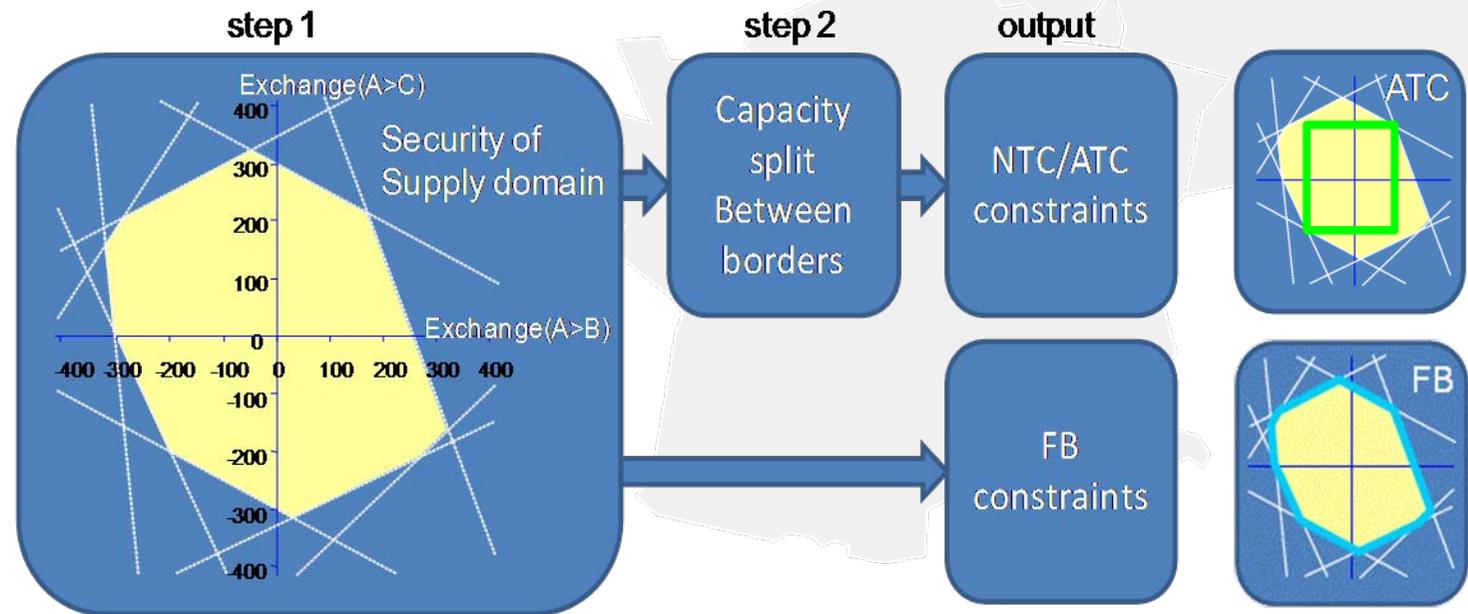


Cycle	Business Dates		Initial FB parameters	Qualified FB parameters	Remarks
	From	To			
CWE enhanced FB learning process (prior to ATC MC)					
1	16/11/09	20/11/09	3h30 & 10h30 TS		
2	4/1/10	8/1/10	3h30 & 10h30 TS	3h30 & 10h30 TS	Introduction of FB qualification process & impossible corners concept
3	1/2/10	5/2/10	3h30 & 10h30 TS	3h30 & 10h30 TS	Introduction of unlikely corners concept
4	1/3/10	7/3/10	3h30 & 10h30 TS	3h30 & 10h30 TS	First trial on FB verification process (for previous cycle timestamp). FB space verification on 1/2 at 10h30
5	29/3/10	4/4/10	3h30 & 10h30 TS	3h30 & 10h30 TS	Introduction of the possibility of impacting remedial action on PTDF FB space verification on 3/3 at 10h30
6	28/4/10	2/5/10	24 TS /day	3h30 & 10h30 TS	Go-live of centralized FB prototype Introduction of 24 TS / day D2CF merge FB space verification on 29/3 at 10h30
7	23/5/10	29/5/10	24 TS /day	3h30 & 10h30 TS	FB space verification on 27/5 at 10h30
8	30/6/10	6/7/10	24 TS /day	3h30 & 10h30 TS	FB space verification on 1/7 at 10h30
9	16/9/10	16/9/10	24 TS /day		Only initial FB parameters computation (FB qualification not executed because of ressources problems)
10	20/10/10	26/10/10	24 TS /day	3h30 & 10h30 TS	Stabilization cycle
CWE enhanced FB data for FB MC impact analyse study (after ATC MC)					
11	22/11/10	5/12/10	24 TS /day	24 TS /day	
12	4/1/11	17/1/11	24 TS /day	24 TS /day	

# FB increases the capacity offered to the market (1/2)

## - Theory -

- ▶ For a given Security of Supply domain, the NTC/ATC domain is only a part of this security domain (because of the capacity splitting between borders made by the TSOs) while the FB domain is the full security domain itself.
- ▶ As such, the FB mechanism will offer more trading opportunities to the market, which is indeed confirmed during the FB experimentation.

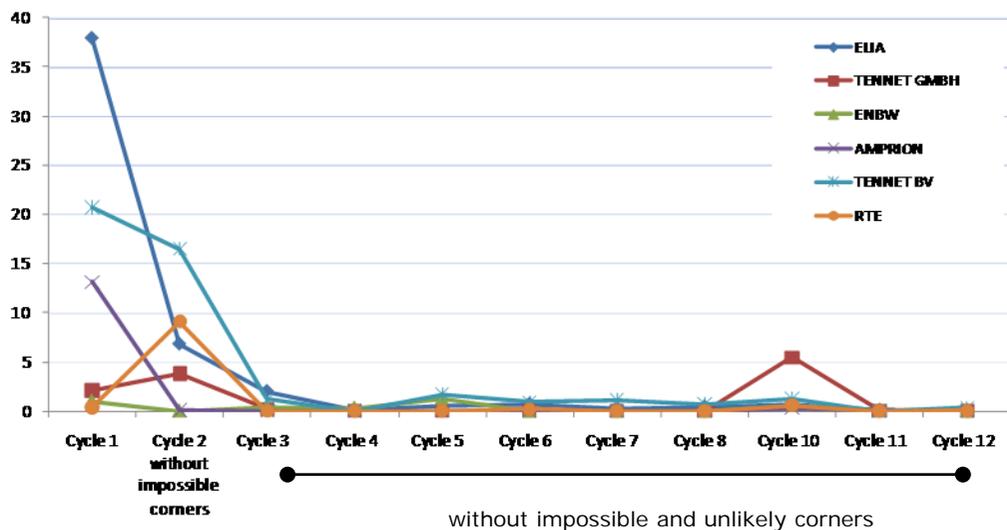


# FB increases the capacity offered to the market (2/2)

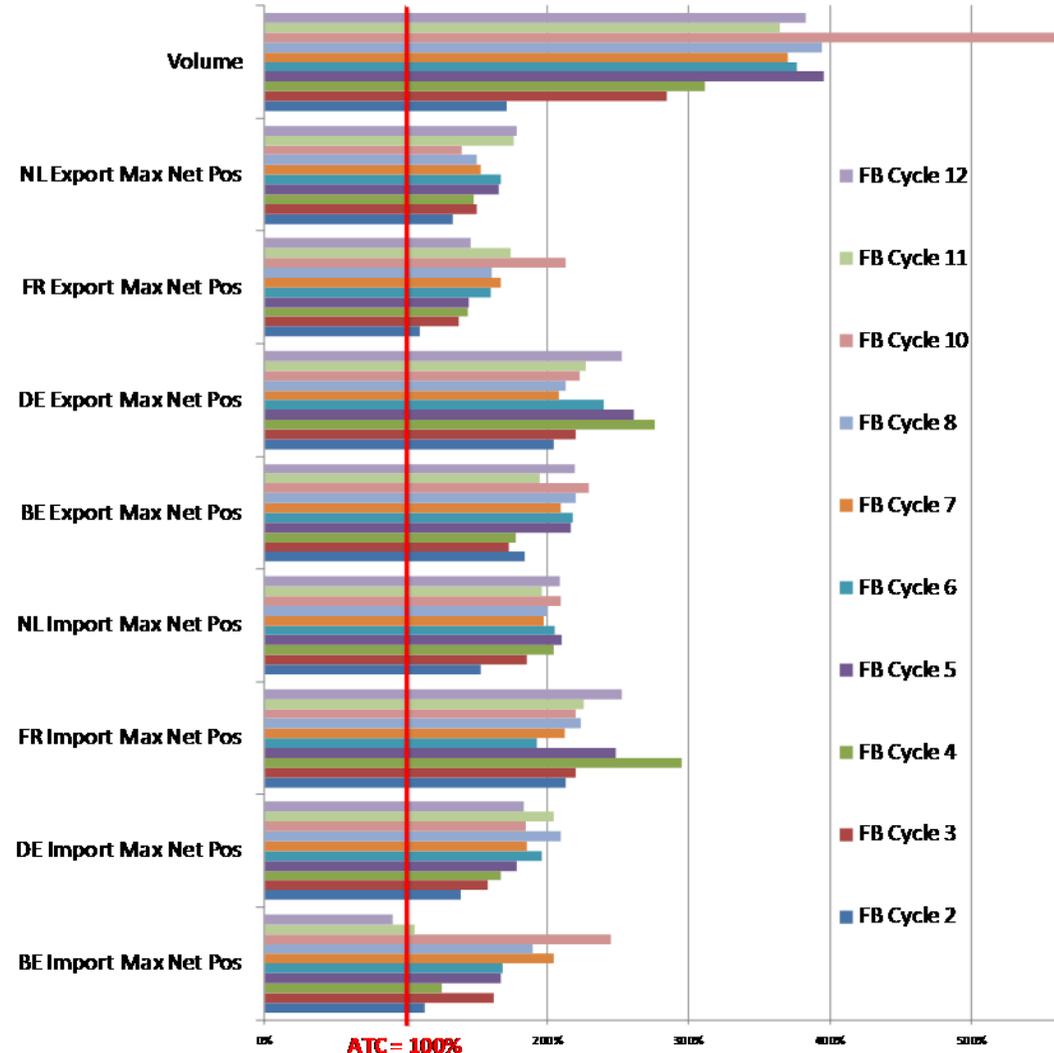
## - Experimentation results-

- ▶ This theoretical principle has been confirmed with 2010 experimentation results as show in the figures below
- ▶ NB: cycles 1 and 2 show the learning process during the FB experimentation

**Indicator 1: are the ATC corners within the FB search space?**  
**Number of cases per timestamp of CB overloaded in a corner**



**Indicators 2 & 3: Volume and "max / min" Net Positions**  
**FB vs ATC comparison**



# FB improves the cooperation between TSOs

- ▶ The FB description is **closer to the reality of the grid**, which induces a natural need for **increased cooperation and information exchange between the CWE TSOs** in the FB operational process.  
This is in contrast to the opacity and lack of physical meaning of the NTC values.  
Furthermore an increase in the level of coordination between the TSOs is facilitated
- ▶ Under FB, **interdependency of the cross-border exchanges is reflected from the beginning of the process for all the directions of the capacity space**. This is in contrast to the current coordinated NTC process where the first step (initial local TSO computation) is not coordinated.

