



Documentation of the CWE FB MC solution

As basis for the formal approval-request

Brussels, 9th May 2014

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1 Management summary

The purpose of this approval document is to provide all Regulators of the CWE region with complete information regarding the go-live solution of the CWE Flow Based Market Coupling (FB MC) in order to facilitate their approval procedure. Since formal approval is asked for the Flow Based Market Coupling solution, this document covers the new coordinated Flow Based capacity calculation and CWE-specific parts of the Market Coupling solution.

The CWE Market Coupling Solution

The specific CWE Flow Based Market Coupling solution is a regional part of the NWE Market Coupling Solution.

Similar to the CWE ATC MC, during the daily operation of Market Coupling the available capacity (final Flow Based parameters including the Critical Branches and the PTDF-matrix) will be published at 10:30. Market Parties will have to submit their bids and offers to their local PX before gate closure time. In case results cannot be calculated, the Fallback mechanism for capacity allocation will be applied at NWE level and there will be a Full or Partial Decoupling of the PXs, following the NWE Procedures.

The solution is operated via a set of connected systems. These systems are operated by TSOs, jointly or individually, PXs, jointly or individually, CASC and clearing houses. Daily operations consist of three phases: provision of network data (Flow Based parameters), calculation of results, and post publication processes.

Fallback arrangement (capacity allocation)

In the CWE MC procedures, a Fallback situation occurs when the Incident Committee declares that, for any reason, correct Market

Coupling results cannot be published before the Decoupling deadline.

The principle of the CWE Fallback arrangement is to allocate ATCs derived from the Flow Based parameters via a “shadow explicit auction” and a Full Decoupling of the PXs. This means an isolated fixing by PXs, performed after having reopened their order books.

Rollback

Rollback provides a reversion to CWE ATC Market Coupling. This could be applied in the event of an incident which has triggered the Fallback solution that cannot be resolved within an acceptable period of time and that therefore the risk to continue with the FB MC is estimated too high. This procedure will only be available for a maximum of two months (with a potential extension by two additional months if decided by the CWE JSC) after the launch of Flow Based Market Coupling. However, if Rollback must be applied, it will be in operation until the incident has been found and solved.

Rollback may also be triggered in the event that Flow Based has led to unexpected and unacceptable market outcomes which were not detected during the external parallel run (e.g. as the parallel run were performed with ATC based Order Books).

The Algorithm

The Project Partners of the NWE-Project have selected Euphemia as the algorithm to calculate daily market results. Euphemia is a branch-and-bound algorithm designed to solve the problem of coupling spot markets with block orders. It handles all technical requirements set by the NWE and CWE projects, including step and interpolated orders, flow based network under PTDF representation,

ATC links and DC cables (possible with ramping, tariffs and losses). Euphemia outputs net export positions 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.

Capacity Calculation

The CWE TSOs have designed a coordinated procedure for the determination of Flow Based capacity parameters. This procedure consists of the following main steps

- Merging
- Pre-qualification
- Centralized Initial-Flow Based parameter computation
- Flow Based parameter qualification
- Flow Based parameter verification
- LTA inclusion check
- LTN adjustment

This method has now been tested in the external parallel run since January 2013. TSOs have developed the methodology from prototype to industrialization.

Any changes to the methodology during the parallel run were subject to change control, documented and published.

Economic Assessment

Extensive validation studies have been performed by the Project Partners, showing positive results. Among others, the studies show an approximate increase in day-ahead market welfare for the region of 95M Euro on an annual basis (based on extrapolated results of the average daily welfare increase, during the external parallel run

from January to December 2013). Full price convergence in the whole region improves significantly, although some partial convergence is lost because of the intrinsic Flow Based price properties. The net effect though is that the spread between average CWE prices is reduced.

Impacts on price formation and volatility have also been observed (c.f. Annex 16.10).

These calculations were performed, using current results of ATC MC and comparing them with simulated FB(I) MC. In order to further validate the results, the Project Partners have performed additional analyses, e.g. the domain reduction study (Annex 16.11)

Latest Flow Based simulations can be found in the daily parallel run publication on CASC's website.

Intuitiveness

Based on the inconclusive outcome of the Intuitiveness study¹, the Project is not yet in a position to make a recommendation whether to start with FB or FBI. The outcome of the public consultation will hopefully bring additional guidance for the decision.

Transparency

The Project Partners will publish various operational data and documents related to Flow Based Market Coupling, in compliance with European legislation and having considered demands of the Market

¹ Please refer to the Intuitiveness study in annex 16.13.

Parties and the Regulators. These publications will support Market Parties in their bidding behaviour and facilitate an efficient functioning of the CWE wholesale market, including long term price formations and estimations. Explanations for some non-fulfilled requests of Market Parties are provided in chapter 10.5.2.

Monitoring

For monitoring purposes the National Regulatory Authorities get additional (confidential) data and information. Based on national and EU-legislation, on reasonable request from the NRAs, the Project will provide all Project related data for monitoring purposes. Publications of monitored information can be commonly agreed from case to case.

2 Introduction

After having signed the Memorandum of Understanding of the Pentilateral Energy Forum on Market Coupling and security of supply in the Central West European (CWE) region in 2007, the TSOs and PXs of CWE have put in place a project that was tasked with the design and implementation of the Market Coupling solution in their region. As a first step, the project partners have decided to implement an ATC based Market Coupling which went live on November 9th 2010. Parallel to the daily operation of the ATC-Based Market Coupling, the Project Partners have been working on the next step which is the implementation of a Flow Based Market Coupling in CWE.

Work has progressed and the Flow Based Market Coupling solution was improved. Results of more than 16 months of the external parallel run, covering all seasons and typical grid situations, have shown clear benefits of the FB methodology.

The purpose of the report at hand with all annexes is to provide the Regulators of the CWE region with a complete set of documentation describing the final Flow Based Market Coupling solution in order to facilitate the local approval procedure. It is structured in the following chapters:

- General principles of Market Coupling
- Coordinated Flow Based capacity calculation
- CWE Market Coupling solution
- Fallback solution
- Rollback solution
- Functioning of the algorithm
- Economic validation
- Transparency / publication of data
- Monitoring
- Calculation of bilateral exchanges

- Contractual scheme
- Change control

The Project aims at a readiness target date end of September 2014 with a subsequent contingency period of maximum 8 weeks. The go-live of course relies upon several dependencies such as Market Parties' acceptance and readiness, readiness of IT systems and successful testing, approval by National Regulatory Authorities, appropriate management of interactions with other extension projects as well as availability of other NWE/SWE parties for testing.

3 General principles of Market Coupling

3.1. General principle of Market Coupling

Market Coupling is both a mechanism for matching orders on power exchanges (PXs) and an implicit 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 subject to sufficient Cross-Zonal Capacity (CZC) being made available for day-ahead implicit allocation; matching results are subject indeed to capacity constraints calculated by Transmission System Operators (TSOs) which may limit the exchanges between the coupled markets.

Market prices and Net Positions of the connected markets are simultaneously determined with the use of the available capacity defined by the TSOs. The transmission capacity made available to the Market Coupling is thereby efficiently and implicitly allocated. If no transmission capacity constraint is active, then there is no price difference between the markets. If one or more transmission capacity constraints are active, a price difference between markets will occur.

3.2. Day-Ahead Flow Based Market Coupling

Market Coupling relies on the principle that when markets with the lowest prices export electricity to markets with the highest prices, there is day-ahead market welfare created by these exchanges. The Market Coupling algorithm (described later on in the document) will optimize the day-ahead market welfare for the whole region, based on the capacity constraints (Flow Based capacity parameters; including the Critical Branches and the PTDF-matrix) and the energy orders. A general example of Market Coupling for two markets illus-

trates how FB MC works. Two situations are possible: the margin on the Flow Based capacities is large enough and the prices of both markets are equalized (price convergence), or the margin of capacities is not sufficient (leading to one or more active constraint(s)) and the prices cannot equalize (no price convergence)². These two cases are described in the following example.

Sufficient margin, price convergence

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 will decrease. If the margin of capacities 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 3-1**.

² The term “convergence” is used in the context of Market Coupling to designate a situation where prices converge up to their equalization. Although prices may get closer to each other too, one says that there is “no price convergence” in all cases where the transmission capacity made available to the Market Coupling is not sufficient to lead to price equalization.

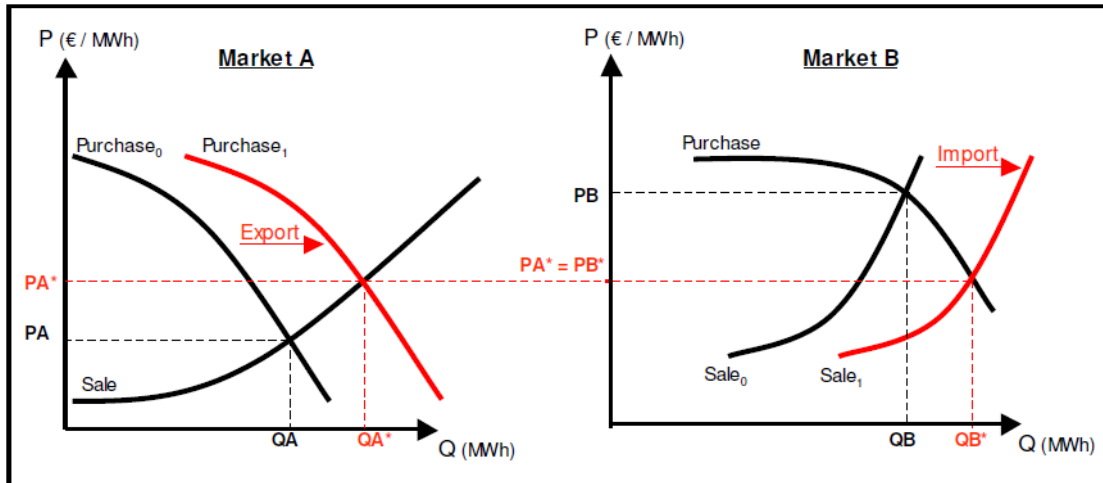


Figure 3-1: Representation of Market Coupling for two markets, no congestion.

Insufficient margin, no price convergence

Another situation illustrated in **Figure 3-2** happens when the capacity margin is not sufficient to ensure price convergence between the two markets. The amount of electricity exchanged between the two markets it then equal to the margin (or remaining capacity) on the active (or limiting) constraint, divided by the difference in flow factors (PTDFs) of the two markets.

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 between the two markets (bidding zones) is the congestion revenue.

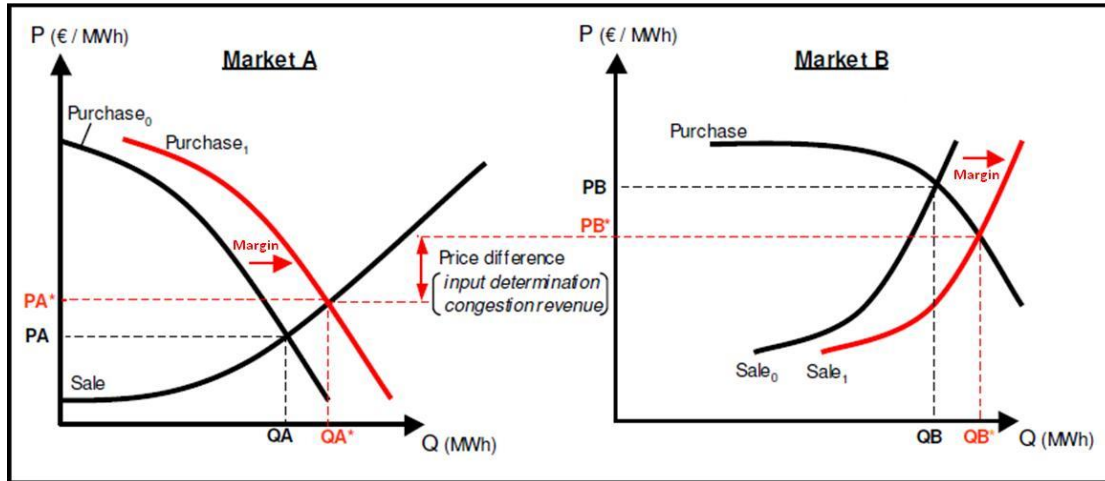


Figure 3-2: Representation of Market Coupling for two markets, congestion case

In “plain” Flow Based Market Coupling a non-intuitive exchange can occur (export from a high priced market to low priced markets), the welfare loss of this exchange is then to the benefit of a higher day-ahead market welfare gain for the whole region, which originates from other exchanges (c.f. chapter 9.3).

4 Coordinated Flow Based capacity domain calculation

The method for capacity calculation described below is fixed since the start of the external parallel run. Final changes, based on experience of the parallel run are documented in detail in Annex 16.1.

An educational, simplified and illustrative example, "How does Flow Based capacity calculation work?" can be found in annex 16.2.

The high level business process for capacity calculation can be found in Annex 16.3.

4.1. Input data

To calculate the Flow Based capacity domain, TSOs have to assess different items which are used as inputs into the model. The following inputs need to be defined upfront and serve as input data to the model:

- Critical Branches / Critical Outages
- Maximum current on a Critical Branch (I_{max})
- Maximum allowable power flow (F_{max})
- Final Adjustment Value (FAV)
- D2CF Files, reference Programs
- Remedial Actions (RAs)
- Generation Shift Key (GSK)
- Flow Reliability Margin (FRM)
- External constraints: specific limitations not associated with Critical Branches

4.1.1. CBCO-selection

A Critical Branch (CB) is a network element, significantly impacted by CWE cross-border trades, which is monitored under certain operational conditions, the so-called Critical Outages (CO). The CBCOs

(Critical Branches/Critical Outages) are determined by each CWE TSO for its own network according to agreed rules, described below.

The CBs are defined by:

- A line (tie-line or internal line), or a transformer, that is significantly impacted by cross-border exchanges,
- An “operational situation”: normal (N) or contingency cases (N-1, N-2, busbar faults; depending on the TSO risk policies).

Critical Outages (CO) can be defined for all CBs. A CO can be:

- Trip of a line, cable or transformer,
- Trip of a busbar,
- Trip of a generating unit,
- Trip of a (significant) load,
- Trip of several elements.

CB selection process

The assessment of Critical Branches is based on the impact of CWE cross-border trade on the network elements and based on operational experience that traced back to the development of coordinated capacity calculation under ATC:

Indeed, the TSOs developed the coordinated ATC methodology that is in daily operation as of November 2010, based on FB ingredients. The so-called 16 corner check is based on a check on a limited number of grid elements: the Critical Branches. The advantage of this approach is that there is already significant operational experience with the application of Critical Branches as part of a grid security analysis, and that it facilitates a consistent transition from ATC to FB as well. Indeed, the Critical Branches that are applied within the 16 corner check, boiled down to relevant sets based on the op-

erational ATC experience. The experienced gained in ATC operations therefore already provided a relevant set of initial Critical Branches for FB operations.

This set has then been updated according to the following process:

A set of PTDFs is associated to every CBCO after each Flow Based parameter calculation, and gives the influence of the net position of any bidding zone on the CBCO. If the $PTDF = 0.1$, this means the concerned hub has 10% influence on the CBCO, meaning that 1 MW in change of net position of the hub leads to 0.1 MW change in flow on the CBCO. A CB or CBCO is NOT a set of PTDF. A CBCO is a technical input that one TSO integrates at each step of the capacity calculation process in order to respect security of supply policies. CB selection process is therefore made on a daily basis by each TSO, who check the adequacy of their constraints with respect to operational conditions. The so-called flow based parameters are NOT the Critical Branches, they are an output of the capacity calculation associated to a CB or CBCO at the end of the TSO operational process. As a consequence, when a TSO first considers a CBCO as a necessary input for its daily operational capacity calculation process, it does not know, initially, what the associated PTDF are.

A CB is considered to be significantly impacted by CWE cross-border trade, if its maximum CWE zone-to-zone PTDF is larger than a threshold value that is currently set at 5%.

This current threshold has been set following security assessments performed by TSOs, by the iterative process described below:

TSOs have carried out some alternative computations of Flow Based parameters, using scenarios where only the threshold was set to different values. Depending of the threshold values, some Critical Branches were included or not in Flow Based parameters computa-

tion, resulting in a capacity domain more or less constraining for the market. Taking some extreme “vertices” of the resulting alternative Flow Based domains, TSOs assessed whether these domains would be safe, and more precisely to identify at which point the exclusion of CB not respecting the threshold would lead to unacceptable situations, with respect to CWE TSOs risk policies. If for one given threshold value, the analyses would conclude in unacceptable situations (because the removal of some constraints would allow an amount of exchanges that TSOs could not cope with as they would not respect standard SOS principles, like the standard N-1 rule), then this simply meant that the threshold was too high. Following this approach and assessing different values, CWE TSOs came to the conclusion that 5% was an optimal compromise, in terms of size of the domain versus risk policies.

TSOs want to insist on the fact that the identification of this threshold is driven by two objectives:

Bringing objectivity and measurability to the notion of “significant impact”. This quantitative approach should avoid any discussion on internal versus external branches, which is an artificial notion in terms of system operation with a cross-border perspective.

Above all, guaranteeing security of supply by allowing as many exchanges as possible, in compliancy with TSOs risks policies, which are binding and have to be respected whatever the capacity calculation concept (ATC or Flow Based). In other words, this value is a direct consequence of CWE TSOs risk policies standards (which do not change with Flow Based), adapted to Flow Based principles.

It is important to keep in mind that these CB selection principles cannot be seen as a single standalone study performed by CWE

TSOs. Rather, CWE TSOs have applied over time a continuous (re-assessment process that has started with the computations of bilateral capacities and been developed with FB, in order to elaborate a relevant CB set and determine afterwards an adequate threshold. The 5% value is therefore an ex-post, global indicator that cannot be opposed automatically, which means without human control, to an individual CB in a given timestamp.

CWE TSOs constantly monitor the Critical Branches which are fed into the allocation system in order to assess the relevance of the threshold over time. So far (meaning, during the external parallel run), active Critical Branches, i.e. the CBs having actually congested the market, have – with the exception of some rare cases – respected the threshold value of 5%,. This would tend to confirm the adequacy of the current value.

Practically, this 5% value means that there is at least one set of two bidding zones in CWE for which a 1000 MW exchange creates an induced flow bigger than 50 MW (absolute value) on the branch. This is equivalent to say that the maximum CWE “zone to zone” PTDF of a given grid element should be at least equal to 5% for it to be considered objectively “critical” in the sense of Flow Based capacity calculation.

For each CBCO the following sensitivity value is calculated:

$$\text{Sensitivity} = \max(\text{PTDF (BE)}, \text{PTDF (DE)}, \text{PTDF (FR)}, \text{PTDF (NL)}) - \min(\text{PTDF (BE)}, \text{PTDF (DE)}, \text{PTDF (FR)}, \text{PTDF (NL)})$$

If the sensitivity is above the threshold value of 5%, then the CBCO is said to be significant for CWE trade.

A pre-processing is performed during the Flow Based parameter calculation which results in a warning for any CBCO which does not

meet pre-defined conditions (that is, the threshold). The concerned TSO then has to decide whether to keep the CBCO or to exclude it from the CBCO file.

Although the general rule is to exclude any CBCO which does not meet the threshold on sensitivity, exceptions on the rule are allowed: if a TSO decides to keep the CBCO in the CB file, he has to justify it to the other TSOs, further-more it will be systematically monitored by the NRAs.

Should the case arise, TSOs may initiate discussions on the provided justifications in order to reach a common understanding and a possible agreement on the constraints put into the capacity calculation process. TSO know only at the end of the capacity calculation process the detailed and final PTDFs, while the Critical Branch is required in the beginning as an input of the capacity calculation process³.

CWE TSOs therefore commit to critically assess their set of Critical Branches in two respects:

³ A frequent explanation for having eventually a CBCO associated to PTDFs not respecting the threshold is the usage of a Remedial Action. Indeed, if it happens that a CBCO is too limiting, the TSO owner will try to release some margin on this CB by implementing a Remedial Action (see dedicated section later in this document). The Remedial Action will have as an effect to decrease the sensitivity of the CB towards the cross-border exchanges: by decreasing the influence of the exchanges on the load of the line, more trades will become possible. In this situation, it is legitimate to "keep" the CBCO.

1. On the one hand with a “close-to-operations” perspective, considering the threshold as a fixed reference. In this framework, CWE TSOs operators and FB experts assess ex-post the relevance of the CBs against this threshold. Eventually, this assessment may result in discarding the CB from the FB computation, but in any case this will not happen on a daily basis, after just one occurrence, but rather after an observation and security analysis phase potentially lasting several months. On the contrary, upholding a CB that chronically violates the present agreed threshold shall be objectively justified and reported to NRAs in dedicated reports.
2. On the second hand, the threshold itself needs to be regularly, if not changed, at least challenged. This is more a long-term analysis which needs several months of practical experience with FB operations. Once this experience is gained, CWE TSOs will re-consider the relevance of the thresholds by looking at the following criteria with a focus on active CBs :
 - Frequency and gravity of the threshold violations
 - Nature of the justifications given to keep some CBs
 - Or, on the contrary, absence of threshold violation.

The main idea is therefore to assess the “distance” between the threshold and the set of active CBs. This distance can be inappropriate in two aspects:

- Either the threshold is too high, which will be the case if too many CB violate it while valid justifications are given
- Either it will be too low, which will be the case if all active CB systematically respect it over a representative period of time.

In both cases, the shadow price (> 0 when the CB becomes active), that is information provided to NRAs within the monitoring frame-

work, can also be a useful indicator to assess market impact of the active CBs, especially when they are far from the agreed threshold.

4.1.2. Maximum current on a Critical Branch (I_{max})

The maximum allowable current (I_{max}) is the physical limit of a Critical Branch (CB) determined by each TSO in line with its operational criteria. I_{max} is the physical (thermal) limit of the CB in Ampere, except when a relay setting imposes to be more specific for the temporary overload allowed for a particular Critical Branch-Critical Outage (CBCO).

As the thermal limit and relay setting can vary in function of weather conditions, I_{max} is usually fixed at least per season.

When the I_{max} value depends on the outside temperature, its value can be reviewed by the concerned TSO if outside temperature is announced to be much higher or lower than foreseen by the seasonal values.

I_{max} is not reduced by any security margin, as all margins have been covered by the calculation of the Critical Outage by the Flow Reliability Margin (FRM, c.f. chapter 4.1.8 and Final Adjustment Value (FAV, c.f. chapter 4.1.4).

4.1.3. Maximum allowable power flow (F_{max})

The value F_{max} describes the maximum allowable power flow on a CBCO in MW. It is given by the formula:

$$\mathbf{F_{max} = \sqrt{3} * I_{max} * U * \cos(\varphi) / 1000 [MW],}$$

where I_{max} is the maximum permanent allowable current (in A [Ampere]) for a CB. The value for $\cos(\varphi)$ is set to 1, and U is a fixed value for each CB and is set to the reference voltage (e.g. 225kV or 400kV) for this CB.

4.1.4. Final Adjustment Value (FAV)

With the Final Adjustment Value (FAV), operational skills and experience that cannot be introduced into the Flow Based-system can find a way into the Flow Based-approach by increasing or decreasing the remaining available margin (RAM) on a CB for very specific reasons which are described below. Positive values of FAV in MW reduce the available margin on a CB while negative values increase it. The FAV can be set by the responsible TSO during the qualification phase and during the verification phases. The following principles for the FAV usage have been identified:

- A negative value for FAV simulates the effect of an additional margin due to complex Remedial Actions (RA) which cannot be modelled and so calculated in the Flow Based parameter calculation. An offline calculation will determine how many MW can additionally be released as margin; this value will be put in FAV.
- A positive value for FAV as a consequence of the verification phase of the Flow Based domain, leading to the need to reduce the margin on one or more CBs for system security reasons. The overload detected on a CB during the verification phase is the value which will be put in FAV for this CB in order to eliminate the risk of overload on the particular CB.

Any usage of FAV will be duly elaborated and reported to the NRAs for the purpose of monitoring⁴ the capacity calculation.

4.1.5. D2CF Files, reference Programs

The 2-Days Ahead Congestion Forecast files (D2CF files), provided by the participating TSOs for their grid two-days ahead, are a best estimate of the state of the CWE electric system for day D.

Each CWE TSO produces for its zone a D2CF⁵ file which contains:

- Net exchange programs of the reference day. This is the reference program for the calculations. The reference day is:
 - for Tuesday to Friday: D-1 (most recent program)
 - for Monday: D-3 (previous Friday)
 - For Saturday and Sunday: D-7 (previous week)
 - For bank holidays and specific outages, a reference day will be determined and fixed in a separate calendar approved by all CWE TSOs
- the exchange program on DC cables for the same reference day
- best estimation for the planned grid outages, including tie-lines and the topology of the grid as foreseen until D-2
- best estimation for the forecasted load and its pattern
- best estimation for the forecasted wind and solar generation

⁴ Details on monitoring are given in the dedicated chapter 11. Besides, a template of the monitoring reports is available in Annex 16.17).

⁵ The Austrian D2CF will be integrated before Go Live.

- best estimation for the outages of generating units, based on the latest info of availability of generators
- best estimation of the production of generating units, in line with outage planning, forecasted load and reference program, and in line with the expected total generation.

The PST tap position is usually neutral in the D2CF but well justified exceptions should be allowed.

For each timestamp, the local D2CF file has to be balanced in terms of production and consumption, in coherence with the reference program. Any residual imbalance will be adjusted by each TSO by adapting production and/or load until balance is achieved.

The D2CF files will be merged together with DACF (Day-Ahead Congestion Forecast) files of non CWE-TSOs, to the exception of APG which D2CF is expected to be integrated in the CWE merge before Go Live, to obtain the base case according to the merging rules described in this document (c.f. chapter 4.2.1).

Individual procedures

Amprion:

For every day D there are 24 D2CF files generated by Amprion. These D2CF files describe the load flow situation for the forecasted business day as exactly as possible. In order to provide an adequate forecast Amprion generates the D2CF files in the following way:

The basis of a D2CF file is a "snapshot", (i.e. a "photo") of the grid from a reference day.

In a first step the topology is adjusted according to the business day. Here are all components put into operation (which were switched off in the snapshot) and all forecasted outages (for the business day) are included in the D2CF file. After that the genera-

tion pattern is adapted to the schedule of the exchange reference day.

In the next step the wind and solar forecasts are included in the D2CF file by using dedicated wind and solar GSKs. This process is based on local tools and uses external weather forecasts made available to Amprion.

As a next step, the so-called "slack deviation" (unbalance between generation and load) is determined and this deviation is spread over all loads in the grid of Amprion. After this the resulting net position is adapted to the one of the reference day, but distributing the deviations over the loads.

To summarize, the provision of the Amprion D2CF data set is based on 5 main steps.

1. Take snapshot from the reference day as basis
2. Include topology for business day and adjust generation pattern
3. Include wind and solar forecast
4. Adapt net position of Amprion
5. Deviations (slack) are spread over all loads

Elia:

Load profile and cross-border nominations of the reference day are used. The topology of the grid is adjusted by use of the information of a local outage-planning-system (including generator maintenance) as known at time of preparation of D2CF, which is between 17:00 18:00. This includes possible preventive topology Remedial Actions needed for specific grid maintenance.

The load is automatically adjusted to account for the difference in the load of the reference day and the predicted load of the day D.

The best estimate is used to determine all production units which are available to run, with a determination of the Pmin and Pmax to be expected on the business day (depending on whether units are foreseen for delivery of ancillary services or not).

The production program is adjusted based on the calculated GSK, and on the Pmin and Pmax prepared.

PST tap positions are put at 0 in order to make a range of tap positions available as Remedial Action, except if overloads can be expected in the base case in a likely market direction, in which case 2 to 4 steps could be made on some PST at Elia borders.

TransnetBW:

D2CF files are elaborated according to the following steps:

- Choose a proper snapshot (last available working-day for working-days; last weekend for the weekend) as a basis
- Adjust the topology by use of the information of a local outage-planning-system (including generator maintenances)
- Adjust generation in feed to the available generator-schedules. For generators with no schedules available adjust to the schedules of the reference day.
- Implement the forecasted wind generation and adjust the exchange programme to the exchange program of the reference day
- Adjust the load to the load-forecast
- Slack balance is distributed on load and balancing power plants.

RTE:

French D2CFs are based on an automatic generation of 24 files, created with several inputs:

- Up to 24 snapshots if available for the 24 hours, less in other cases
 - These snapshots are selected in the recent past to be the best compromise possible between the availability of snapshots, generation pattern, load pattern and exchanges.
 - Topology is adapted to the situation of the target day (planned outages and forecast of substation topology)

Depending on the reference exchange programs, topology can also be adapted to avoid constraints in N and N-1 situations.
- Load is adjusted based on load forecasts for the concerned time horizon.
- Generation is adjusted based on planned "D-1" patterns or realized "D-X" patterns (meaning: historical situations anterior to the day when the D2CF process is happening), with some improvements:
 - renewable generation (PV and wind generation) is updated based on forecasts available for the concerned time horizon,
 - for large units, generation is adjusted, based on maintenance forecast (provided on a weekly basis by producers, and adapted during the week).

⇒ 24 hourly files are produced in this way.

For each file, an adjustment is performed on generation, to reach the expected reference exchange program and produce the final 24 French D-2 grid models.

A loadflow is launched to check the convergence.

TenneT DE (TTG):

The D2CF data generation at TenneT DE starts after the day-ahead nominations are known. The starting point is a database with a reference topology. The topology is then adapted with the planned outages. TTG has a D-2 forecast for load, wind and solar energy of the TTG control area. These control area-wide forecasts are projected onto the corresponding nodes of the data set. Due to the RefProg

concept, the net position (= control area balance = sum of injections from the interconnectors) of the TTG control area must have a certain target value. The target value is prescribed by the exchange schedules with the neighbouring TSOs of the reference day plus corrections between the German TSOs.

In other words, the sum of loads and generation in the D2CF needs to meet the reference exchange, which is normally not the case due to forecast errors and uncertainties of the reference exchange. Consequently, the D2CF generation/load must be adjusted. Basically, there are several ways how to implement the reference exchange into the D2CF: adapting the load (either the load forecast or the load on the individual nodes in the dataset which comprises implicitly the generation in lower voltage levels including renewables forecasts) or the generation (wind- and solar forecast or conventional generation schedules). TenneT D decided to use a mixed option in order to limit the overall error. Since the load on the individual nodes in the datasets can become very small or even negative due to renewables infeed it was decided to adapt the forecasts instead to better distribute the imbalance towards reference exchange.

Therefore, in order to meet the target net position, in a first step load, wind and solar forecasts are adapted within the range of the average forecast errors.

In a second step the conventional generation is adjusted using a merit-order list. The starting point of the generation pattern is given by the PPP schedules (production forecast sent by power plant operators). Any remaining mismatch after the second step is balanced via the load nodes. After balancing the data set, some additional quality checks are made (convergence, voltages, active and reactive power). The PST taps are always set to neutral position.

The TTG D2CF is sent to Amprion (together with the TTG GSK) for the German pre-merging in order to generate the D2CF for the German control block (c.f. below).

TenneT NL:

TenneT starts the D2CF creation process with a grid study model. This model which represents the topology of the business day by making use of the information of the local outage-planning (including generator maintenances) as known at time of preparation of D2CF, which is between 17:00-18:00 at D-2.

The model is then adapted for the Load & Production forecasts (directly derived from the forecasts received from the market) and cross-border nominations of the reference day, which become available at 17:00.

After the forecasts have been imported TenneT starts to redistribute the production of all dispatchable units (which are not in maintenance) above 60MW (further called: GSK Units). This redispatch of production is done in order to match the GSK methodology as described in the GSK chapter of this document. All GSK units are redispatched pro rata on the basis of predefined maximum and minimum production levels for each active unit. The total production level remains the same.

The maximum production level is the contribution of the unit in a predefined extreme maximum production scenario. The minimum production level is the contribution of the unit in a predefined extreme minimum production scenario. Base-load units will have a smaller difference between their maximum and minimum production levels than start-stop units.

With P_{i0} being the initial MW dispatch of unit i , and P_{i1} being the new dispatch of unit i after the redispatch, then

$$P_{i1} = P_{\min_i} + (P_{\max_i} - P_{\min_i}) \frac{(\sum_k P_{k0} - \sum_k P_{\min_k})}{(\sum_k P_{\max_k} - \sum_k P_{\min_k})} \quad (\text{eq. 1})$$

PST tap position is put at 0 in order to make a range of tap positions available as Remedial Action, except if overloads can be expected in the base case in a likely corner, in which case 2 to 4 steps could be made on some PST

For the DC cables the Exchange programs of reference days are used. In case the cable is out of service on the target day, the program of the cable will be distributed over the loads.

Afterwards, production and load are redistributed and an AC load-flow is performed in which the grid is checked for congestions and voltage problems. During this process there is an automatic adjustment of loads to correct the difference in the balance between the reference program of the execution day and the data received in the prognosis of Market Parties for this day.

Remark on the individual procedures:

If one can observe methodological variants in the local parts of the base case process, it is to be reminded that the latter remains within the continuity of the currently applied process, and that reconsidering the Grid Model methodology (either in its local or common aspects) is not part of the CWE FB implementation project. There actually exists an ENTSO-E initiative in order to align European TSOs practices towards the ACER capacity calculation cross-regional roadmap, but in any case the following sequence will have to be respected:

- Entry into force of the CACM network codes
- Design of a CGM methodology by ENTSO-E

- Validation of the methodology by NRAs
- Design of an implementation plan.