## FB improves SoS concerning unusual market directions

- ▶ SoS for the usual market directions remains unchanged irrespective of the coordinated NTC or FB method.
- ▶ For the unusual market directions, however, **the SoS under FB is improved as under FB no assumptions need to be made** for those unusual market directions. Flow-based gives a more accurate description of the Security of Supply domain.



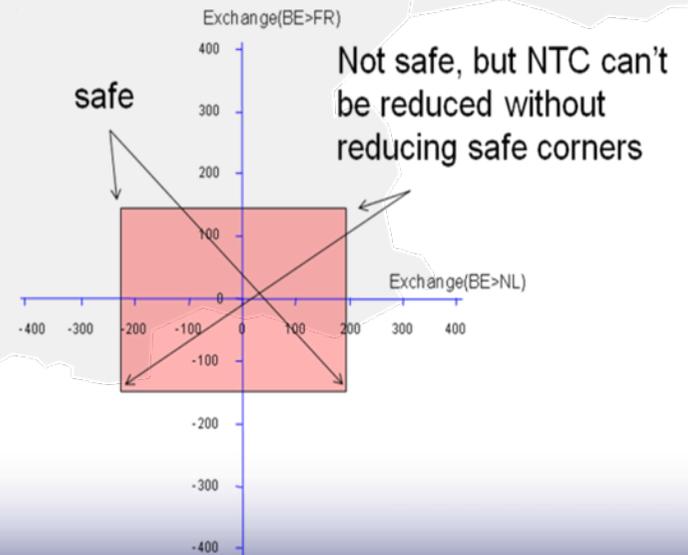
# FB improves SoS concerning unusual market directions

## - Example for Belgium -

The dominant market patterns for Belgium are South>North or North>South. Therefore Elia maximizes its NTCs for these patterns. But then the sum of import NTC [resp. export NTC] turns out to be higher than the maximum admissible import [resp. maximum admissible export] of Belgium.

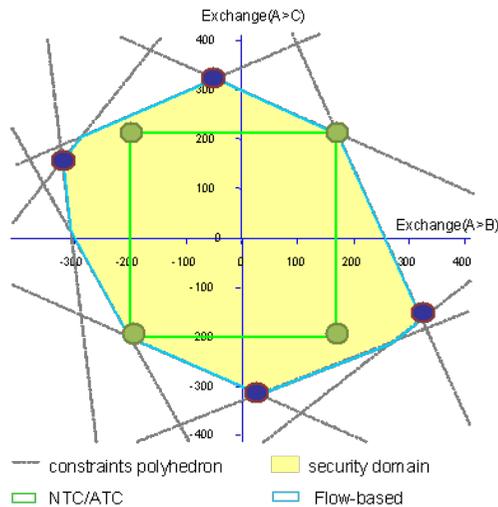
Elia cannot provide both maximum capacities to the market for being transited South>North or North>South, and safe import or export limits at the same time. This is an inherent limitation of the NTC methodology

Elia chooses to provide maximum capacities to the market, but if one day the market behaves differently than foreseen, and reaches one of the unlikely corners, Elia will have to use exceptional D-1 and real-time measures to guarantee grid security. FB simply removes this issue.



# FB addresses transparency requirements and concerns on market players understanding

- ▶ **The non-redundant FB parameters** containing PTDF factors and margins associated to the critical branches, **will be communicated to the market before allocation.**
- ▶ Additionally, in order to ease the transition from ATC and to provide market players with more grip on the FB domain, **a simplified description of the FB domain can be supplied:** it could consist in figures representing maximal bilateral exchanges and net positions allowed by the FB constraints.



## FB space trades feasibility check

**Reference time:**

10.04.2007  
10h - 11h

**1) Check volume (interactive module)**

Here you can check the simultaneous execution of trading volumes of the markets involved in the CWE Market Coupling

**2) Max volume (information module)**

Here you can find the maximal trade volumes (MWh/h) which can be physically transported between two Hubs under the condition that no other trade is executed between other Hubs.

HUB TO HUB EXCHANGES	Hub-to-Hub trade in MWh/h (please insert values)	Test 1: hub to hub inside FB space	direction -->	direction <--
DE=>BE	0	OK	683	2169
DE=>NL	0		600	2376
DE=>FR	0		552	7596
NL=>BE	0		1108	1560
NL=>FR	0		1287	1152
BE=>FR	0		1891	2292

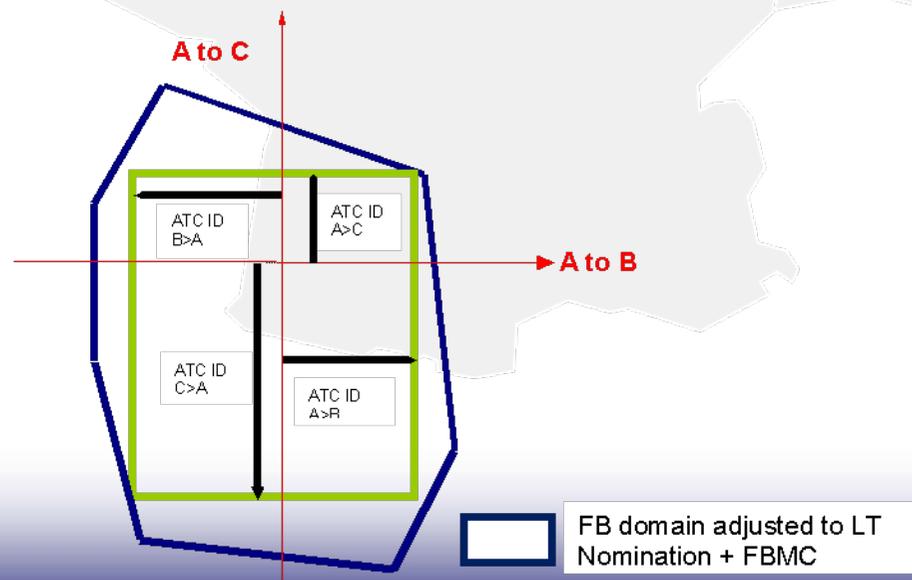
HUB POSITION	Hub Positions trade in MWh/h (please insert values)	Test 1: sum hub positions = 0	Test 2: hub positions inside FB space	export	import
DE	3000	OK	KO	890	11602
BE	-2435			2886	2493
FR	1243			8865	2777
NL	-1808			3487	3090

Disclaimer: All values are only valid for demonstration purposes and do not reflect realistic physical conditions

# CWE D-1 FB compatibility with intraday ATC

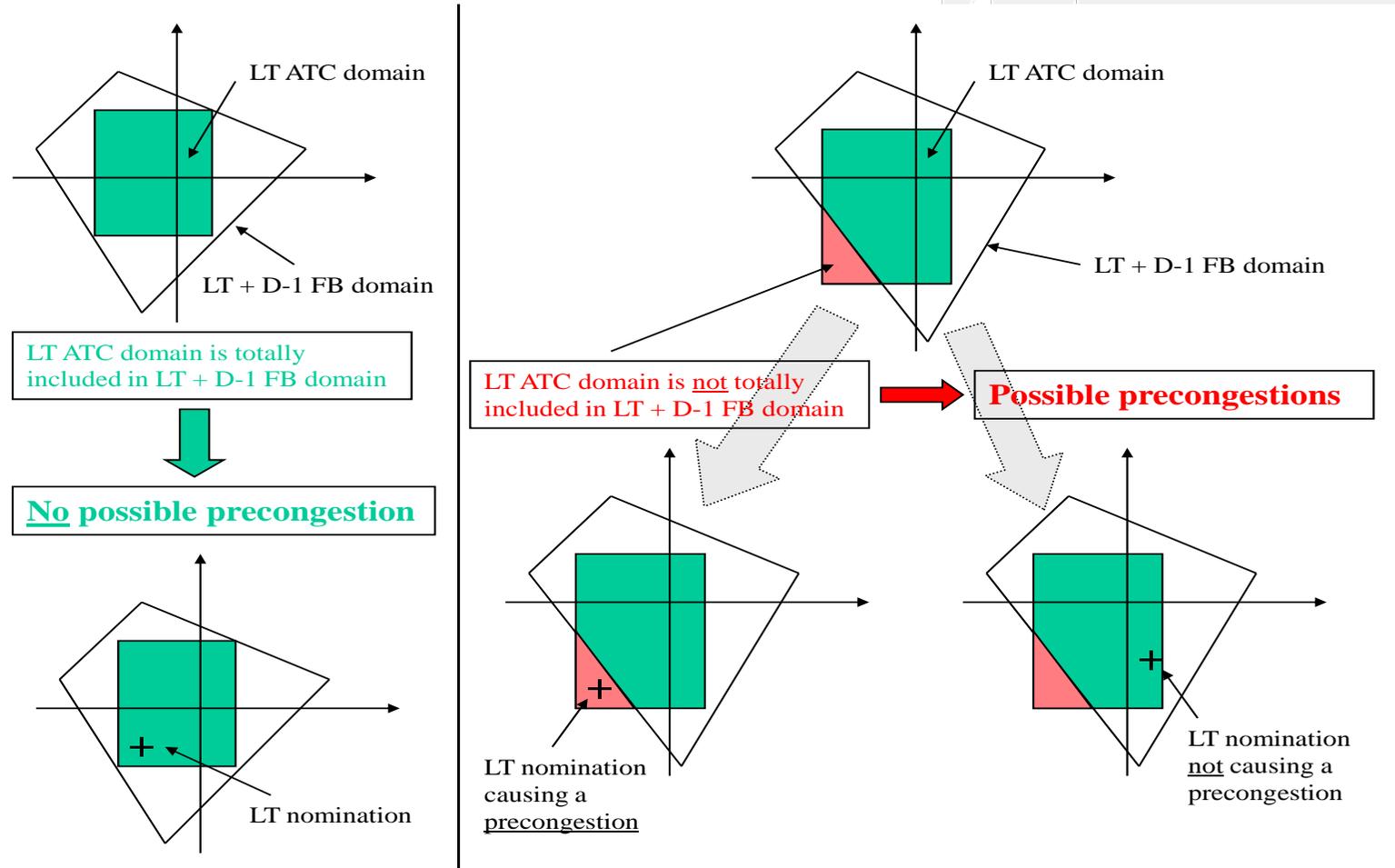
As long as FB is not implemented in intraday, FB for D-1 compatibility with the current intraday ATC is ensured:

- **FB for D-1 is compatible with the current intraday ATC usage for allocation:** whatever the clearing point of the FBMC, CWE TSOs will always be able to find 8 non-negative ID ATCs respecting the security.
- CWE TSOs recommend an **initial coordinated splitting of the FB domain, proposed to the market in D-1**, followed by a further **local increase/decrease based on DACF merged files and validated by a coordinated verification of all the TSOs** (same verification process as currently applied in D-1).
- The implementation of this option is linked with resource availability for TSOs for the ID coordinated verification step. **In case not enough operational resources are available, bilateral intraday capacity increase should not be allowed.**



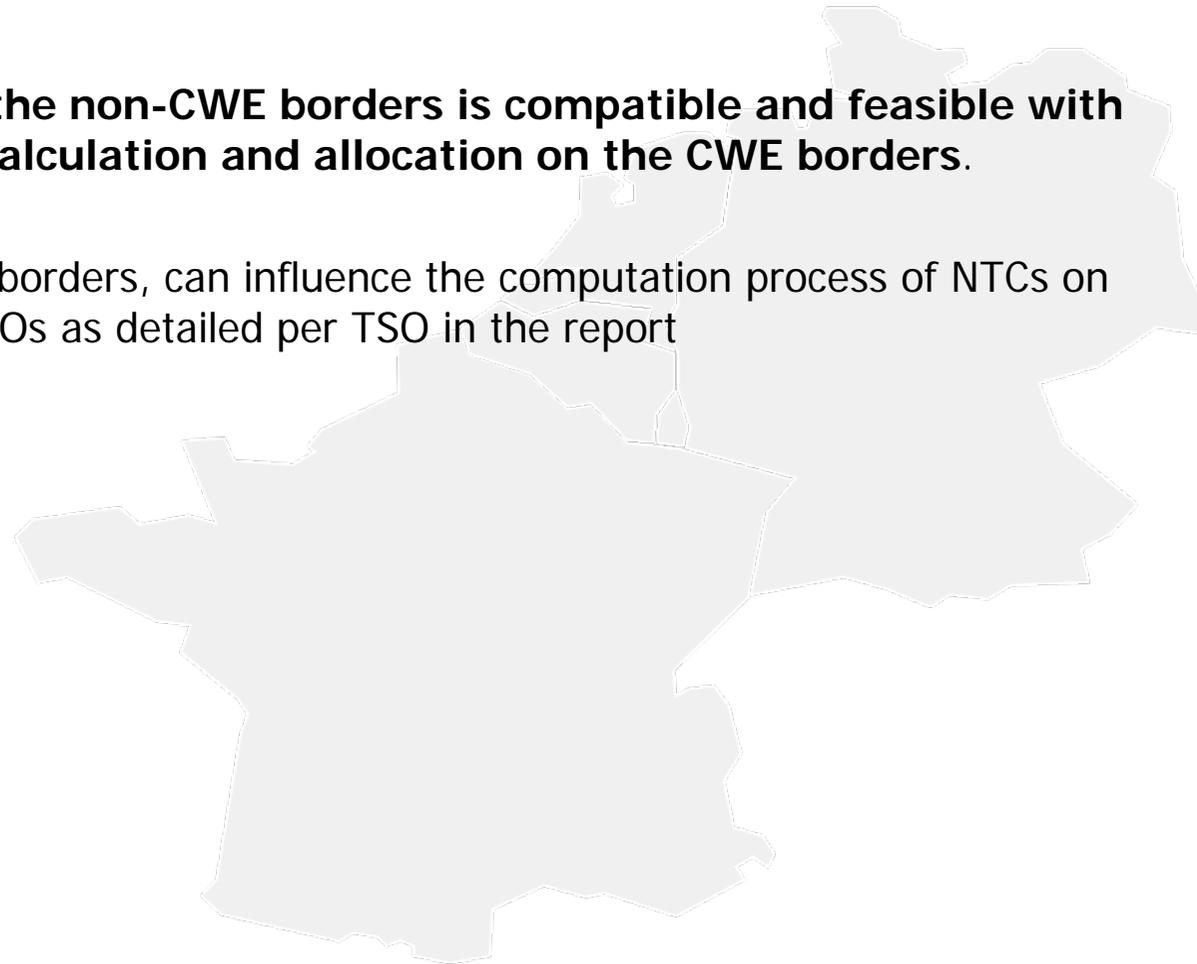
# CWE D-1 FB compatibility with LT ATC

- ▶ The compatibility is granted if the long term capacity domain offered to the market is fully included in the FB domain.
- ▶ Practically this means that there will be no negative capacities (no 'precongestions') before the market coupling (which was the case during 2010 experimentation).



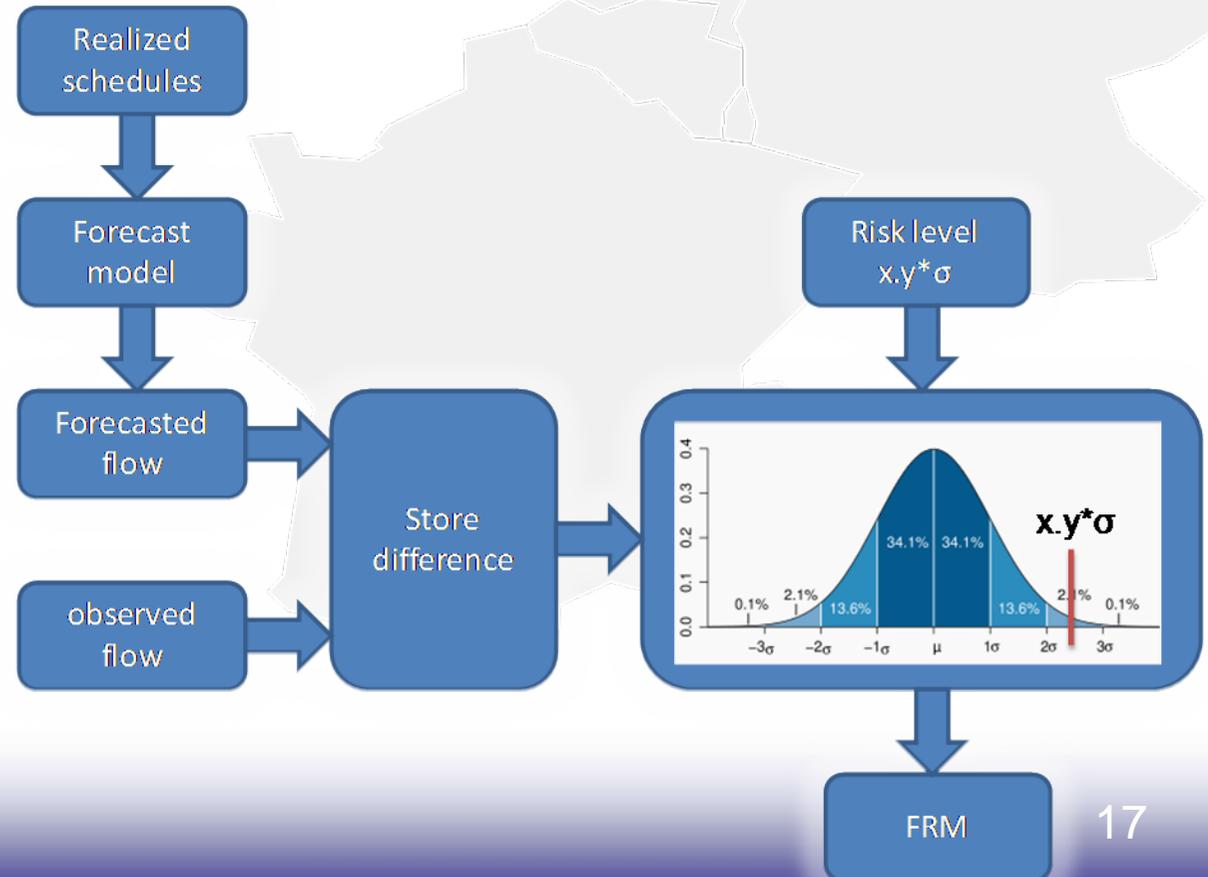
# CWE D-1 FB compatibility with D-1 NTC computation of the non-CWE borders

- ▶ D-1 NTC computation of the non-CWE borders is compatible and feasible with introducing FB capacity calculation and allocation on the CWE borders.
- ▶ Switching to FB on the CWE borders, can influence the computation process of NTCs on other borders of the CWE TSOs as detailed per TSO in the report



# FRM assessment / model quality study

- ▶ The FRM is a margin taken on the critical branch flow to take into account uncertainties inherent to a D-2 capacity calculation process, due to operation of load-frequency controls and data collection and measurement.
- ▶ Prior to FB implementation in CWE, but also once it will be live, an FRM continuous statistical refinement is to be done through comparison per CB of observed flows (snapshot flows) and flows estimated by the FB model based on realized schedules.
- ▶ FRM will provide a reference to monitor future changes /improvements in part of the process and/or the input data.
- ▶ FRM is based on the comparison of estimated flow and the observed flow.