Consequently, an implementation roadmap for the European CGM is not available yet.

4.1.6. Remedial Actions ⁶

During Flow Based parameter calculation CWE TSOs will take into account Remedial Actions (RA) that are allowed in D-2 while ensuring a secure power system operation i.e. N-1/N-k criterion fulfilment.

In practice, RAs are implemented via entries in the CB file. Each measure is connected to one CBCO combination and the Flow Based parameter calculation software treats this information.

The calculation can take explicit and implicit RAs into account. An explicit Remedial Action (RA) can be

- changing the tap position of a phase shifter transformer (PST)
- topology measure: opening or closing of a line, cable, transformer, bus bar coupler, or switching of a network element from one bus bar to another
- curative (post-fault) redispatching: changing the output of some generators or a load.

Implicit RA can be used when it is not possible to explicitly express a set of conditional Remedial Actions into a concrete change in the load flow. In this case a FAV (c.f. chapter 4.1.4) will be used as RA.

⁶ Didactic examples of different types of Remedial Actions (including explicit and implicit variants) can be found in Annex 16.4).

These explicit measures are applied during the Flow Based parameter calculation and the effect on the CBs is determined directly.

The influence of implicit RA on CBs is assessed by the TSOs upfront and taken into account via the FAV factor, which changes the available margins of the CBs to a certain amount.

Each CWE TSO defines the available RAs in its control area. As cross-border Remedial Actions will be considered only those which have been agreed upon by common procedures (for example limited number of tap position on CWE PST) or explicit agreement (as in ATC process). The agreed actions are assumed binding and available.

The general purpose of the application of RAs is to modify (increase) the Flow Based domain in order to support the market, while respecting security of supply. This implies the coverage of the LTA (allocated capacity from long term auctions) domain as a minimum target.

Some RAs, with a significant influence on elements of neighbouring grids – especially cross-border RAs – have to be coordinated before being implemented in the CB file. The coordination of cross-border Remedial Actions maintains the security of supply when increasing the capacity that can be offered to the market. Common procedures, indicating amongst others which Remedial Actions can be applied for the capacity calculation stage, have been implemented to facilitate this.

The guidelines⁷ for the application of RAs imply that the RAs described in the CB files can change during the daily Flow Based process in the qualification and verification phase (e.g. as a result of a PST coordination process).

If needed, and in an effort to include the LTA domain, all possible coordinated Remedial Actions will be considered in line with the agreed list of Remedial Actions. Each TSO could, if this does not jeopardise the system security, perform additional RA in order to cover the LTA domain.

During the D-2 / D-1 capacity calculation process, TSOs have the opportunity to coordinate on PST settings. This coordination aims to find an agreement on PST settings which covers all the TSOs needs. The focus is to cover the LTA and if possible the NTCs⁸. This means that the LTAs/NTCs will not cause overloads on CBs within the Flow Based method. TSOs try to reach this by using only internal RAs as a first step. If this would not be enough the CWE wide PSTs are taken into account in order to mitigate the overloads.

⁷ These “guidelines” encompass the operators’ expertise and experience gained over the years, combined with the application of operational procedures, and is neither translated nor formalized in documentation designed to external parties.

⁸ NTCs will only be available during the external parallel run period. After go-live, TSOs will use another reference Flow Based domain – based on the experience built during the external parallel run which will be communicated to Regulators and Market Parties.

The basic principle of the PST coordination is the following:

- local calculation: TSOs try to cover the NTC/LTA domain using their own PSTs. If this is not sufficient, the TSO incorporate the PSTs of other TSOs in their local load flow calculations. In the end, every TSO comes up with a proposal for the PST tap positions in the CWE region, and the corresponding corners/situations in which the PST should be used.
- exchange of proposals: the proposal(s) is(are) shared between TSOs for review.
- review, coordination, confirmation: TSOs review the proposals and coordinate/agree on the final setting. This is to avoid that contradictory Remedial Actions are used in the same situation. The result is considered to be firm before the verification phase. The information (if necessary an updated CB file) must be transferred to the D-1 and D processes.

PSTs available for coordination are located in Zandvliet/Vaneyck, Gronau, Diele and Meeden. PST coordination is performed between Amprion, Elia, RTE and TenneT (DE and NL).

The coordination process is not necessarily limited to PST adjustment, but usual topology actions can also be considered at the same time and in the same way as the PST setting adjustment.

A prerequisite of a well-functioning coordination is that all involved parties have a dedicated timeframe to perform this coordination. This timeframe should be at best in the night between the initial Flow Based computation and the final Flow Based computation. The PST coordination should start before midnight.

4.1.7. Generation Shift Key (GSK)

The Generation Shift Key (GSK) defines how a change in net position is mapped to the generating units in a bidding area. Therefore, it contains the relation between the change in net position of the market area and the change in output of every generating unit inside the same market area.

Due to convexity pre-requisite of the Flow Based domain, the GSK must be linear.

Every TSO assesses a GSK for its control area taking into account the characteristics of its network. Individual GSKs can be merged if a hub contains several control areas.

A GSK aims to deliver the best forecast of the impact on Critical Branches of a net position change, taking into account the operational feasibility of the reference production program, projected market impact on units and market/system risk assessment.

In general, the GSK includes power plants that are market driven and that are flexible in changing the electrical power output. This includes the following types of power plants: gas/oil, hydro, pumped-storage and hard-coal. TSOs will additionally use less flexible units, e.g. nuclear units, if they don't have sufficient flexible generation for matching maximum import or export program or if they want to moderate impact of flexible units.

The GSK values can vary for every hour and are given in dimensionless units. (A value of 0.05 for one unit means that 5% of the change of the net position of the hub will be realized by this unit).

Individual procedures

German GSK:

The German TSOs have to provide one single GSK-file for the whole German Hub. Since the structure of the generation differs for each German TSO, an approach has been developed, that allows the sin-

gle TSO to provide GSK's that respect the specific character of the generation in their own grid and to create out of them a concatenated German GSK in the needed degree of full automation.

Every German TSO provides a reference file for working days, bank holidays and weekends. Within this reference file, the generators are named (with their node-name in the UCTE-Code) together with their estimated share within the specific grid for the different time-periods. So every German TSO provides within this reference-file the estimated generation-distribution inside his grid, that adds up to 1.

An example: Reference-file of TSO A for a working day

00:00 – 07:00:

GenA (Hard-Coal)	0,3
GenB (Hard-Coal)	0,3
GenC (Gas)	0,1
GenD (Hydro)	0,2
GenE (Hydro)	0,1

07:00 – 23:00

GenC (Gas)	0,3
GenD (Hydro)	0,5
GenE (Hydro)	0,2

23:00 – 24:00:

GenB (Hard-Coal)	0,2
GenC (Gas)	0,3
GenD (Hydro)	0,4
GenE (Hydro)	0,1

In the process of the German merging, Amprion (later common system) creates out of these individual reference-files, depending on the day (working day / week-end / bank holiday), a specific GSK-file for every day. Therefore, every German TSO gets its individual share, currently depending on its share of the German load (e.g TransnetBW: ca 14%, TTG: ca 32%, Amprion: ca 34,5%, 50Hz: ca 19,5 %). The content of the individual reference-files will be multiplied with the individual share of each TSO. This is done for all TSOs and so a GSK-file is created for every day. The share is linked to the consumption over the year and the share within the TSO of this consumption.

Example: Taking the reference-file above, assuming TSO A is TransnetBW, it leads to the following shares in the concatenated German GSK-file:

00:00 – 07:00:

GenA (Hard-Coal)	$0,3 * 0,14 = 0,042$
GenB (Hard-Coal)	$0,3 * 0,14 = 0,042$
GenC (Gas)	$0,1 * 0,14 = 0,014$
GenD (Hydro)	$0,2 * 0,14 = 0,028$
GenE (Hydro)	$0,1 * 0,14 = 0,014$

07:00 – 23:00:

GenC (Gas)	$0,3 * 0,14 = 0,042$
GenD (Hydro)	$0,5 * 0,14 = 0,07$
GenE (Hydro)	$0,2 * 0,14 = 0,028$

23:00 – 24:00:

GenB (Hard-Coal)	$0,2 * 0,14 = 0,028$
GenC (Gas)	$0,3 * 0,14 = 0,042$
GenD (Hydro)	$0,4 * 0,14 = 0,056$
GenE (Hydro)	$0,1 * 0,14 = 0,014$

With this method, the knowledge and experience of each German TSO can be brought into the process to obtain a representative GSK. With this structure, the nodes named in the GSK are distributed over whole Germany in a realistic way, and the individual factor is relatively small.

Individual distribution per German TSO

TransnetBW:

Based on an internal analysis performed for the year 2012, a seasonal dependence of power plant availability can be highlighted. In order to model it, the GSK is updated every season as described hereinafter.

The potential of power plants is determined depending of the period of the year for working days, weekend and furthermore differentiated between peak and off-peak hours.

The coefficient is determined as:

$$\text{Coefficient Powerplant}_i = \frac{\text{Available potential of the power plant } i}{\sum \text{Available potential of the power plants in the TNG zone}}$$

In winter and spring: there is no differentiation between peak/off-peak/working days and weekend, since the hard coal power plants are either feeding in the grid or not in operation. The GSK is therefore composed only of hydraulic units.

In the summer season, there is a differentiation between working days and weekend:

For the working days in off-peak hours, one hard coal power plant is generally available and therefore taken in consideration in the GSK.

For the rest of the time, the GSK is only composed of the hydraulic units.

In autumn, for the peak hours (weekend and working days), only the hydraulic units are available. For the off-peak hours, the hard coal power plants, which have power-potential, are as well added in the GSK.

Amprion:

Amprion established a monthly standard-process in order to keep the GSK as close as possible to the reality. In this process Amprion checks for example whether there are new power plants in the grid or whether there is a block out of service. According to these monthly changes in the grid Amprion updates its GSK.

If needed Amprion adapts the GSK in meantime during the month. In general Amprion only considers middle and peak load power plants as GSK relevant. With other words basic load power plants like nuclear and lignite power plants are excluded to be a GSK relevant node.

From this it follows that Amprion only takes the following types of power plants: hard coal, gas and hydro power plants. In the view of Amprion only these types of power plants are taking part of changes in the production.

All blocks which are considered as GSK relevant have the same GSK factor.

TenneT Germany:

Similar to Amprion, TTG considers middle and peak load power plants as potential candidates for GSK. This includes the following

type of production units: coal, gas, oil and hydro. Nuclear power plants are excluded upfront.

In order to determine the TTG GSK, a statistical analysis on the behavior of the non-nuclear power plants in the TTG control area has been made with the target to characterize the units. Only those power plants, which are characterized as market-driven, are put in the GSK. This list is updated regularly.

All blocks which are considered as GSK relevant have the same GSK factor.

Dutch GSK:

TenneT B.V. will dispatch the main generators in such a way as to avoid extensive and not realistic under- and overloading of the units for extreme import or export scenarios. The GSK for the TenneT B.V. control area contains all units with a maximum infeed above 60 MW. Unavailability due to outages are considered in the GSK.

All GSK units (including available GSK units with no production in de D2CF file) are redispatched pro rata on the basis of predefined maximum and minimum production levels for each active unit. The total production level remains the same.

The maximum production level is the contribution of the unit in a predefined extreme maximum production scenario. The minimum production level is the contribution of the unit in a predefined extreme minimum production scenario. Base-load units will have a smaller difference between their maximum and minimum production levels than start-stop units.

With P_{i0} being the initial MW dispatch of unit i , and P_{i1} being the new dispatch of unit i after the redispatch, then

$$P_{i1} = P_{\min_i} + (P_{\max_i} - P_{\min_i}) \frac{(\sum_k P_{k0} - \sum_k P_{\min_k})}{(\sum_k P_{\max_k} - \sum_k P_{\min_k})} \quad (\text{eq. 1})$$

where "k" is the index over all active GSK units.

The linear GSK method also provides new GSK values for all active GSK units. This is also calculated on the basis of the predefined maximum and minimum production levels:

$$GSK_i = \frac{P_{\max_i} - P_{\min_i}}{\sum_k P_{\max_k} - \sum_k P_{\min_k}} \quad (\text{eq. 2})$$

where "k" is the index over all active GSK units.

The 24-hour D2CF is adjusted, as such that the net position of the Netherlands is mapped to the generators in accordance to eq.1.

The GSK is directly adjusted in case of new power plants. TTB includes the outage information of generators daily in the GSK, which is based on the information sent by Market Parties.

Belgian GSK:

Elia will use in its GSK all flexible and controllable production units which are available inside the Elia grid (whether they are running or not). Units unavailable due to outage or maintenance are not included.

The GSK is tuned in such a way that for high levels of import into the Belgian hub all units are, at the same time, either at 0 MW or at Pmin (including a margin for reserves) depending on whether the units have to run or not (specifically for instance for delivery of primary or secondary reserves). For high levels of export from the Belgian hub all units are at Pmax (including a margin for reserves) at the same time.

For the Nuclear units P_{min} is equal to P_{max} . For pumped storage plants P_{min} is set equal to $-P_{max}$.

After producing the GSK, Elia will adjust production levels in all 24 hour D2CF to match the linearised level of production to the reference program as illustrated in the figure 4-1.

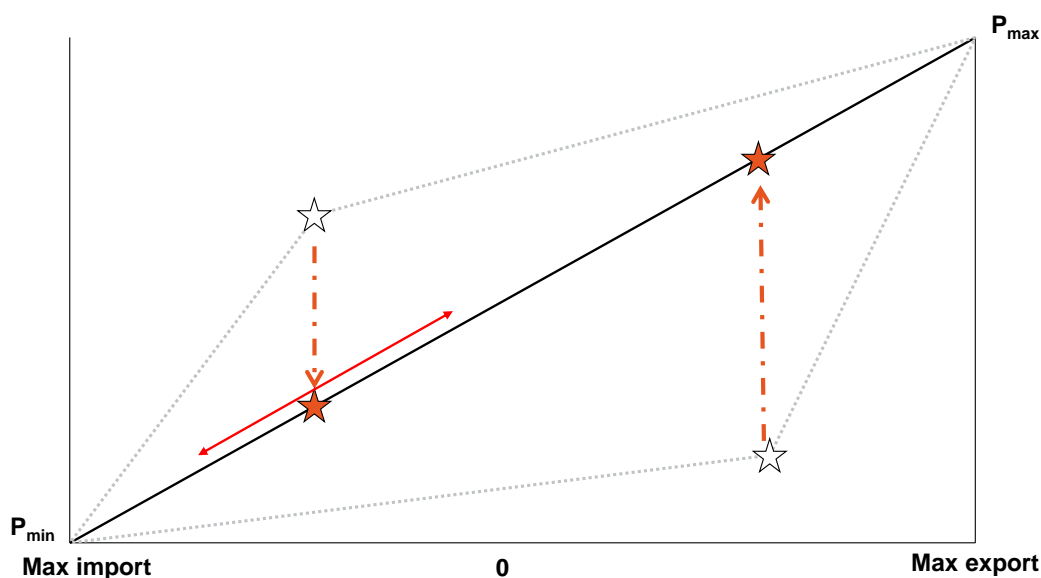


Figure 4-1: Belgian GSK.

French GSK:

The French GSK is composed of all the units connected to RTE's network.

The variation of the generation pattern inside the GSK is the following: all the units which are in operations in the base case will follow the change of the French net position on a pro-rata basis. That means, if for instance one unit is representing $n\%$ of the total generation on the French grid, $n\%$ of the shift of the French net position will be attributed to this unit.

About 50Hertz and APG:

50Hertz sends its D2CF and GSK files which improves the quality of the German data set.

At the moment of drafting this document, the AT grid is only considered with DACF datasets during FBP calculation.

Due to the large distance of AT and 50HZ to the CWE borders, not considering 50HZ and APG Critical Branches within the CWE FB calculation is not considered a problem. Adding APG D2CF to the DE-AT market area during FBP calculation (APG already generates D2CF files and GSKs for CEE region) would however improve the quality of the model. APG has recently joined the project and this straightforward improvement is expected before CWE FB goes live.

Summary and overview concerning the variability of the GSKs during the day:

- Elia and TTB use GSKs according to their GSK concept, which means constant values over the day.
- The German TSOs have two GSKs for two different periods of a day as described above (peak, off-peak).
- Since RTE is using pro-rata GSK, the values in the French GSK file change every hour.

4.1.8. Flow Reliability Margin (FRM)

The origin of the uncertainty involved in the capacity calculation process for the day-ahead market comes from phenomena like external exchanges, approximations within the Flow Based methodology (e.g. GSK) and differences between forecasts and realized programs. This uncertainty must be quantified and discounted in the allocation process, in order to prevent that on day D TSOs will be confronted with flows that exceed the maximum allowed flows of their grid elements. This has direct link with the firmness of Market

Coupling results. Therefore, for each Critical Branch, a Flow Reliability Margin (FRM) has to be defined, that quantifies at least how the before-mentioned uncertainty impacts the flow on the Critical Branch. Inevitably, the FRM reduces the remaining available margin (RAM) on the Critical Branches because a part of this free space that is provided to the market to facilitate cross-border trading must be reserved to cope with these uncertainties.

The basic idea behind the FRM determination is to quantify the uncertainty by comparing the Flow Based model to the observation of the corresponding timestamp in real time. More precisely, the base case, which is the basis of the Flow Based parameters computation at D-2, is compared with a snapshot of the transmission system on day D. A snapshot is like a photo of a TSO's transmission system, showing the voltages, currents, and power flows in the grid at the time of taking the photo. This basic idea is illustrated in the figure 4.2.

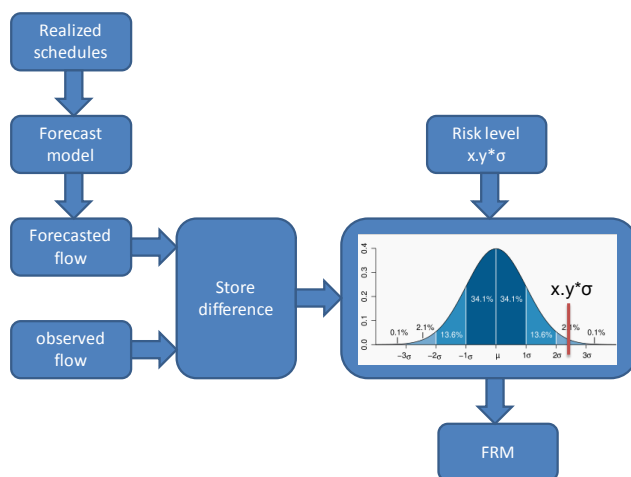


Figure 4-2: FRM Assessment Principle

In order to be able to compare the observed flows from the snapshot with the predicted flows in a coherent way, the Flow Based model is adjusted with the realized schedules corresponding to the

instant of time that the snapshot was created. In this way, the same commercial exchanges are taken into account when comparing the forecast flows with the observed ones (e.g. Intraday trade is reflected in the observed flows and need to be reflected in the predicted flows as well for fair comparison).

The differences between the observations and predictions are stored in order to build up a database that allows the TSOs to make a statistical analysis on a significant amount of data. Based on a predefined risk level⁹, the FRM values can be computed from the distribution of flow differences between forecast and observation.

By following the approach, the subsequent effects are covered by the FRM analysis:

- Unintentional flow deviations due to operation of load-frequency controls
- External trade (both trades between CWE and other regions, as well as trades in other regions without CWE being involved)
- Internal trade in each bidding area (i.e. working point of the linear model)
- Uncertainty in wind generation forecast

⁹ The risk level is a local prerogative which is closely linked to the risk policy applied by the concerned TSO. Consequently, the risk level considered by individual TSOs to assess FRM from the statistical data may vary. This risk level is a fixed, reference that each TSO has to respect globally in all questions related to congestion management and security of supply. This risk level is a pillar of each TSO's risk policies.

- Uncertainty in Load forecast
- Uncertainty in Generation pattern
- Assumptions inherent in the Generation Shift Key (GSK)
- Topology
- Application of a linear grid model

When the FRM has been computed following the above-mentioned approach, TSOs may potentially apply a so-called “operational adjustment” before practical implementation into their CB definition. The rationale behind this is that TSOs remain critical towards the outcome of the pure theoretical approach in order to ensure the implementation of parameters which make sense operationally. For any reason (e.g.: data quality issue), it can occur that the “theoretical FRM” is not consistent with the TSO’s experience on a specific CB. Should this case arise, the TSO will proceed to an adjustment. It is important to note here that:

This adjustment is supposed to be relatively “small”. It is not an arbitrary re-setting of the FRM but an adaptation of the initial theoretical value. It happens only once per CB during the FRM analysis (in other words, the TSO will not adjust its FRM at any Flow Based computation). Eventually, the operational FRM value is computed once and then becomes a fixed parameter in the CB definition.

This adjustment process is not expected to be systematic, but rather rare on the contrary, as much effort is put on the representativeness of the theoretical values.

The differences between operationally adjusted and theoretical values shall be systematically monitored and justified, which will be formalized in a dedicated report towards CWE NRAs (cf. annex 16.5).¹⁰

The theoretical values remain a “reference”, especially with respect to any methodological change which would be monitored through FRM.

For matter of clarification, we remind here that for each CB (or CBCO for the N-1 cases), the FRM campaign leads to one single FRM value which then will be a fixed parameter in the CB definition. FRM is not a variable parameter.

However, since FRM values are a model of the uncertainties against which TSOs need to hedge, and considering the constantly changing environment in which TSOs are operating, and the statistical advantages of building up a larger sample, the very nature of FRM computation implies regular re-assessment of FRM values. Consequently, TSOs consider recomputing FRM values, following the same principles but using updated input data, on a regular basis, at least once per year.

¹⁰ A dedicated, confidential report on FRM (FRM values and operational adjustment for main active Critical Branches of the parallel run) is available in Annex 16.5.

The general FRM computation process can then be summarized by the following figure:



Step 1: elaboration of statistical distributions, for all Critical Branches, in N and N-1 situations.

Step 2: computation of theoretical (or reference) FRM by applying of a risk level on the statistical distributions.

Step 3: Validation and potentially operational adjustment. The operational adjustment is meant to be used sporadically, only once per CB, and systematically justified and documented.

CWE TSOs intend a regular update, at least once a year, of the FRM values using the same principles. Exceptional events¹¹ may trigger an accelerated FRM re-assessment in a shorter time frame, but in all cases one should keep in mind that for statistical representativeness, the new context integrated into new FRM values needs to be encompassed in several months of data.

In practice, FRM values currently used in the parallel run have been computed end of 2012 on the basis of the winter 2010-2011 and

¹¹ Exceptional events could be: important modification of the grid (new line, decommissioning of large generating units...), change in the capacity calculation method, enlargement of the coupled area, implementation of advanced hybrid coupling etc...

summer 2011 period. The graphical overview below displays the FRM values associated to the main active CBs of the internal parallel run of 2012. One can basically notice here that:

- FRM values spread between 5% and 20% of the total capacity Fmax of the line, depending on the uncertainties linked to the flows on the CBCOs.
- Operational adjustments are performed in both directions (increase or decrease calculated FRM value), and essentially consist in correcting outliers, or missing, high reference values.

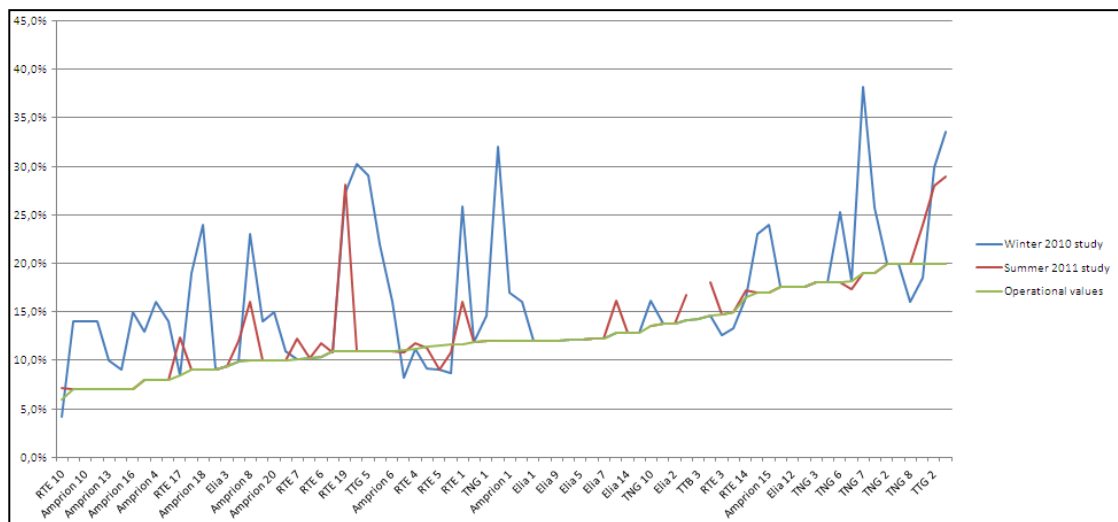


Figure 4-3: Graphical overview of the operational FRM values for the active CBs of the parallel run (CB labelling is purely arbitrary and does not correspond to the future fixed anonymization)

The values that will be used for go-live are currently being assessed on the basis of year 2013 data by CWE TSOs, and should be implemented by the end of May 2014. In this way, observation of new FRM values is guaranteed during the parallel run. A specific report

will be communicated to the NRAs in this respect which will indicate for each active CB of the current parallel run:

- The reference FRM
- The operational adjustment¹² and its justification.

4.1.9. Specific limitations not associated with Critical Branches (external constraints)

Besides electrical Critical Branches, other specific limitations may be necessary to guarantee a secure grid operation. Import/Export limits declared by TSO are taken into account as “special” Critical Branches, in order to guarantee that the market outcome does not exceed these limits. TSOs remind here that these constraints are not new, since already taken into account implicitly when computing NTCs¹³. With Flow Based, they appear explicitly and their usage is justified by several reasons, among which:

¹² Operational adjustment is not a daily operational step but a single adjustment possibly done on FRM values when the latter are computed.

¹³ Discrepancies can be identified in some cases, for instance when the sum of export (respectively import) NTCs of a given hub are larger than the export (respectively import) EC of the same hub in FB. These discrepancies can have several reasons :

1. At implementation level, the ATC and FB model obviously differ, which could lead to slightly different results.
2. The NTCs belong to an « unlikely » situation (typically, the double Belgium export), therefore it is foreseeable that just summing up NTCs on borders and comparing them with ECs can lead to differences.

- Avoid market results which lead to stability problems in the network, detected by system dynamics studies.

Avoid market results which are too far away from the reference flows going through the network in the base-case, and which in exceptional cases would induce extreme additional flows on grid elements, leading to a situation which could not be verified as safe by the concerned TSO during the verification step (c.f. chapter 4.2.5). In other words, FB capacity calculation includes contingency analysis, based on a DC loadflow approach. This implies that the constraints determined are active power flow constraints only. Since grid security goes beyond the active power flow constraints, issues like:

- voltage stability,
- dynamic stability,
- ramping (DC cables, net positions),

need to be taken into account as well. This requires the determination of constraints outside the FB parameter computation: the so-called external constraints (ECs).

One also needs to keep in mind that EC are therefore crucial to ensure security of supply and are in this respect systematically implemented as an input of the FB calculation process. In other words, the TSO operator does not decide including or not an EC on a given day (or even hour), he will always integrate an external constraint whatever the current operational conditions are, in order to prevent unacceptable situations.

In the case that an external constraint is limiting the market, it receives a shadow price. Indeed, the shadow price indicates the welfare increase when the constrained element is marginally relieved. The shadow price, a useful indicator to assess the market impact of

a given CB, will be part of the active constraint reporting towards NRAs.

External constraints versus FRM:

FRM values do not help to hedge against the situations mentioned above. By construction, FRMs are not covering voltage and stability issues which can occur in extreme cases, not only because FB is based “only” on a DC model, but also because as they are statistical values looking “backward”, (based on historical data), they cannot cover situations which never happened. And this is exactly the purpose of external constraints, to prevent unacceptable situations (which by definition did not happen), like voltage collapses or stability issues on the grid.

Therefore, FRM on the one hand (statistical approach, looking “backward”, and “inside” the FB DC model) and external constraints on the other hand (deterministic approach, looking “forward”, and beyond the limitations of the FB DC model) are complementary and cannot be a substitute to each other. Each TSO has designed its own thresholds on the basis of complex studies, but also on operational expertise acquired over the years.

The advantage of FB in this respect is that it makes the design and activation of external constraints fully transparent. Not only are the EC explicit Critical Branches (while they are taken into account implicitly when computing NTCs) but also are they easily identifiable in the publication. Indeed, their PTDFs are straightforward (0;0;0;1 or -1, the margin being the import/export limit) and can be directly linked to its owner resp. country, since it relates to the 1 or -1 in the PTDF matrix. Therefore CWE TSOs consider that full transparency is already provided in this respect.

The following sections will depict in detail the method used by each TSO¹⁴ to design and implement external constraints.

German External Constraint:

Amprion, TRANSNETBW and TTG have decided to implement an external constraint for the German CWE net position (export/import limit). The main reason for this is to avoid market results which are too far away from the expected flows going through the German network, and which cannot be verified as safe during the flow based process.

The value of the external constraint depends on the German CWE reference programs, which are included in the German D2CF. With respect to this reference the German export/import will be restricted to a reasonable level. An algorithm ensures that the values of the export/import limits are within a reasonable range. The choice of this range is based on experiences with the current maximum NTC values, which restrict the maximum German export/import towards CWE region.

The following picture illustrates the determination of the export/import limits in more detail:

¹⁴ Any time a TSO plans to change its method for EC implementation, it will have to be done with NRAs' agreement, as it is the case for any methodological change.

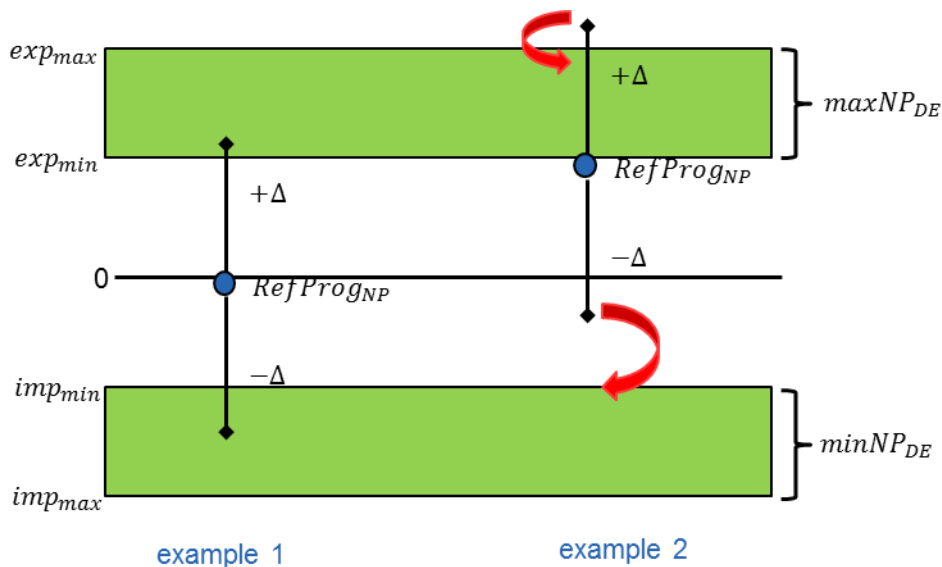


Figure 4-3: Export/import limits illustration.

On the left hand side (example 1) the export limit is set to the value $(RefProgNP+\Delta)$ and the import limit is set to $(RefProgNP-\Delta)$. In example 2 an export limit of $(RefProgNP+\Delta)$ would be too high; the limit set to exp_max . The value of $(RefProgNP-\Delta)$ for an import limit would be too low, so it is set to imp_min .

Currently, the German TSOs use the following parameters:

$$\Delta = 5000\text{MW}$$

$$imp_{min} = -4400\text{MW}; \quad imp_{max} = -6000\text{MW}; \quad exp_{min} = 5600\text{MW}; \quad exp_{max} = 7000\text{MW}$$

Dutch External Constraint:

TenneT NL determines the maximum import and export constraints for the Netherlands based on off-line studies, which also include voltage collapse and stability analysis during different import and export situations. The study can be repeated when necessary and may result in an update of the applied values for the external constraints of the Dutch network.

Belgian External Constraint:

Elia uses an import limit constraint which is related to the dynamic stability of the network. This limitation is estimated with offline studies which are performed on a regular basis.

French External Constraint:

The external constraints of the French network are designed to avoid non-representative results from the Flow Based capacity calculation which would potentially be unsecure.

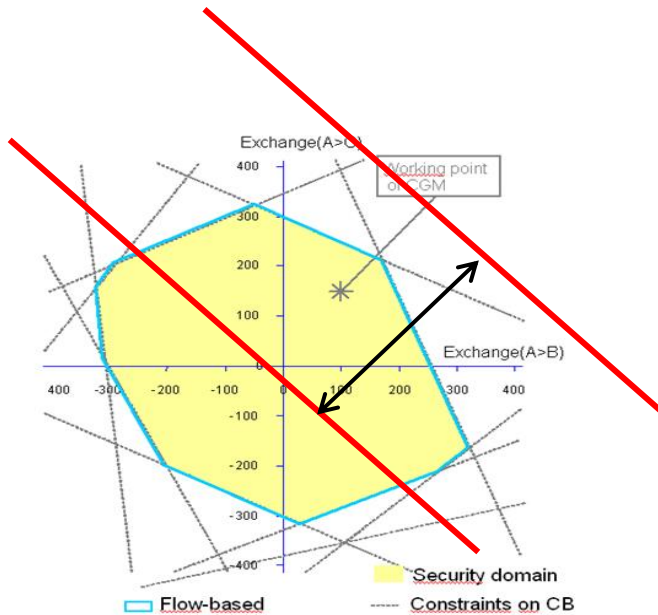
In the ATC process, more than one D2CF file are used to calculate NTCs, for example one for an export situation and one for an import situation.