## 2 – Flow-Based market coupling market impact analysis

TSOs and PXs deliverable

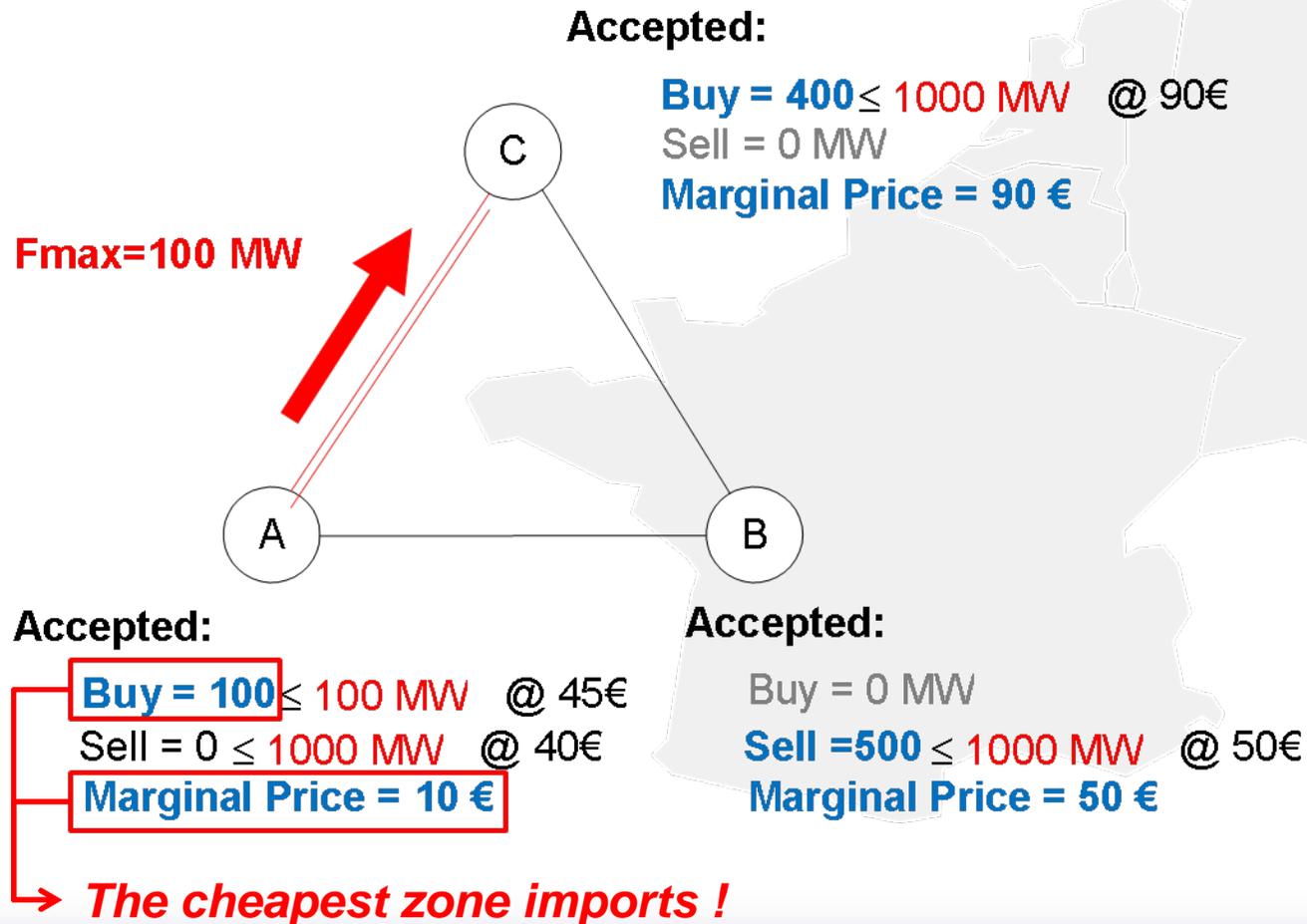
# Market Impact - Orientation

- ▶ Objective: assess the impact of FB capacity calculation on markets
- ▶ Means: simulation of market clearing with FB constraints
  - ▶ On 2 times 2 weeks:
    - ▶ From 22-11-2010 to 05-12-2010
    - ▶ From 04-01-2011 to 17-01-2011
- ⇒ *No possible extrapolation to 1 year.*
- ▶ Results: evolution of indicators (welfare...) between ATCMC and:
  - ▶ Flow-Based MC (FBMC)
  - ▶ Flow-Based Intuitive MC (FBIMC)
  - ▶ Infinite capacity MC ('copper plate')

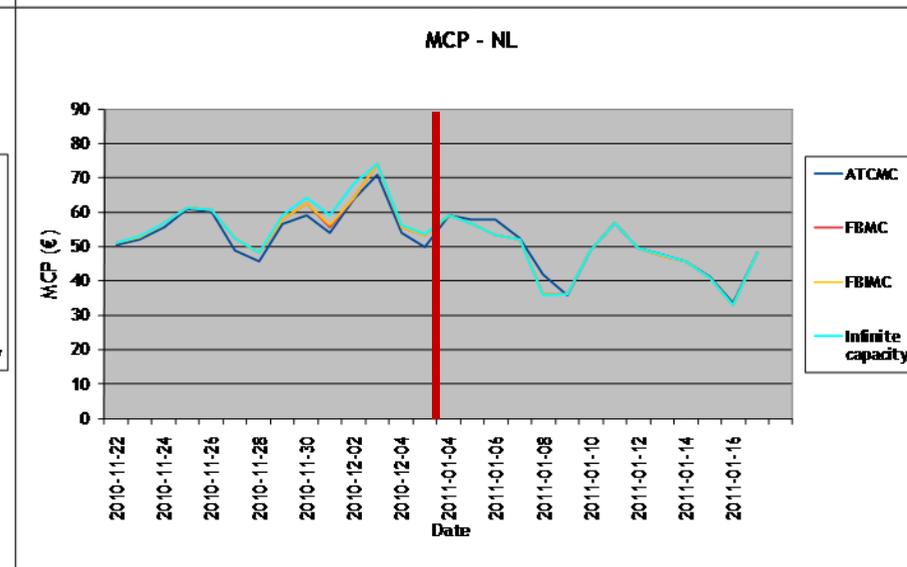
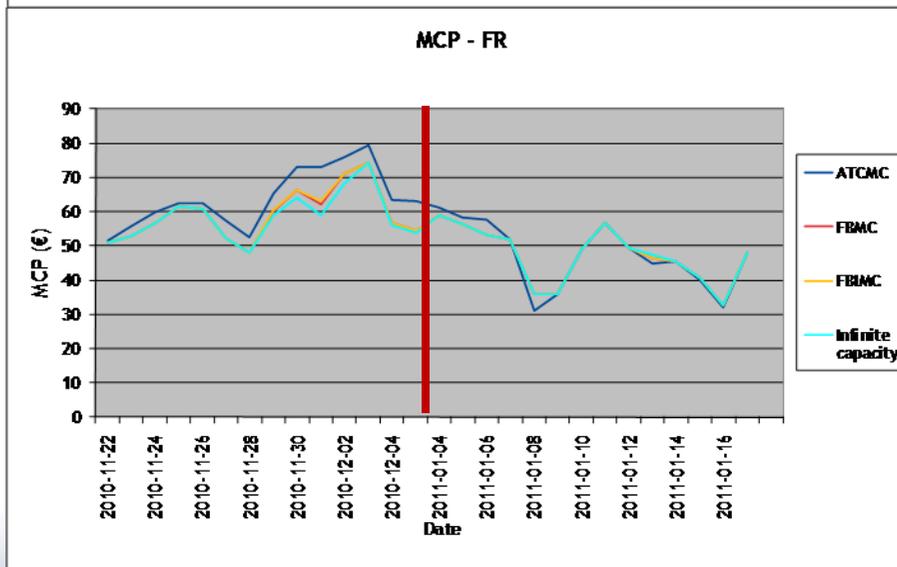
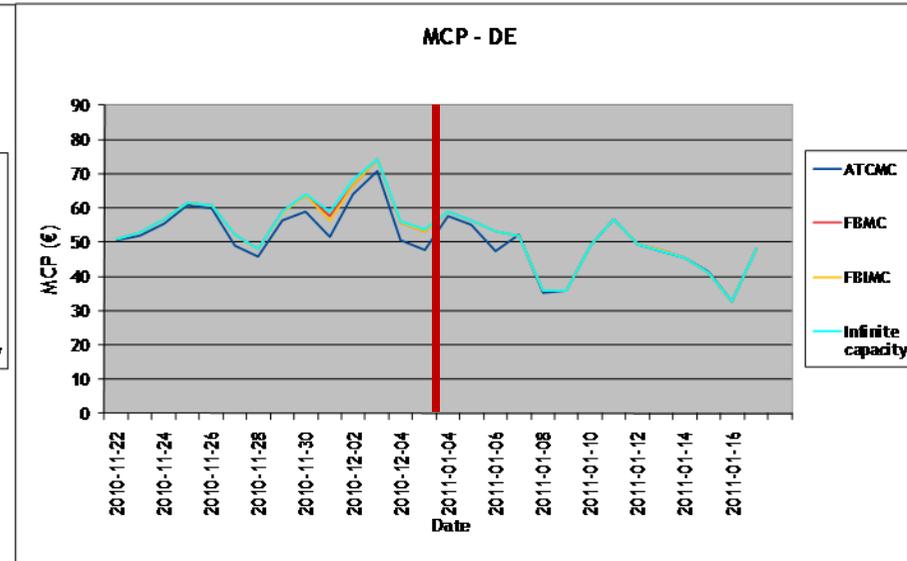
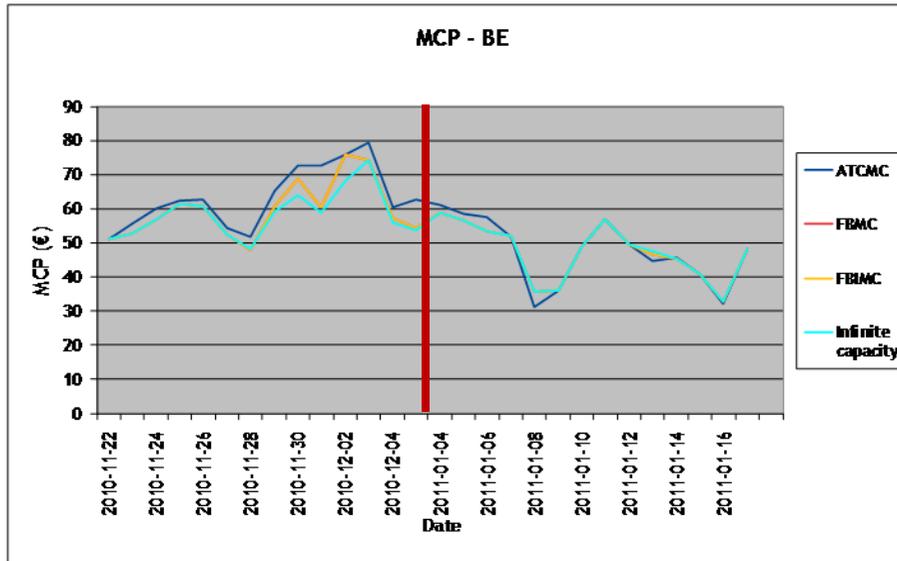