When no recent file reflecting the relevant cross-border exchange direction (import or export tendency) is available, no calculation is performed. Experience shows that, if changes introduced in the file to reach the correct exchanges are too numerous, results cannot be used, because confidence in the results becomes too small. This is due, among others, to an increase of the uncertainties resulting from the GSK methodology correlatively to the gap with the reference exchange in the D2CF file. In this case, NTC values are taken from previous studies (weekly, monthly), performed with files more representative of the concerned cross-border exchange direction.

In Flow Based, it's not possible to proceed as such, as one single file is used for both exchange directions.

To avoid unreliable and potentially unsecure results, RTE has decided to define a 'shift criterion':

- Results are fully accepted when included into the validity domain defined as: Reference Exchanges +/- Shift criterion

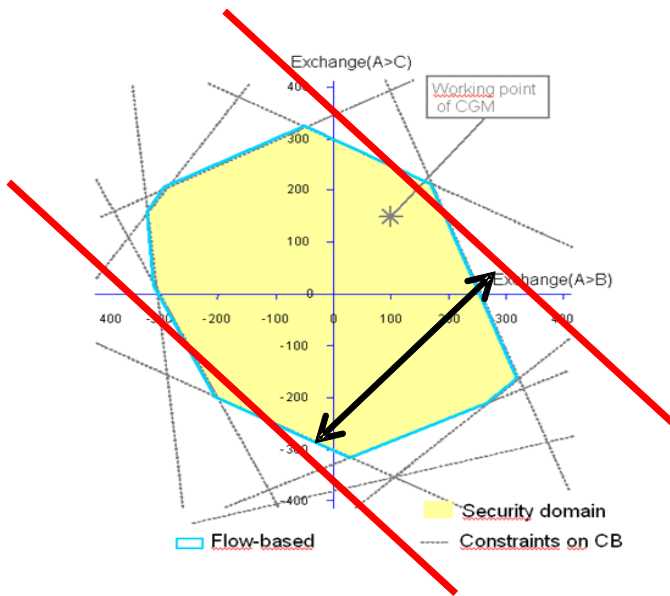


“Validity” domain, between
 Max Export = Ref Exchanges (FR>BE + FR>DE) + Criterion
 Max Import = Ref Exchanges (BE>FR + DE>FR) - Criterion

By expertise, the ‘shift criterion’ is fixed at 4000 MW. A shift superior to this value could lead to situations where RTE has no operational experience and would not be able to fully assess the risks taken (especially in counter-tendency cases with potential shifts of 7000MW as already observed during the parallel run). More precisely, FRM implemented at Go Live would not be based on such important shifts of the French net positions.

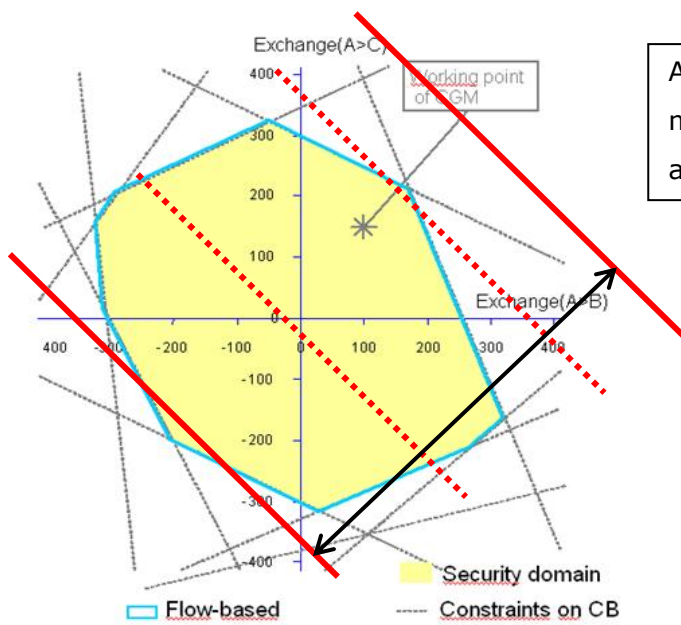
When results are outside the validity domain (case of counter-tendency), they are accepted if a previous study had shown their validity.

These studies are performed based on D2CF files representative of the relevant exchange directions, during weekly or monthly calculation cycles, and are published at the end of each weekly cycle. The weekly published values are taken to produce an “acceptability domain”.

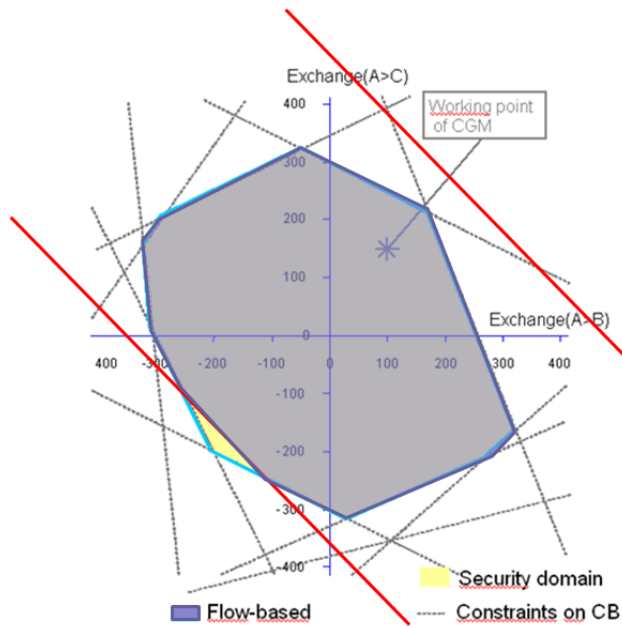


“Acceptability” domain, between
 Max Export = $\Sigma(\text{NTC FR}>\text{BE} + \text{NTC FR}>\text{DE})$
 Max Import = $\Sigma(\text{NTC BE}>\text{FR} + \text{NTC DE}>\text{FR})$

Final acceptable domain is the concatenation of these two domains, 'Acceptability + Validity'.



Acceptable domain allowed to the market, before taking into account all the Critical Branches.



Final domain given to the market, after taking into account all the Critical Branches

Remark:

By construction, the acceptable domain adapts to the recent exchange directions, day after day and as soon a D2CF file reflecting a new market direction is available, the acceptability is changed accordingly, for the next calculation.

Day1	Validity Domain		Acceptability Domain		Acceptable Domain	
Reference	Max	Max	Max	Max	Max	Max
Exchanges	Import	Export	Import	Export	Import	Export
1000	-3000	5000	-4000	4000	-4000	5000
4000	0	8000	-4000	4000	-4000	8000
3000	-1000	7000	-4000	4000	-4000	7000
-1000	-5000	3000	-4000	4000	-5000	4000

Day2	Validity Domain		Acceptability Domain		Acceptable Domain	
Reference	Max	Max	Max	Max	Max	Max
Exchanges	Import	Export	Import	Export	Import	Export
-4000	-8000	0	-5000	4000	-8000	4000
-4000	-8000	0	-5000	4000	-8000	4000
-4000	-8000	0	-5000	4000	-8000	4000
-4000	-8000	0	-5000	4000	-8000	4000

4.2. Coordinated Flow Based Capacity Calculation Process

4.2.1. Merging

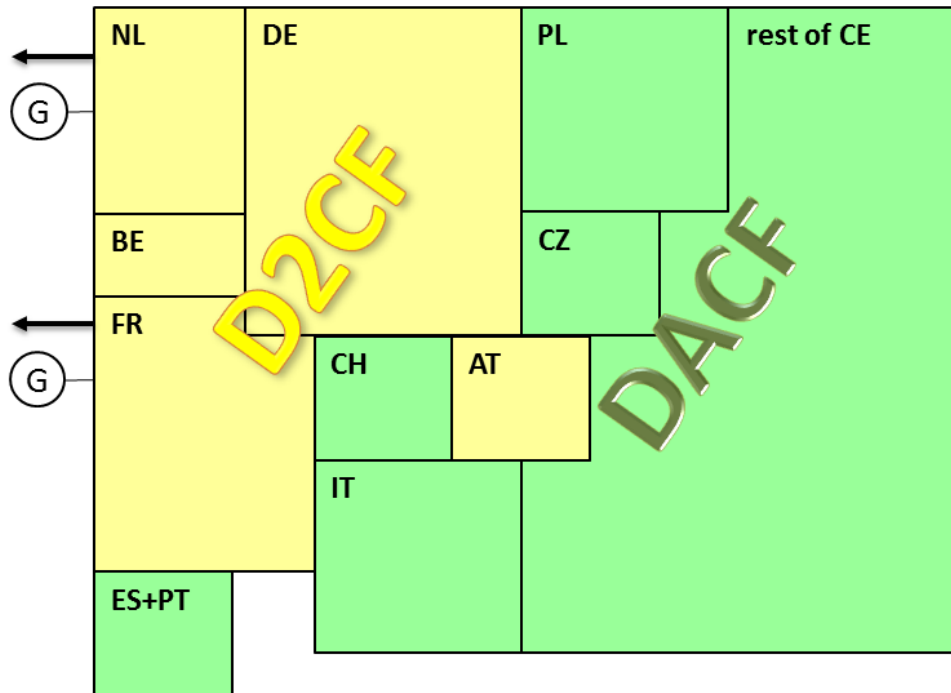
Basis for the calculation process is a model of the grid, the Common grid Model (CGM) that represents the best forecast of the corresponding hour of the execution day (day D). Due to the timeline within the process, the creation of the CGM has to be performed two-days ahead of day D. The CGM is a data set created by merging individual grid models by a merging entity.

This data set contains

- the single D-2CF data sets from CWE TSOs: Elia (BE), RTE (FR), TenneT (NL), TenneT (DE), Transnet BW (DE), Amprion (DE), 50HzT (DE) and APG (AT)
- the DACF data sets from the non-participating TSOs of continental Europe

The network of German Control Block (GCB) is composed of EnDK (DACF), TenneT DE, Transnet BW, Amprion, 50Hertz and CREOS in a pre-merge. DC cables linked to other control blocks are handled as injections in the model. The schedules on these cables are consistent with the reference exchange programs.

The DACF data sets of non-participating TSOs, corresponding to the agreed reference timestamp, are needed to take the physical influences of these grids properly into account when calculating transfers between FR-BE-NL-DE. In the figure below not shown zones are external zones which are represented as positive or negative injections.



The merging process will be done in the following steps, according to the internationally agreed merging rules:

1. Check of individual data sets of the participating and non-participating TSOs:
 - Check for format
 - Check loadflow convergence
2. Balance check (import/export situation) according to scheduled balance of reference timestamp. In case of mismatch, balance adjustment according to the internal CWE Merging Guidelines.
3. Merging process:
 - Check interconnector status. If necessary adjustment according to the CWE Merging Guidelines

Note: the merging activity is not a fully automatic one and comprises a sanity check (format compliance, tie-lines status, country balance) of each individual file with a specific operational procedure in case of inconsistencies.

4.2.2. Pre-qualification¹⁵

Before the first Flow Based parameter calculation the TSO checks the consistency of the applied CB-file with the forecasted grid-situation. Special attention is given to the Remedial Actions (RA) described in the CB-file. Every TSO has to check, if the described RAs are available in the forecasted grid situation, or if some adaptations might have to be done. This pre-qualification step also contains, if necessary, the information sharing and coordination with adjacent TSOs.

4.2.3. Centralized Initial-Flow Based parameter computation

The Flow Based parameters computation is a centralized computation. As the whole grid is linearized, the calculation can be done with the much faster DC approach and delivers two main classes of parameters needed for the following steps of the FB MC.

¹⁵ Prequalification is a CB assessment phase available at any moment of the FB process, during which each TSO can assess the relevance of its CB set, with respect to the operating conditions at the moment of capacity calculations. Therefore, operational experience plays a major role. Concretely, this phase is facilitated by a tool which allows an efficient review of the Critical Branches, as well as a cross comparison of interconnectors and associated Remedial Actions. As such, prequalification is an introduction to qualification since it provides the first elements to be discussed and coordinated between TSOs later during the FB process, which is why it is presented here before qualification in the operational sequence. In practice, prequalification can be done before each FB common computation.

i) Remaining Available Margin (RAM):

As the reference flow (F_{ref}) is the physical flow computed from the common base case, it reflects the loading of the Critical Branches given the exchange programs of the chosen reference day. Out of the formula:

$$RAM = F_{max} - F_{ref} - FRM - FAV$$

The calculation delivers, with respect to the other parameters, the free margin for every CB. This RAM is one of the inputs for the subsequent process steps.

ii) Power Transfer Distribution Factors (PTDFs):

The PTDFs are calculated by varying the exchange program of a zone (=market area), taking the zone-GSK into account. For every single zone-variation the effect on every CB loading is monitored and the effect on the loadflow is calculated in percent (e.g. additional export of BE of 100 MW has an effect of 10 MW on a certain CB => PTDF = 10%). The GSK for the zone has an important influence on the PTDF, as it translates the zone-variation into an increase of generation in the specific nodes.

The PTDF characterizes the linearization of the model. In the subsequent process steps, every change in the export programs is translated into changes of the flows on the CBs by multiplication with the PTDFs.

4.2.4. Flow Based parameter qualification

The operational Flow Based parameter qualification process is executed locally by each TSO, and covers amongst others the following action. For each non-redundant CB, limiting the Flow Based-domain, the TSO checks, if Remedial Actions (RA) are at hand, that could enlarge the Flow Based-domain. This is in coherence with the local capacity calculation procedures and risk policies. Depending on the

nature and the complexity of the specific RA, the RAs could be applied explicitly in the CB-file by a detailed description or, if too complex and the effect is known or can be estimated, by adapting the Final Adjustment Value (c.f. chapter 4.1.4). Close coordination between CWE TSOs is needed for the application of the different RAs. A coordination of cross-border Remedial Actions enhances the security of supply and can increase the capacity that can be offered to the market. Information sharing among TSOs plays a key role in this respect. Common procedures indicating amongst others which Remedial Actions will be applied for this capacity calculation.

The aim is to qualify in this stage the maximum Flow Based domain that can be given, with respect to the TSO's risk policies. The following criteria and parameters can help and guide through this phase:

- The Flow Based domain should be comparable with the one of the previous day (i.e. max net positions comparison) if the environment did not change significantly (i.e. consumption forecast, outages, renewable energy forecasts)
- The Flow Based domain should be bigger than the LTA domain
- The current reference program has to be inside the Flow Based-domain, nor may there be violations of the formula:
$$F_{ref} > F_{max} - FRM - FAV.$$

4.2.5. Flow Based parameter verification

After the qualification phase, the TSOs provide an updated CB file to the Common System. Based on this updated CB-file, a second Flow Based-parameter calculation is started. This next calculation delivers the largest possible Flow Based domain that respects the Security of Supply (SoS) domain. During the verification step, TSOs check

whether the computed Flow Based domain is secure, with a possibility to identify constraints through an AC load flow analysis. Therefore, at this step of the process, TSOs have the possibility to ascertain the correctness of the Flow Based parameters generated by the centralized computation:

- TSOs can check the grid security in the relevant points (e.g. vertices) of the Flow Based domain by customizing the generation pattern to the commonly observed one for the corresponding vertex instead of using the linear GSK
- TSOs can perform a full AC load flow analysis of the relevant points, thereby taking into account reactive power flows
- TSOs can check if the voltage limits of the equipment are respected
- TSOs can assess voltage stability (voltage collapse)
- TSOs can investigate extreme net positions

If security issues are discovered, TSOs can update their Critical Branch files (by adding new CBs, that were not perceived upfront as being limiting (for instance in the case of combined and/or unusual scheduled outages), or by adapting the Final Adjustment Value).

After the verification step and possibly adaptation of the CB-file, the final Flow Based-parameter calculation can be performed, which includes adjustment to long-term nominations (c.f. chapter 4.2.7) and presolve (c.f. chapter 4.3.1) steps.

4.2.6. LTA inclusion check

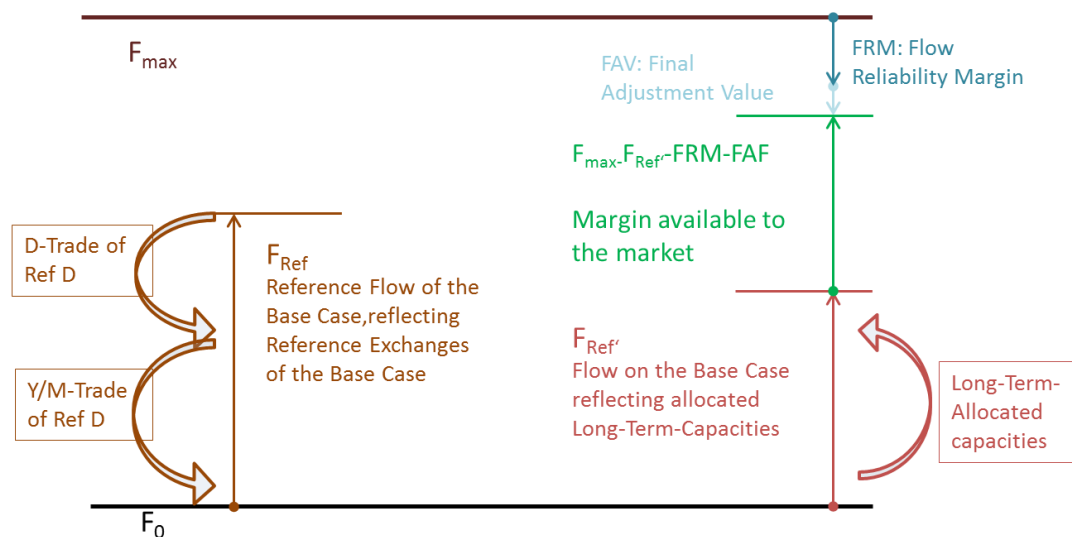
Given that Programming Authorisations for long term allocated capacity (LTA) have already been sent out in D-2 Working Days (according to the current version of the Auction Rules), the long-term-allocated capacities of the yearly and monthly auctions have to be

included in the initial Flow Based-domain which is calculated, before taking into account the cross-border nominations. This will avoid that the flow based domain provided to the day-ahead allocation (after taking into account the cross-border nominations) would not include the 0 hub-position point. This can be checked after each Flow Based-parameter-calculation. The fundamental reasons for designing this "LTA coverage" are explained in details in Annex 16.6. The figure below illustrates the calculation, that has to be done: After each calculation a check can be performed if the remaining available margin after LTA adjustment is negative. For every presolved CB the following check is performed

$$F_{ref}^* = F_{ref} - \sum_{i=hub} PTDF_i * (Ref_{prog\ i} - LTA_i)$$

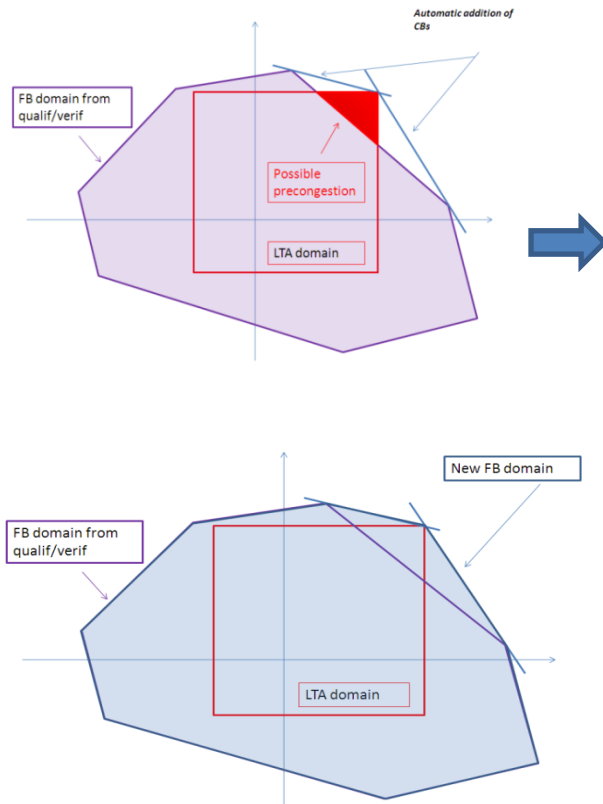
and then the following equation is checked

$$RAM^* = F_{max} - F_{ref}^* - FRM - FAV < 0$$



If the remaining margin is smaller than zero, this means the LTA is not fully covered by the Flow Based domain. In this case, a method is applied that enlarges the Flow Based-domain in a way, that all LTA are included. Virtual CBs are created and introduced, which re-

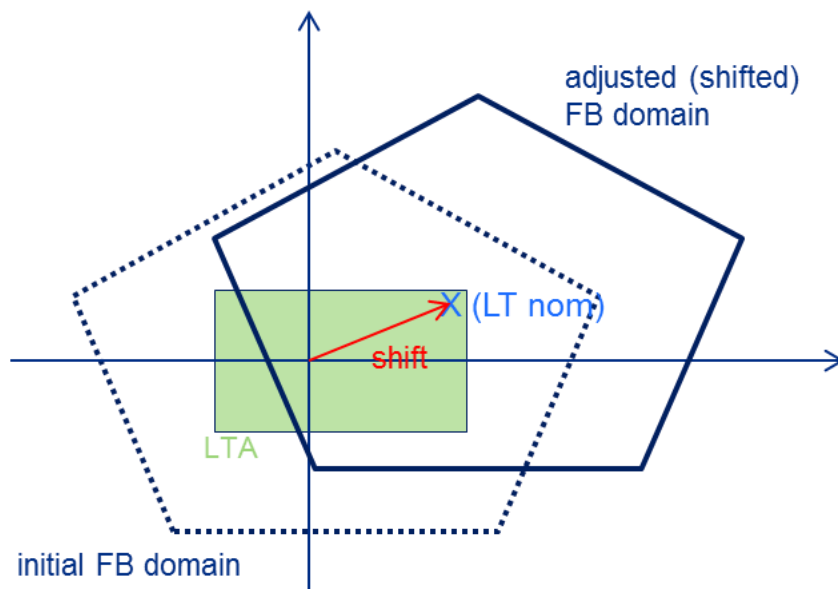
place the CB for which $RAM < 0$, and that guarantee the inclusion of all LTA, as illustrated in the figure below.



4.2.7. LTN adjustment

As the reference flow (F_{ref}) is the physical flow computed from the common base case, it reflects the loading of the Critical Branches given the exchange programs of the chosen reference day. There-

fore, this reference flow has to be adjusted to take into account only the effect of the LTN (Long Term Nominations) of day D as soon as they are known¹⁶. The effect on the domain is schematically visualized in the following figure.



For the LTN adjustment, the same principle has to be applied for every constraining element. A linear “backward-forward-calculation” with the LTNs multiplied with the PTDFs delivers the flow on the CBs affected by these LTNs. The remaining margin for the DA-allocation can be calculated by:

¹⁶ A description of the publication of the initial and final FB domain can be found in Annex 16.6.

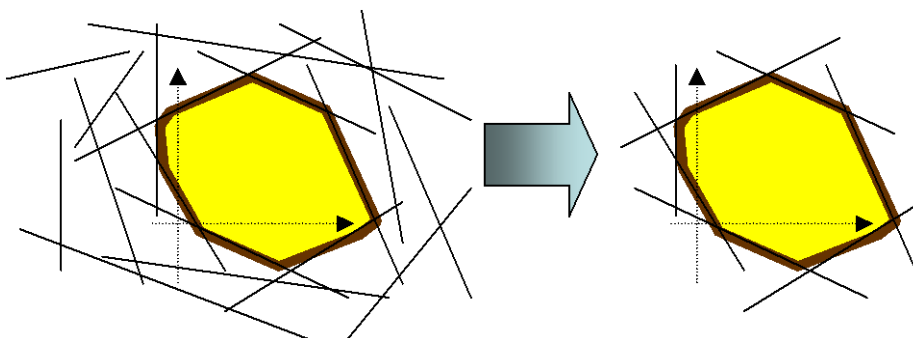
$$RAM = Fmax - Fref' - FRM - FAV$$

$$Fref' = Fref + (LTN - RefProg)*PTDF$$

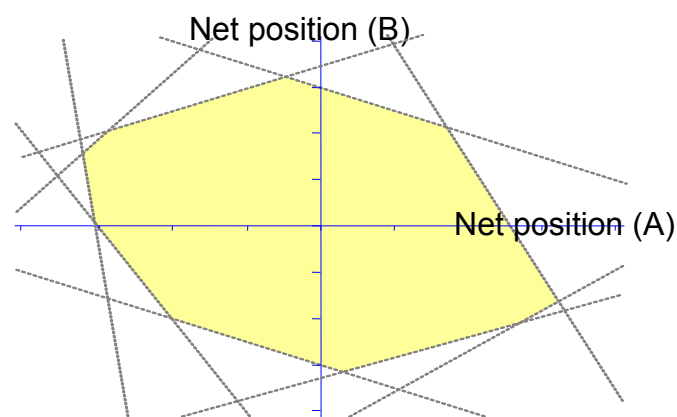
4.3. Output data

4.3.1. Flow Based capacity domain

The Flow Based parameters that have been computed indicate what net positions, given the Critical Branches that are specified by the TSOs in CWE, can be facilitated under the Market Coupling without endangering the grid security. As such, the Flow Based parameters act as constraints in the optimization that is performed by the Market Coupling mechanism: the net positions of the bidding zones in the Market Coupling are optimized in a way enabling that the day-ahead market welfare is maximized while respecting the constraints provided by the TSOs. Although from the TSO point of view all Flow Based parameters are relevant and do contain information, not all Flow Based parameters are relevant for the Market Coupling mechanism. Indeed, only those Flow Based constraints that are most limiting the net positions need to be respected in the Market Coupling: the non-redundant constraints. The redundant constraints are identified and removed by the TSOs by means of the so-called presolve. This presolve step is schematically illustrated in the two-dimensional example below:



In the two-dimensional example shown above, each straight line in the graph reflects the Flow Based parameters of one Critical Branch. A line indicates for a specific Critical Branch, the boundary between allowed and non-allowed net positions: i.e. the net positions on one side of the line are allowed whereas the net positions on the other side would overload this Critical Branch and endanger the grid security. As such, the non-redundant, or presolved, Flow Based parameters define the Flow Based capacity domain that is indicated by the yellow region in the two-dimensional figure above. It is within this Flow Based capacity domain (yellow region) that the net positions of the market can be optimized by the Market Coupling mechanism. A more detailed representation of a two-dimensional Flow Based capacity domain is shown hereunder.



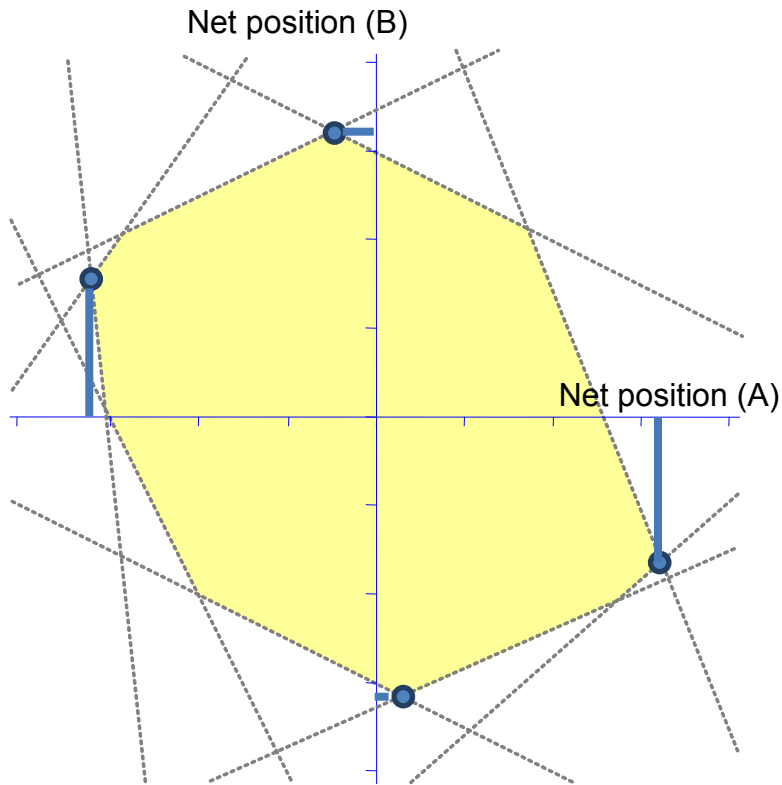
The intersection of multiple constraints, two in the two-dimensional example above, defines the vertices of the Flow Based capacity domain.

4.3.2. Flow Based capacity domain indicators

From the Flow Based capacity domain, indicators can be derived that characterize the Flow Based-domain and provide additional in-

formation of the domain. These indicators are published (see chapter 10) or monitored by the NRAs (see chapter 11)

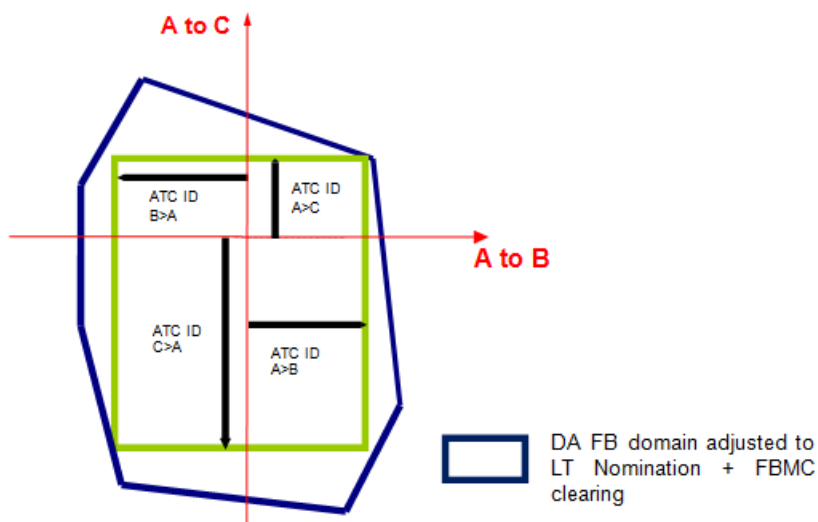
- Flow Based-Volume: “volume” of the domain
 - The volume is computed in $n-1$ dimensions, where n is the number of hubs participating in the CWE FB MC (as the sum of the n net positions must be zero).
 - The volume can be compared with the volume of another domain, for instance the LTA domain (Long-Term Allocated capacity domain).
 - The intersection of different volumes can be computed, for instance the intersection of the Flow Based domain and the LTA domain.
- Flow Based-vertices: Net positions of the Flow Based-vertices
- Min-Max net positions: Minimum and maximum net position values for each hub, feasible within the Flow Based domain (by assuming that all other CWE hubs contribute to this specific Min-Max net position). An illustration of the Min-Max net positions feasible within the Flow Based domain for the two-dimensional example used so far, is shown in the figure below (the respective vertices are indicated by the blue dots, whereas the corresponding Min-Max net positions are highlighted by the blue lines).
- Min-Max bilateral exchanges between any two hubs, feasible within the Flow Based domain (by assuming that all other exchanges in CWE contribute to this specific Min-Max bilateral exchange).



4.4. Initial ID ATC Computation

4.4.1. Introduction

The hereafter described procedure is an intermediate step, to make the D-1 Flow Based method compatible with the current ID ATC process. The aim is to assess ID ATC values deduced from the D-1 Flow Based parameters, which have been adjusted according to the D-1 FB MC results. The ID ATCs can be considered as a leftover of the D-1 Flow Based capacity as illustrated below. With that respect the initial ID ATC computation is not a new capacity calculation process.



The calculated ID ATCs are then used in the same way as the current ID ATCs. This chapter focuses on the process of the ID ATC computation. The input and output parameters are described and the iterative method is explained using a pseudo-code and an example calculation.

4.4.2. Input data

Despite the two days per year with a long-clock change, there are 24 timestamps per day. The following input data is required for each timestamp:

- Market Coupling net positions
- presolved Flow Based parameters adjusted to LT nominations; curtailed to zero margins in case of a negative RAM
- tolerance margin (in MW), with the possibility to activate it for every country by the respective TSO (may be used in order to propose minimum ID ATC values).

4.4.3. Output data

The calculation leads to the following outputs for each timestamp:

- initial ID ATC
- number of iterations that were needed for the ID ATC computation
- branches with zero margin after the ID ATC calculation
- indication if the tolerance margins were activated, and if so, which ID ATC was affected by this

4.4.4. Algorithm

The ID ATC calculation is an iterative procedure and part of the so-called post-coupling process.

Starting point

First, the remaining available margins (RAM) of the pre-solved CBs, which were given to the DA market at the end of the pre-coupling process, have to be adjusted to the MC results. The adjustment is performed using the net positions resulting from the day-ahead MC and the corresponding zone-to-hub PTDFs. The resulting margins serve as a starting point for the iteration (step $i=0$) and represent an updated Flow Based domain from which the ID ATC domain is determined.