# Market Impact - Intuitiveness

## Exemple of non-intuitive situation

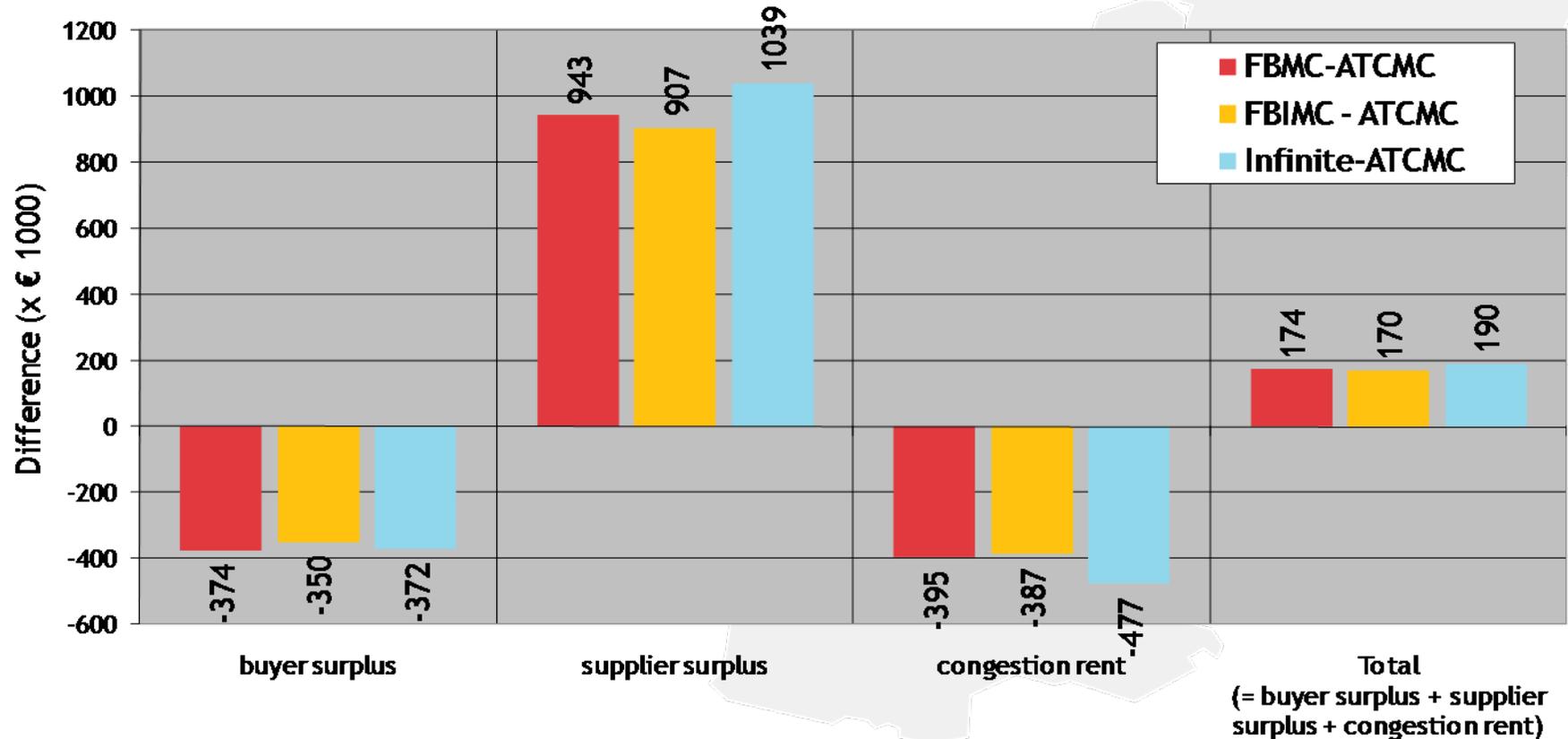


# Market Impact – Daily baseload price



# Market Impact – Social Welfare (DAMW) 1/3

Daily average welfare difference (relative to ATC)

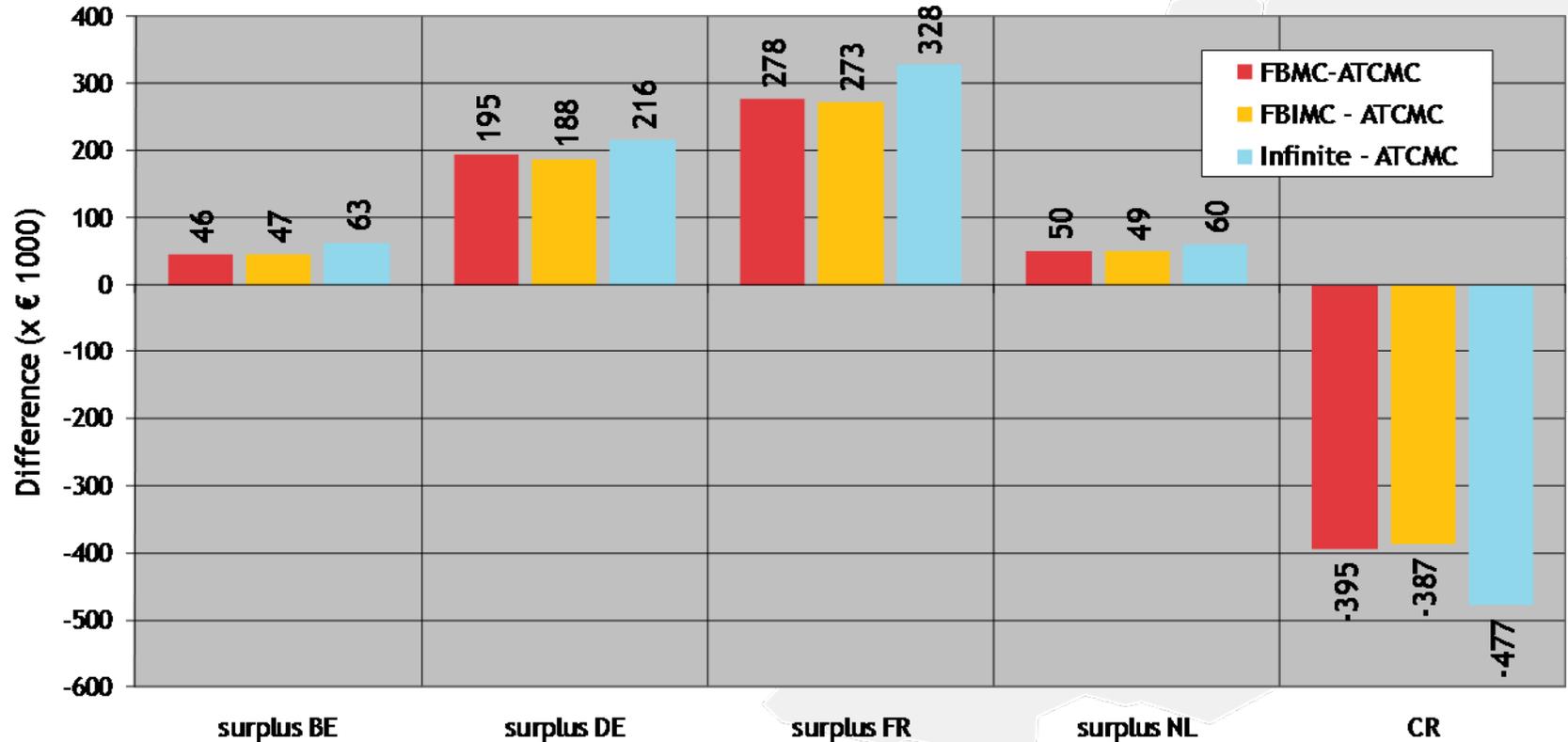


ATC to FB ⇔ More than 89% of possible welfare increase.  
 ⇔ More than 81% decrease of congestion rent.



# Market Impact – Social Welfare (DAMW) 2/3

Daily average welfare difference (relative to ATC)

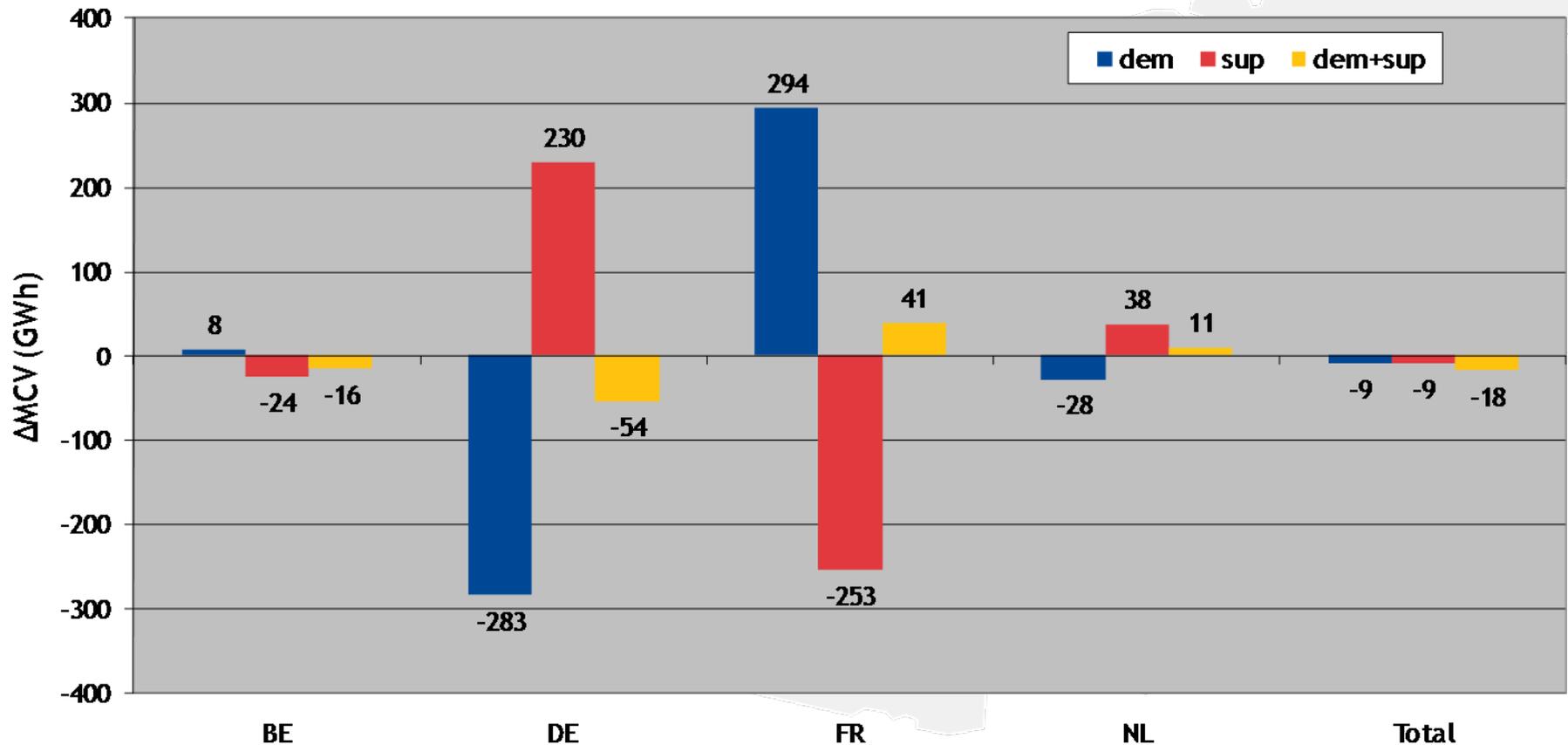


All countries benefit from the social welfare increase.