From the non-anonymized presolved zone-to-hub PTDFs ($PTDF_{z2h}$), one computes zone-to-zone PTDFs ($pPTDF_{z2z}$), where only the positive numbers are stored¹⁷:

$$pPTDF_{z2z}(A > B) = \max(0, PTDF_{z2h}(A) - PTDF_{z2h}(B))$$

with $A, B = DE, FR, NL, BE$ at the moment. Only zone-to-zone PTDFs of neighbouring market area pairs are needed (e.g. $pPTDF_{z2z}(DE > BE)$ will not be used).

Iteration

The iterative method applied to compute the ID ATCs in short comes down to the following actions for each iteration step i:

1. For each CB, share the remaining margin between the CWE internal borders that are positively influenced with equal shares.
2. From those shares of margin, maximum bilateral exchanges are computed by dividing each share by the positive zone-to-zone PTDF.
3. The bilateral exchanges are updated by adding the minimum values obtained over all CBs.
4. Update the margins on the CBs using new bilateral exchanges from step 3 and go back to step 1.

¹⁷ Negative PTDFs would relieve CBs, which cannot be anticipated for the ID capacity calculation.

This iteration continues until the maximum value over all critical branches of the absolute difference between the margin of computational step $i+1$ and step i is smaller than a stop criterion.

The resulting ID ATCs get the values that have been determined for the maximum CWE internal bilateral exchanges obtained during the iteration and after rounding down to integer values.

After algorithm execution, there are some Critical Branches with no remaining available margin left. These are the limiting elements of the ID ATC computation.

The computation of the ID ATC domain can be precisely described with the following pseudo-code:

```
While  $\max(\text{abs}(\text{margin}(i+1) - \text{margin}(i))) > \text{StopCriterionIDATC}$ 
  For each CB
    For each non-zero entry in pPTDF_z2z Matrix
       $\text{IncrMaxBilExchange} = \text{margin}(i) / \text{NbShares} / \text{pPTDF\_z2z}$ 
       $\text{MaxBilExchange} = \text{MaxBilExchange} + \text{IncrMaxBilExchange}$ 
    End for
  End for
  For each ContractPath
     $\text{MaxBilExchange} = \min(\text{MaxBilExchanges})$ 
  End for
  For each CB
     $\text{margin}(i+1) = \text{margin}(i) - \text{pPTDF\_z2z} * \text{MaxBilExchange}$ 
  End for
End While
ID_ATCs = Integer(MaxBilExchanges)
```

Configurable parameters:

- StopCriterionIDATC (stop criterion); recommended value is 1.e-3

- NbShares (number of CWE internal commercial borders); current value is 4.

Tolerance margin

The tolerance margin introduces minimum ID ATC values on borders between CWE market areas. This optional process step¹⁸ comes after the original ID ATC determination and is therefore based on the results obtained before.

The tolerance margin can be activated by one or more CWE TSOs, which are neighbours to the border, by setting a non-zero value into a reference table. Such TSOs are here labelled with 'TSO_act'.

	TTG	TTB	Amp	TNG	RTE	Elia
DE->NL	0	0	0			
NL->DE	0	0	0			
NL->BE		0				0
BE->NL		0				0
BE->FR					0	0
FR->BE					0	0
FR->DE			0	0	0	
DE->FR			0	0	0	

The value in the table is valid for the whole day (all timestamps) and remains unchanged until it is reset by the responsible TSO_act.

¹⁸ Since the CWE FB project considers the DA market only, the usage of the ID tolerance margin should be discussed in the current ID framework.

The tolerance margin is only accepted within the algorithm if it does not introduce overloadings on the CB of those TSO, which did not activate the tolerance margin (labelled with TSO_other). But the CBs of TSO_act can be overloaded with respect to this procedure.

The following procedure describes the calculation of the tolerance margin:

Define first the TSO(s)/countries having activated the tolerance margin in the ID ATC computation as 'TSO_act', whereas the other TSOs are identified as 'TSO_other'. Then perform the following check, which may result in an adjustment of the ID ATCs corresponding to the borders of TSO_act:

```
FOR all TSO_act DO
  Store the old ID ATC values of TSO_act
  IF the ID ATCs of TSO_act < tolerance margin THEN
    Set TSO_act ID ATCs to the tolerance margin value
  IF this leads to overloaded TSO_other CBs THEN
    Discard the new ID ATCs for TSO_act and retrieve the stored ones
  ELSE
    Store and apply the new set of TSO_act ID ATCs
```

The tolerance margin¹⁹ used for the ID ATC calculation takes into account the level of uncertainty of the ID ATC calculation based on the D2CF grid model. Given the uncertainty level of these calculations in the D-2 stage, some TSOs have the possibility to put a minimum value on the ID ATC in order not to prematurely and maybe

¹⁹ The tolerance margin is one of the options currently being investigated by a dedicated workgroup and out of scope of this approval package.

unnecessarily block the market. The initial value of the ID ATC will then not be initially lower than the tolerance margin, however security calculations performed after day-ahead market coupling (e.g. using DACF) might still reduce or increase the ID ATC in line with system security requirements.

The ID ATC initially at zero might not be confirmed by the recalculation, therefrom the possible usage of the tolerance margin.

4.5. Capacity calculation on non CWE borders (hybrid coupling)

Capacity calculation on non CWE borders is out of the scope of the CWE FB MC project. CWE FB MC just operates provided capacities (on CWE to Non-CWE-borders), based on approved methodologies.

The standard hybrid coupling solution which is proposed today is in continuity with the capacity calculation process already applied in ATC MC. By "standard", we mean that the influence of "exchanges with non-CWE hubs" on CWE Critical Branches is not taken into account explicitly at capacity calculation phase (no PTDF relating exchanges CWE <-> non-CWE to the load of CWE CBs). However, this influence physically exists and needs to be taken into account to make secure grid assessments, and this is done in an indirect way. To do so, CWE TSOs make assumptions on what will be the eventual non-CWE exchanges, these assumptions being then captured in the D2CF used as a basis, or starting point, for FB capacity calculations. What's more, uncertainties linked to the aforementioned assumptions are integrated within each CB's FRM. As such, these assumptions will impact the available margins of CWE Critical Branch-

es. However, strictly speaking, no margin is explicitly booked for non-CWE exchanges on CWE CBs.

CWE partners together with NWE are committed to study, after go-live, potential implementation of the so-called “advanced hybrid coupling solution”, that consists in taking directly into account the influence of non CWE exchanges on CWE CBs (which means, practically, the addition of new PTDFs columns in the FB matrix and therefore less reliance on TSOs’ assumptions on non CWE exchanges, since the latter would become an outcome of the FB allocation).

4.6. Backup and Fallback procedures for Flow Based capacity calculation

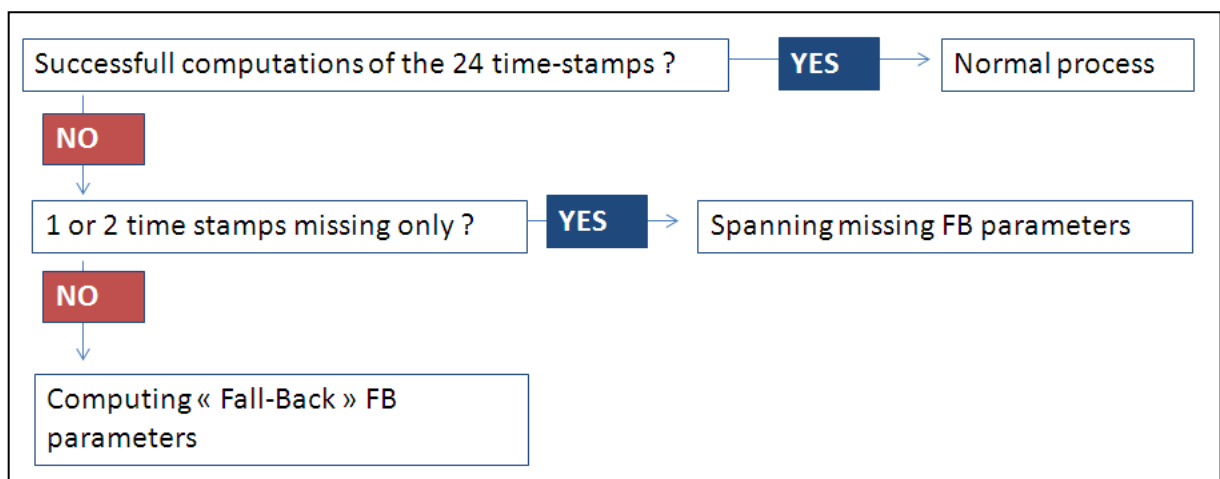
Introductory disclaimer: please note that this section is related to capacity calculation Fallback principles only. Therefore, its aim is neither to address operational Fallback procedures, nor to consider market-coupling Fallbacks (decoupling).

In some circumstances, it can be impossible for CWE TSO to compute Flow Based Parameters according to the process and principles. These circumstances can be linked to a technical failure in the tools, in the communication flows, or in corrupted or missing input data. Should the case arise, and even though the impossibility to compute “normally” Flow Based parameters only concern one or a couple of hours, TSOs have to trigger a Fallback mode in order to deliver in all circumstances a set of parameters covering the entire day. Indeed, market-coupling is only operating on the basis of a complete data set for the whole day (ALL timestamps must be available), mainly to cope with block orders.

The approach followed by CWE TSOs in order to deliver the full set of Flow Based parameters, whatever the circumstances, is twofold:

- First, TSOs can trigger “replacement strategies” in order to fill the gaps if some timestamps are missing. Because the Flow Based method is very sensitive to its inputs, CWE TSOs decided to directly replace missing Flow Based parameters by using a so-called “spanning method”. Indeed, trying to reproduce the full Flow Based process on the basis of interpolated inputs would give unrealistic results. The spanning method is described in detail in the following section. These spanning principles are only valid if a few timestamps are missing (up to 2 hours). Spanning the Flow Based parameters over a too long period would also lead to unrealistic results.
- Second, in case of impossibility to span the missing parameters, CWE TSOs will deploy the computation of “Fallback Flow Based parameters”. Their principles are described below in this paragraph.

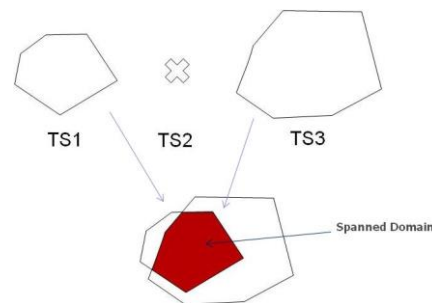
The sketch below will synthesise the general approach followed by CWE TSOs:



Spanning methodology

When Flow Based parameters are missing for less than 3 hours, it is possible to compute spanned Flow Based parameters with an acceptable level of risk, before using Fallback Flow Based parameters. The spanning process is based on an intersection of previous and sub-sequent available Flow Based domains, after adjustment to 0 balance (to delete impact of reference program). At the end of the intersection process pre-calculated spanning margins are added.

Intersection Step: For each TSO, the active CBs from the previous and sub-sequent timestamps are compared and the most constraining ones are taken into consideration (intersection).

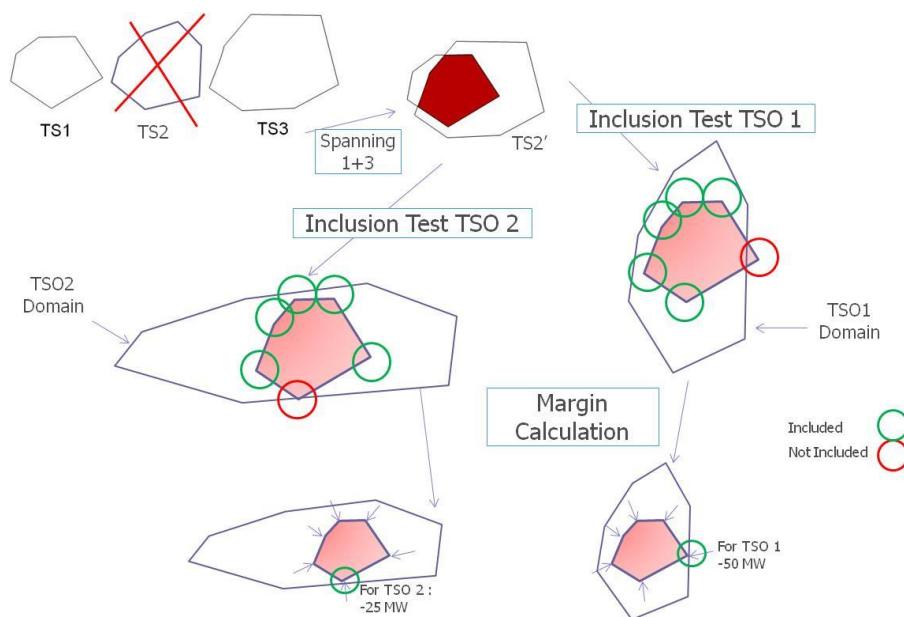


Spanning Margin calculation Step: The aim of this step is to define the spanning margin needed for each TSO to ensure the SoS in case that spanning is applied. This spanning margin is updated every day, after final Flow Based parameters calculation, based on a simulation of 'what could have been the spanned Flow Based parameters', compared to real Flow Based parameters (statistical analysis). To reduce the margin impact on the result, this process is performed per TSO (in this way, results of TSOs with Flow Based parameters that are more fluctuating from one hour to the other are not impacted by results of TSOs with more stable Flow Based parameters).

During this simulation, a raw spanned Flow Based domain is calculated, and a check is done to know if each vertex of the spanned domain is included in the real TSO Flow Based domain (inclusion test):

- If the spanning vertex is inside the original Flow Based domain, no extra margin is needed to ensure the SoS for this TSO.
 - If the vertex is outside, an extra margin would have been necessary to keep the SoS. The size of this extra margin is calculated and stored.
- ⇒ After the full inclusion test, a new reference margin is defined as the maximum of all extra margins from the step before (for each TSO and each time stamp).

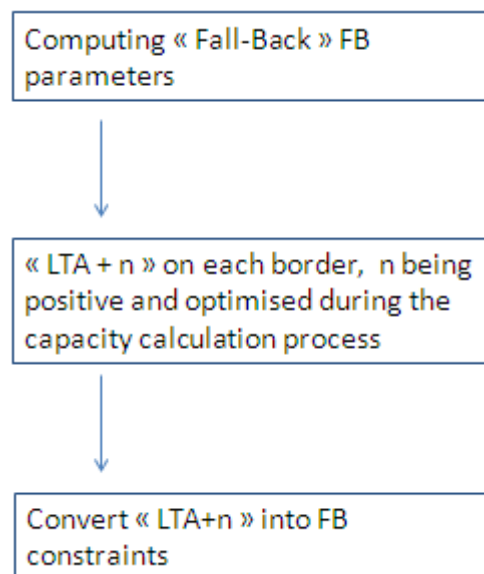
This reference margin is then added to the distribution of the already calculated reference margins from the past (for each time stamp and each TSO), in order to update (with a 90% percentile formula) the new spanning margin.



Fallback Flow Based parameters

When Flow Based parameters are missing for more than 3 hours, CWE have to recompute them in a straightforward way. Indeed, they could be in a downgraded situation where fundamental inputs and/or tooling are missing. For these reasons, CWE TSO will base the Fallback FBParam on existing Long Term bilateral capacities. These capacities can indeed be converted easily into Flow Based external constraints (i.e. import or export limits c.f. chapter 4.1.9 for more details), via a simple linear operation. In order to optimize the capacities provided in this case to the allocation system, CWE TSOs will adjust the long term capacities during the capacity calculation process. Eventually, delivered capacities will be equal to "LT rights + n" for each border, transformed into Flow Based constraints, "n" being positive or null and computed during the capacity calculation process. CWE TSOs, for obvious reasons of security of supply, cannot commit to any value for "n" at this stage.

Principles are summarized in the sketch below:



One can note that in all cases, CWE TSOs commit to deliver Flow Based constraints over the entire day to the Market Coupling system.