# Market Impact – Clearing volumes

$\Delta$ MCV (FBMC - ATCMC)

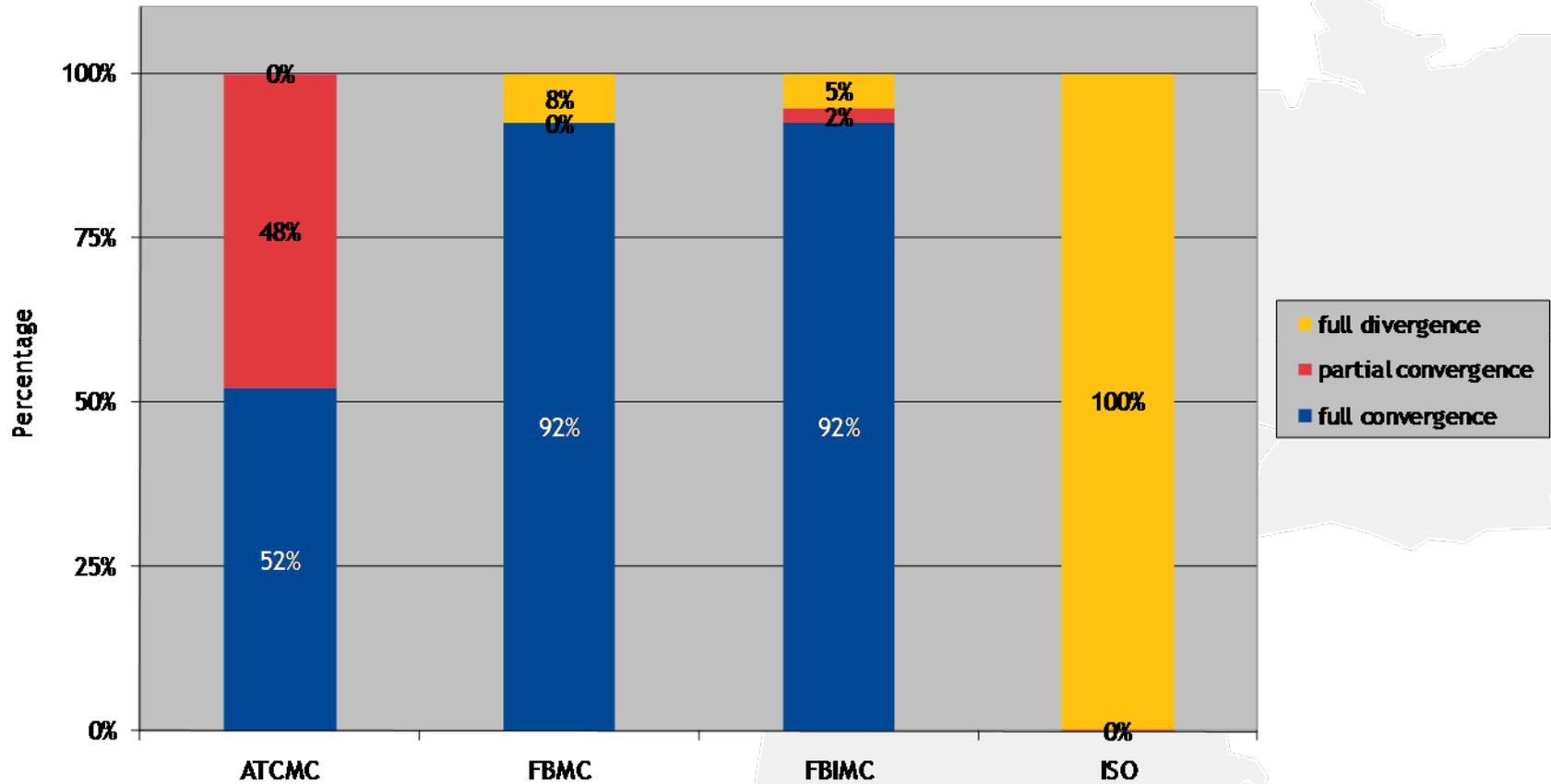


The total demand is overall stable (Total: dem+sup).

The main change is an increase of exports from Germany to France.



# Market Impact – Convergence

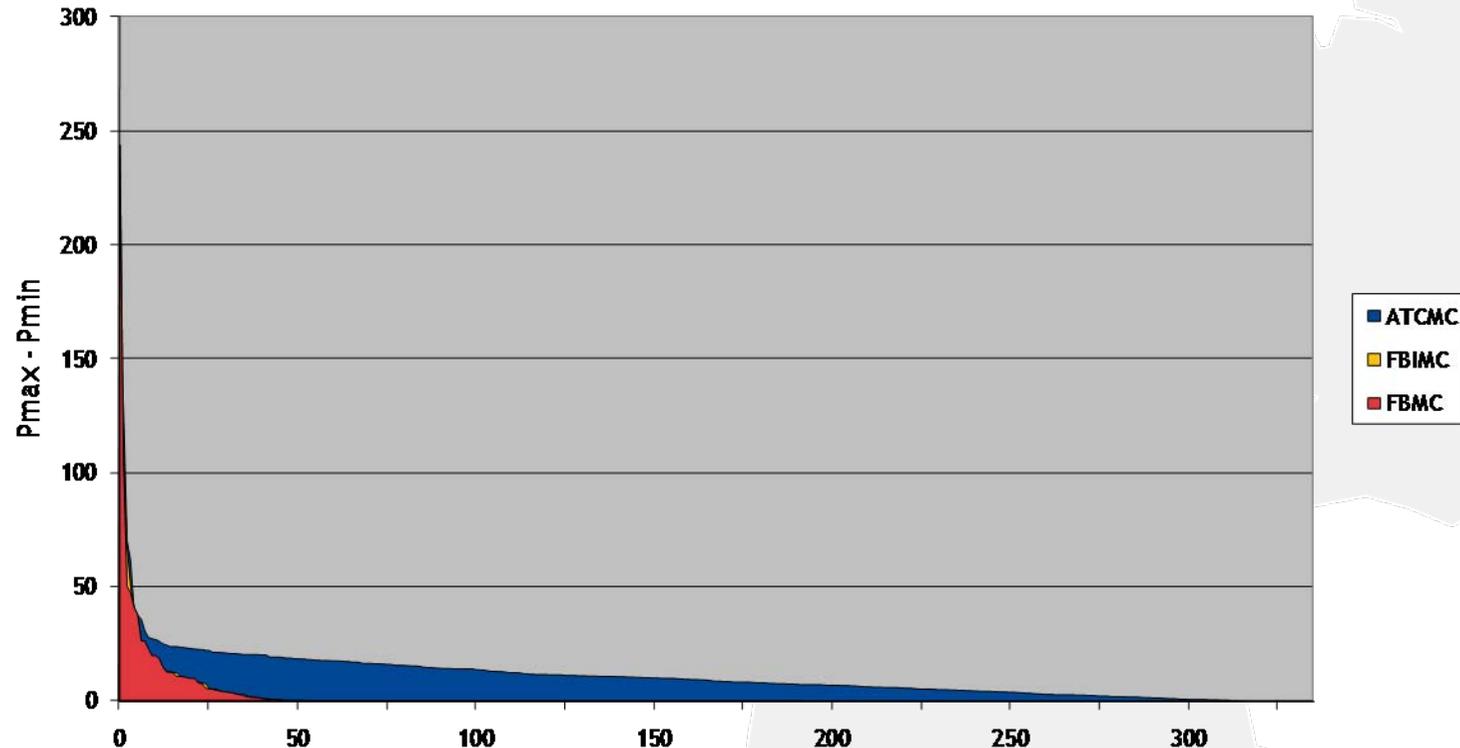


FB (either FB or FBIMC) allowed convergence on 92% of situations instead of 53% for ATC (tolerance: 0.002 €/MW.h). This explains why the congestion rent decreases. Proportion of situations with at least partial convergence decreases in FBMC and FBIMC, however this fact alone is not conclusive as shown in the next slide.



# Market Impact – Divergence 1/2

Price divergence

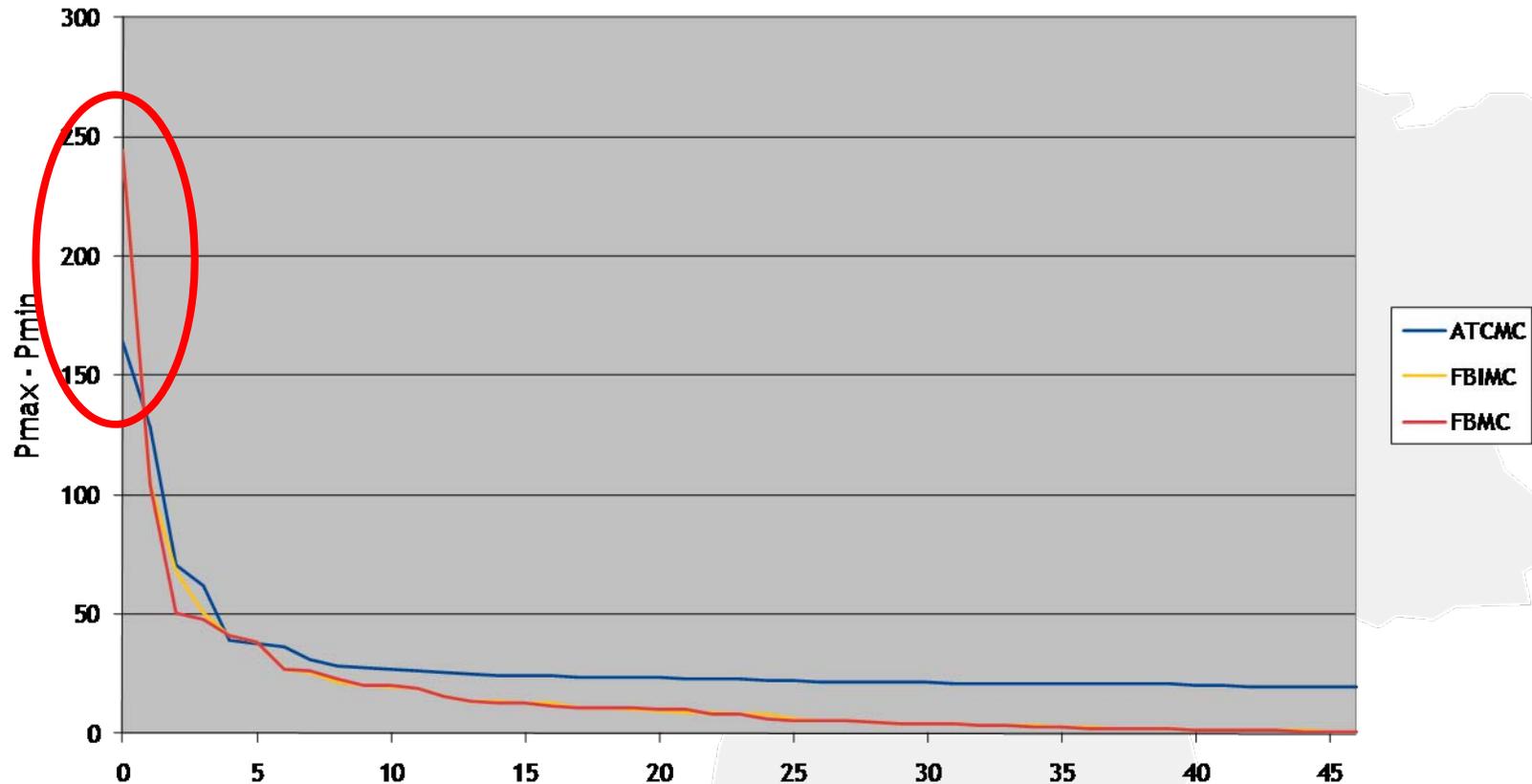


*Pmax-Pmin is the maximum price difference between 2 countries.  
The graph shows the Pmax-Pmin for each hour ranked in decreasing order.*

Divergence is reduced for most hours (thus the congestion rent decreases) but...



# Market Impact – Divergence (zoom) 2/2



Price divergence is higher in FB than in ATC for 1 hour (December 2<sup>nd</sup>, 19:00) It is linked with a higher clearing price in FB than in ATC for Belgium  $\Rightarrow$  FBMC increases welfare (expected) and divergence (unusual).

Analysis show that it is linked to the low resilience of the Belgium market and to current FBMC pricing rules (prices determined by PTDFs). In principle, it is possible to design an ATC set also increasing the welfare and the divergence. Cases of increased divergence will be monitored (frequency...) and analysed further.



# Market Impact – Open points

## ▶ Intuitiveness

- ▶ 2.3% of all situations (16 h) were non-intuitive with FBMC, representing 31% of congested situations.
- ▶ As expected, none were non-intuitive with FBIMC.
- ▶ No degradation of convergence between FBMC and FBIMC has been observed. The welfare decrease is small.

## ▶ Ramping constraints

- ▶ Net position volatility seems to increase the exchanges  
*It increases in this order : ATCMC, FBMC, Infinite capacity MC.*
- ▶ RTE investigates whether the expected level of volatility is a risk for SoS. The subject is already under investigation for ATCMC.

## ▶ Resilience study

- ▶ Study of evolution of price when orders are added has been done for ATCMC and FBMC but not yet for FBIMC.
- ▶ Overall, resilience is improved in FBMC for all hubs (including Belgium), but a poorer resilience of the Belgium market in heavily congested situations was observed and should be monitored.



# Market Impact – Conclusion

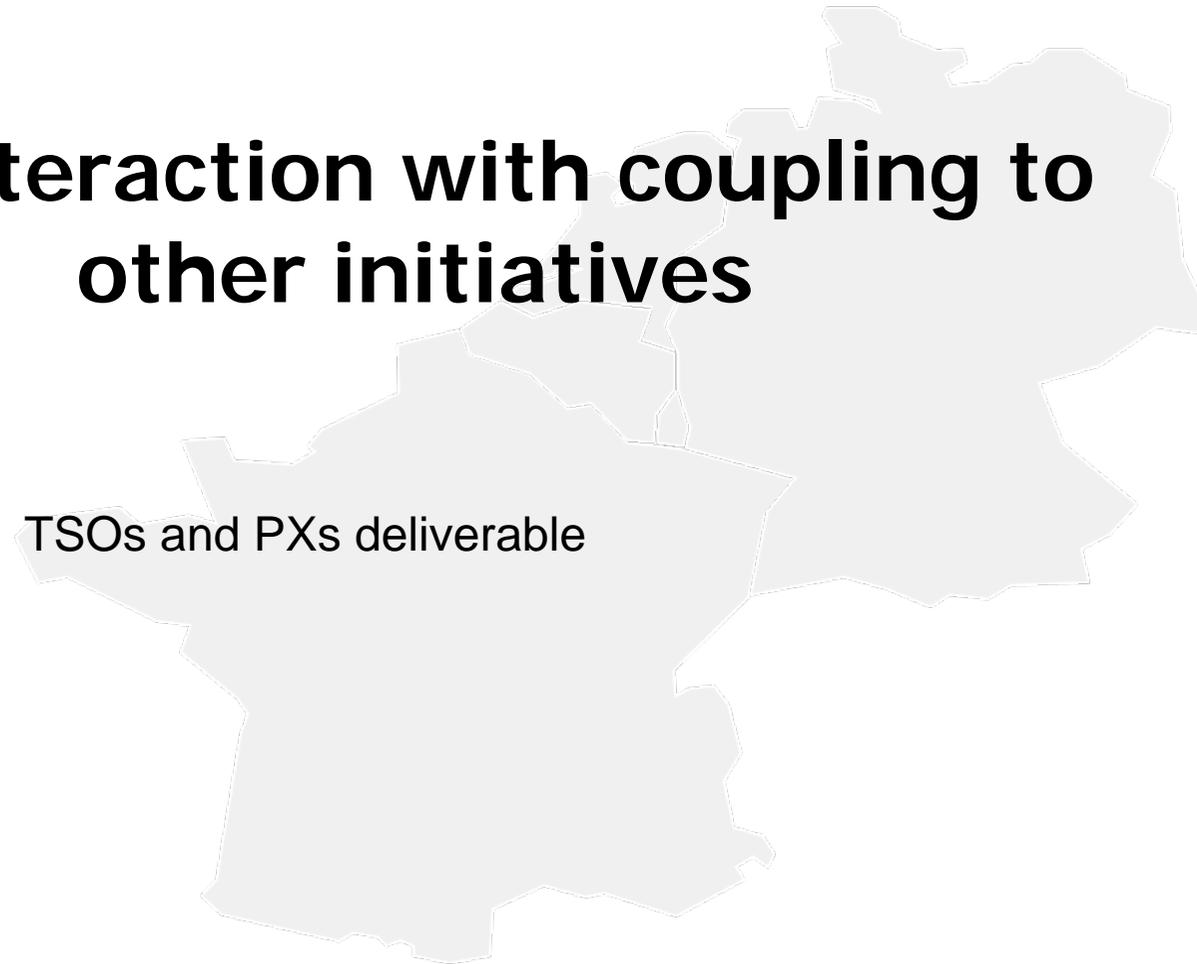
- ▶ On the 2 x 2 weeks simulation period, FBMC and FBIMC have a positive impact on the market compared to ATCMC.
- ▶ Non intuitive situations were found in FBMC. Using FBIMC removes these situations without unacceptable deterioration of the other indicators.
- ▶ TSOs and PXs recommend continuing simulations:
  - ▶ To confirm current conclusions on a longer period.
  - ▶ To configure the coupling method (bidding areas ramping constraints and intuitiveness).





## 3 – Interaction with coupling to other initiatives

TSOs and PXs deliverable



# *Interaction* - Orientation

## ▶ Objective:

Evaluate qualitatively the compatibility coupling with other initiatives given that CWE uses FB market coupling.

## ▶ Means: Qualitative analysis

- ▶ List of possible initiatives
- ▶ Assess the feasibility of coupling

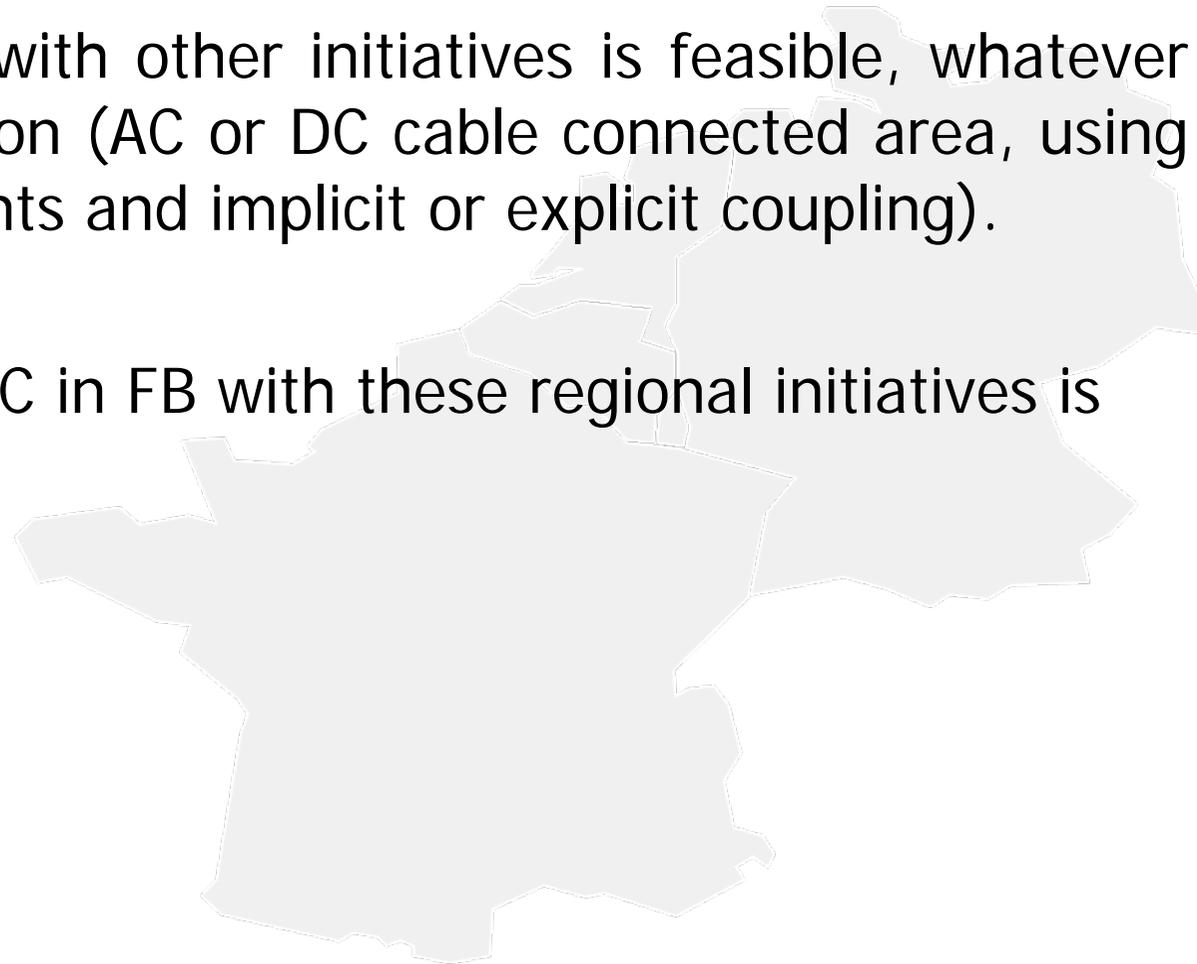


# Interaction – List of possible couplings

- ▶ CWE MC coupling with other initiatives is feasible, whatever the type of extension (AC or DC cable connected area, using FB or ATC constraints and implicit or explicit coupling).

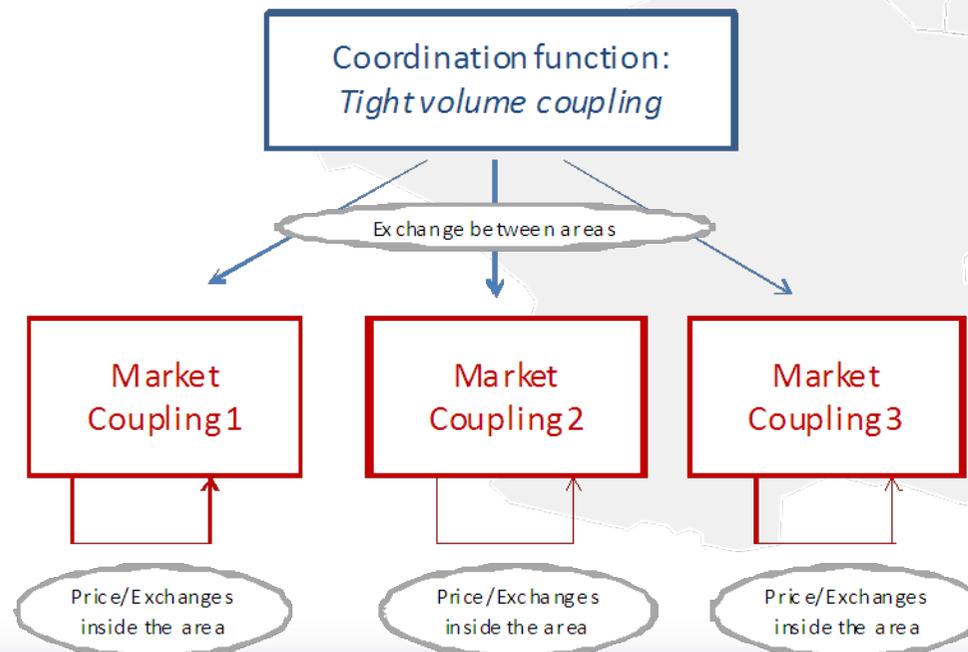
- ▶ Coupling of CWE MC in FB with these regional initiatives is feasible:

- ▶ NWE
- ▶ SWE
- ▶ CSE
- ▶ CEE
- ▶ FUI



# Interaction - Regions with implicit / explicit auctions

- ▶ **Compatibility between different allocation methods is ensured:** CWE FBMC is compatible with neighbouring explicit auctions or with another region under implicit auctions .
  - ▶ In target solution of single price coupling, the algorithm is OK for coupling to FB or ATC regions.
  - ▶ Without single price coupling, tight volume coupling is also possible:



amprion

apx endex

BELPEX

creos

elia

EnBW

EPEX SPOT  
EUROPEAN POWER EXCHANGE

Rte  
Réseau de transport d'électricité

tennet  
Taking power further

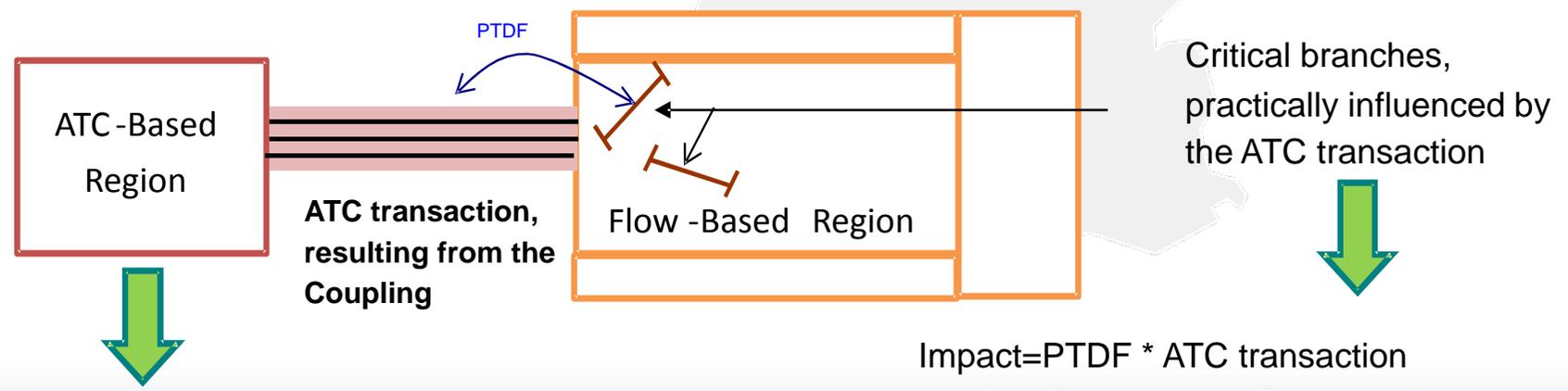
# Compatibility with ITVC

- ▶ ITVC does not handle FB constraints and it is not sure that another solution supporting them is live before FB goes live.
  - ▶ CWE TSO and PXs therefore recommend that a price coupling solution compatible with FB goes live as quickly as possible.
- ▶ However a delay on such a solution might trigger a delay on the FB project
  - ▶ FBMC should be able to go live anyhow.
  - ▶ In the context of change control procedure of the Interim Solution Agreement (ISA), the solution detailed in the next bullet points could therefore be discussed:
- ▶ Either TSO would simply submit CWE ATC values consistent with (i.e. within) the CWE FB domain. This is in fact a matter of choosing one set of NTC inside the FB domain i.e. capacity splitting between borders.
  - ▶ This would be a coordinated choice decided at the time it is needed, and its impact will be limited, since ITVC is interim solution and not supposed to be as efficient as the enduring NWE price coupling anyway.
- ▶ Or FB market coupling is implemented in ITVC.



# Interaction – Advanced ATC/FB coupling

- ▶ In target solutions of single price coupling (with another region under implicit auctions), the algorithm can take into account both FB and ATC constraints, and ensures compatibility between FB areas and ATC areas.
  - ATC transactions influence the flows on critical branches of the FB area (and thus use a part of their physical available margins), and this influence could be taken into account directly in the coupling algorithm.
  - This would avoid to take this influence into account ex-ante (before the coupling), by booking some physical margin of the critical branches in the flow-based area.
  - When FB/ATC hybrid price coupling projects will emerge, CWE TSOs and PXs recommend to consider the possibility of taking into account ATC exchanges impact in the FB model.



Impact = PTDF \* ATC transaction  
 taken into account directly in the branch constraint

# General conclusion from TSOs and PXs

- ✓ The 2010 TSO experimentation has proved that the enhanced FB:
  - ✓ is feasible from an operational point of view
  - ✓ increases the proposed total capacity offered to the market
  - ✓ increases TSO cooperation and SoS in unusual market directions
  - ✓ addresses transparency requirements and concerns on market players understanding
  - ✓ is compatible with the adjacent capacity calculation processes (D-1 NTC computation of the non-CWE borders, Long Term ATC computation, ATC intraday computation)

⇒ From the capacity calculation point of view, the TSOs recommend to continue describing the details of a FB implementation for CWE MC.

- ✓ Overall, through simulations comparing ATC constraints and FB constraints on a short period, the market impact analysis concludes that FB constraints have a positive impact on the market. Non-intuitive situations were found in FBMC. Using FBIMC removes these situations without deteriorating unacceptably the other indicators.

- ✓ CWE MC coupling with other initiatives is feasible, whatever the type of extension (AC or DC cable connected area, using FB or ATC constraints and implicit or explicit coupling).

⇒ TSOs and PXs recommend continuing monitoring the impact on the market while the project is ongoing in order to confirm the observations and to configure the coupling algorithm. Additionally, TSOs and PXs recommend the realization of the steps detailed in the next slide.



# Next steps before go for IT tender

- ▶ In November 2011, a key decisional milestone is scheduled to formally take an investment decision for FB implementation. This decision will be based at least on the following main deliverables which will be provided in September 2011:
  - ▶ TSO's feasibility report based on 2010 Experimentation, including interaction with development of intraday (current report);
  - ▶ Price/Market impact analysis and analysis of the interactions with the coupling to other initiatives performed jointly by PXs/TSOs (Current report, updated in July with more data based on approximately one week of simulation each month);
  - ▶ FRM assessment / model quality study, PRB and computation time analysis, sensitivity analysis, eg. PTDFs (July 2011).;
  - ▶ Implementation details (timings, backups, fallback, ...) ;
  - ▶ Answers to the received questions of external stakeholders to the present document.
- ▶ Pending the above mentioned key decisional milestone, CWE PX & TSO FB MC Go live target date is foreseen for last quarter 2012.