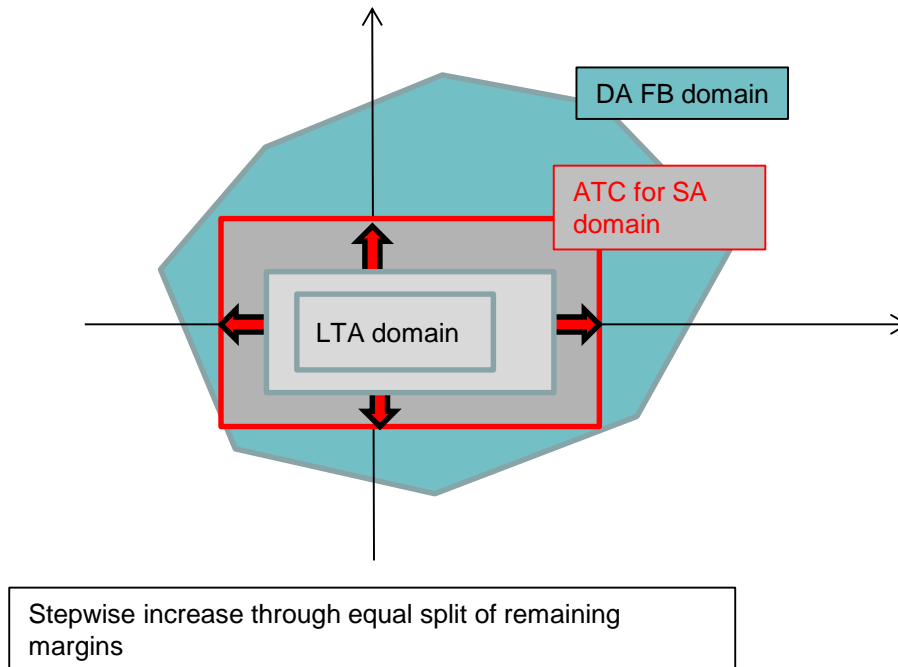
4.7. ATC for Shadow Auctions

Introduction: In case of a decoupling in CWE, the philosophy remains the same as in ATC Market Coupling, explicit shadow auctions (SA) will be organized.

With the TSO CS daily running, 24 Flow Based domains are determined as an input for the FB MC algorithm. In case the latter system fails, the 24 Flow Based domains will serve as the basis for the determination of the SA ATCs that are input to the Shadow Auctions. In other words: there will not be any additional and independent stage of ATC capacity calculation.

As the selection of a set of ATCs from the Flow Based domain leads to an infinite set of choices, an algorithm has been designed that determines the ATC values in a systematic way. The algorithm applied for the determination of the SA ATCs is the same as the algorithm applied to compute the ID ATCs after the FB MC, though the starting point of the computation is a different one. Indeed, the iterative procedure to determine the SA ATC starts from the LTA domain ²⁰as shown in the graph below.

²⁰ Keep in mind that that the LTA domain will systematically be included in the FB one, as explained in chapter 4.2.6.



Input data:

Despite the two days per year with a long-clock change, there are 24 timestamps per day. The following input data is required for each timestamp:

- LTA
- presolved Flow Based parameters that were intended to be sent to the PXs

Output data:

The calculation leads to the following outputs for each timestamp:

- SA ATC
- number of iterations that were needed for the SA ATC computation
- branches with zero margin after the SA ATC calculation

Algorithm:

The SA ATC calculation is an iterative procedure.

Starting point: First, the remaining available margins (RAM) of the presolved CBs have to be adjusted to take into account the starting point of the iteration.

From the presolved zone-to-hub PTDFs ($PTDF_{z2h}$), one computes zone-to-zone PTDFs ($pPTDF_{z2z}$)²¹, where only the positive numbers are stored:

$$pPTDF_{z2z}(A > B) = \max(0, PTDF_{z2h}(A) - PTDF_{z2h}(B))$$

with $A, B = DE, FR, NL, BE$ at the moment. Only zone-to-zone PTDFs of neighboring market area pairs are needed (e.g. $pPTDF_{z2z}(DE > BE)$ will not be used).

The iterative procedure to determine the SA ATC starts from the LTA domain. As such, with the impact of the LTN already reflected in the RAMs, the RAMs need to be adjusted in the following way:

$$RAM = RAM - pPTDF_{z2z} * (LTA - LTN)$$

Iteration: The iterative method applied to compute the SA ATCs in short comes down to the following actions for each iteration step i :

For each CB, share the remaining margin between the CWE internal borders that are positively influenced with equal shares.

From those shares of margin, maximum bilateral exchanges are computed by dividing each share by the positive zone-to-zone PTDF.

²¹ Negative PTDFs would relieve CBs, which cannot be anticipated for the SA capacity calculation.

The bilateral exchanges are updated by adding the minimum values obtained over all CBs.

Update the margins on the CBs using new bilateral exchanges from step 3 and go back to step 1.

This iteration continues until the maximum value over all Critical Branches of the absolute difference between the margin of computational step $i+1$ and step i is smaller than a stop criterion.

The resulting SA ATCs get the values that have been determined for the maximum CWE internal bilateral exchanges obtained during the iteration and after rounding down to integer values.

After algorithm execution, there are some Critical Branches with no remaining available margin left. These are the limiting elements of the SA ATC computation.

The computation of the SA ATC domain can be precisely described with the following pseudo-code:

```
While max(abs(margin(i+1) - margin(i))) > StopCriterionSAATC
    For each CB
        For each non-zero entry in pPTDF_z2z Matrix
            IncrMaxBilExchange = margin(i)/NbShares/pPTDF_z2z
            MaxBilExchange = MaxBilExchange + IncrMaxBilExchange
        End for
    End for
    For each ContractPath
        MaxBilExchange = min(MaxBilExchanges)
```

```
End for
For each CB
    margin(i+1) = margin(i) - pPTDF_z2z * Max-
BilExchange
End for
End While
SA_ATCs = Integer(MaxBilExchanges)
```

Configurable parameters:

StopCriterionSAATC (stop criterion); recommended value is 1.e-3.

NbShares (number of CWE internal commercial borders); current value is 4.

5 The CWE Market Coupling Solution / Daily schedule

This chapter describes the CWE Market Coupling Solution, embedded in and as part of the NWE Price Coupling Solution.

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

- Terminology
- The operational procedures and the roles of the Parties

The high level functional architecture can be found in annex 16.7.

5.1. Definitions related to MC Operation

Normal Procedure: procedure describing the actions to be taken by Agents to operate the CWE FB Market Coupling when no problem occurs.

Backup Procedure: procedure describing the actions to be taken by Agents in order to operate the CWE FB Market Coupling when a problem occurs (when for any reason, the information cannot be produced/exchanged or if a validation fails before the target time, or if it is known or may reasonably be expected that this will not happen before target time).

Fallback Procedure: procedure describing the actions to be taken by Agents in case the information cannot be produced/exchanged either by Normal or Backup Procedure or if a check fails before the Partial/Full Decoupling deadline, or if it is known that this will not happen before the Partial/Full Decoupling deadline.

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

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 backup exists, the Backup procedure is triggered.

Partial/Full Decoupling deadline: latest moment in time to complete some procedure in Normal or Backup mode. If an incident that does not allow applying Normal or Backup procedure (if any) occurs before this time, Fallback procedure is triggered.

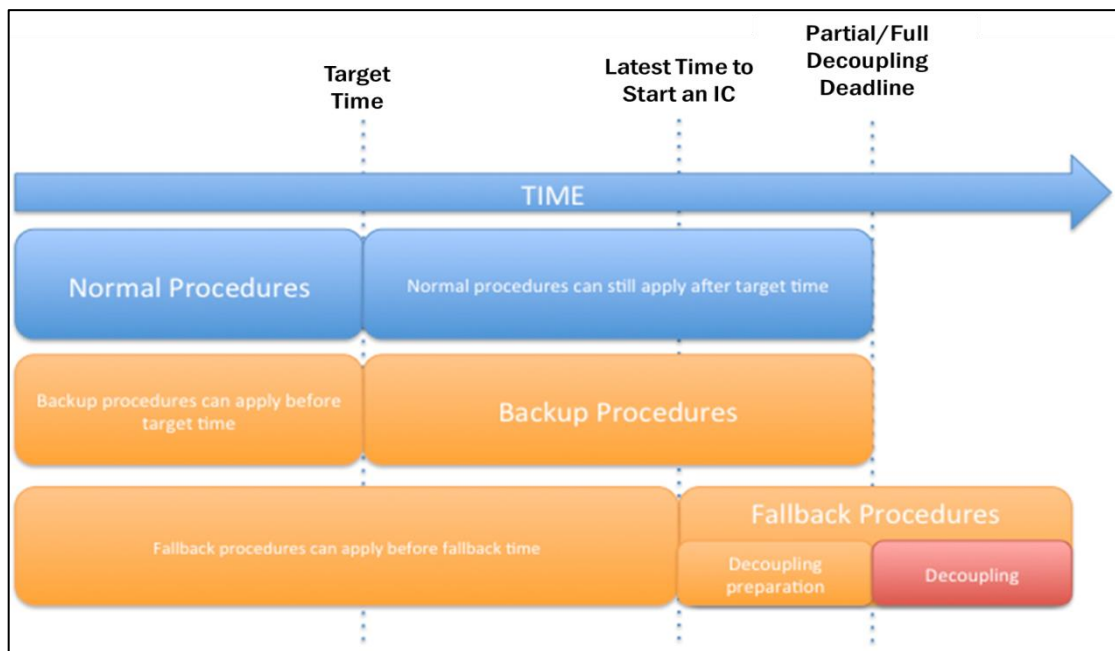


Figure 5-1: Interrelationship between Normal procedures, Backup, and Fallback.

5.2. High Level Architecture

The High Level Architecture is described in the final regulatory report of the NWE Day-Ahead Market Coupling Project (§3.1 resp. 3.7 of NWE Day-Ahead Market Coupling Project, Final Regulatory Report), which has been sent for approval to the NWE National Regulatory Authorities.

This High Level Architecture does not change due to the introduction of Flow Based, but for completeness of the provided information, the above mentioned chapters of the NWE approval package are attached to this document (c.f. annex 16.7).

5.3. 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 Backup 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, Special and Fallback Procedures. In this paragraph we describe them on a high level²².

The following procedures are specific for the local CWE FB MC solution and are not part of the NWE-documentation and approval request.

²² Please refer to annex 16.8 for detailed procedures (to be provided later).

5.3.1. Phase 1: provision of the Cross Zonal Capacities and Allocation Constraints by the TSOs

Phase 1 starts with the sending of the Cross Zonal Capacities and Allocation Constraints to the PX Pre Coupling Module by the CWE TSO Common System and ends when the Cross Zonal Capacities and Allocation Constraints are successfully received by the PXs Pre-Coupling Module.

NOR_1: Cross Zonal Capacities and Allocation Constraints	This procedure describes the first phase of the business process dedicated to the sending of the Cross Zonal Capacities and Allocation Constraints by TSOs and their reception by PXs.
BUP_1: Cross Zonal Capacities and Allocation Constraints	Description of the actions to be performed by the operator in case the normal process described in NOR_1 does not work.

5.3.2. Phase 2: Final Confirmation of the Results

Phase 2 starts with the sending of the Price Coupling Results for the final confirmation to the CWE TSO Common System. This phase ends with the reception of the Global Final Confirmation of the results by the CWE TSO Common System. Hereby, the Price Coupling Results become firm.

NOR_2: Final Confirmation of the Results by the CWE TSO CS	This procedure describes the second phase of the business process dedicated to verify and validate the price coupling results in a normal mode.
BUP_2: Final Confirmation of	Description of the actions to be per-

the Results by the CWE TSO CS	formed by the operator in case the normal process described in NOR_2 does not work.
-------------------------------	---

In case of a negative Global Final Confirmation, an Incident Committee will be triggered according to CWE_FAL_01. For a detailed description of the Fallback mechanism we refer to chapter 0.

5.3.3. Phase 3.1: Price Coupling Results and Scheduled Exchanges

This phase starts with the sending of Price Coupling Results by the CWE TSO Common System (Verification Module) to the CWE TSO Common System (Post Coupling Module). Then, the CWE TSO Common System (Post Coupling Module) will calculate the Scheduled Exchanges (c.f. chapter 12) and send them to the Cross-PX Clearing and Settlement System, the local TSOs and to the Congestion Revenue Distribution System (CRDS). This phase ends with the sending of NWE net positions and Prices from the Cross PX Clearing and Settlement System to the Congestion Revenue Distribution Systems.

NOR_3: Price Coupling Results and Scheduled Exchanges	This procedure describes the first part of the third phase of the business process regarding the steps that have to be performed in a normal mode.
BUP_3: Price Coupling Results and Scheduled Exchanges	Description of the actions to be performed by the operator in case the normal process described in NOR_3 does not work.

5.3.4. Phase 3.2: Trading Confirmation, Scheduled exchanges notification and Congestion Income

This phase starts with the sending of the Trading Confirmation from the Cross PX Clearing and Settlement System to the CCP Shipping System. It ends with the sending of the Scheduled Exchanges Notification from the CCP Shipping System to the TSO Back-End Systems.

NOR_4: Trading Confirmation, Scheduled exchanges notification and Congestion Income	This procedure describes the second part of the third phase of the business process regarding the steps that have to be performed in a normal mode
BUP_4: Trading Confirmation, Scheduled exchanges notification and Congestion Income	Description of the actions to be performed by the operator in case the normal process described in NOR_4 does not work.

5.3.5. Other Procedures

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

Other Procedures	Documents describing various actions to be performed by the PX operator under certain conditions which are not back up or Fallback actions
ROB_01: Organization of the Rollback	Description of the actions to be performed by all concerned parties in case of a failure of the Market Coupling session after its launch

SPE_01 CWE Second Auction	Description of modified timeframe and actions to be performed by the PX operator in case of special or exceptional circumstances leading to a second auction
OTH_01 Glossary	Description of used terminology and abbreviations in order to facilitate the reading of procedures
OTH_02 Internal and External Communications	Description of messages that need to be sent in order to provide an official communication during some particular market situations or technical incidents
OTH_04 CWE Market Operator Tasks and Rotational Scheme	Description of the actions to be performed by CWE Market Operator in case of a switch of the CWE PMB Operator
OTH_05 Change control procedure	Description of the process to follow by all parties in case of change in one of the systems
OTH_06 CWE Publications	Description of the different publications and associated timings

5.3.6. Fallback procedures

Fallback procedures are applicable as soon as an incident occurs that prevents the timely allocation of the CZCs via the implicit allocation process and/or the timely publication of the Market Coupling Results. In this case an Incident Committee is convened where the issue is assessed and in case necessary, potential Fallback solutions will be assessed and agreed upon.

Fallback Procedures	Documents describing the actions that should be performed by the PX operator under Fallback conditions.
FAL_01 Incident Management	Description of the initiation of the Incident Committee and the way discussions should be handled.
FAL_02 Full Decoupling	Description of the actions to be initiated by the operator in case Full Decoupling is declared by the Incident Committee.
FAL_03 Partial Decoupling	Description of the actions to be initiated by the operator in case Partial Decoupling is declared by the Incident Committee.

6 Fallback arrangement for Market Coupling (capacity allocation)

This chapter presents the description of the proposed CWE MC Fallback arrangement in case of a problem in the coupling process once the capacities (Flow Based parameters) have been received by PXs.

The change from ATC to Flow Based does not change the shadow auctions principles as MC Fallback. Regarding the Flow Based capacity calculation Fallback solution, please refer to chapter 4.6.

The Fallback arrangement is described in following sections:

- Fallback situations
- Fallback solutions
- Principle of the Fallback arrangement
- Description of explicit PTRs allocation
- Bids
- Database tool
- Sequence of operations
- Matching and price determination rules

6.1. Fallback situations

A Fallback situation occurs when the NWE price coupling has not given price coupling results at the time limit to trigger the Fallback. The Fallback solution for the CWE Region is described in the Fallback HLFAs of the approved NWE Price Coupling Solution documentation (§9.1 of NWE Day-Ahead Market Coupling Project, Final Regulatory Report), c.f. annex 16.9.

The following paragraphs summarize the most important characteristics related to Fallback from the perspective of Market Parties, operating in the CWE region.

The Fallback 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 (see 5.3, operational procedures). In other words, the Fallback is pronounced if no Market Coupling result can be calculated and validated before the Partial/Full Decoupling deadline of phase 2. For instance:

- some market data may not be generated,
- the algorithm, or the system on which it runs may fail,
- technical validations may return a “non-compliant” result.

One can note that in all cases, CWE TSOs commit to deliver Flow Based Parameters over the entire day to the Market Coupling system.

6.2. Fallback solutions

The Incident Committee will assess and agree on the potential Fallback solution which can be either PCR partial or full decoupling according to the observed incidents and deadlines.

A Partial Decoupling is a situation where it is not possible, for a specific day, to allocate the capacities via the implicit allocation for one or several areas and/or interconnectors before the relevant Partial Decoupling Deadline. After the Partial Decoupling declaration by the Incident Committee, the process will be followed through the NWE Normal procedures, even though the timings are delayed accordingly for the remaining coupled areas and/or interconnectors. For the decoupled areas and/or interconnectors the Local procedures are followed accordingly. If, at the regular publication time, Market Coupling Results have not been published, a PCR external communication message informs Market Parties about a delay in the pro-

cess and the risk of Full Decoupling. In case the Full Decoupling has been declared by the Incident Committee, PXs and TSOs will apply their local procedures for running the local explicit auctions. The Fallback solution for CWE internal borders is shadow explicit auctions via CASC, described in the next paragraphs.

A Full Decoupling known in advance can only be declared in case the previous Market Coupling Session has resulted in a Full Decoupling and the corresponding critical issue could not be solved until the target time for publishing the CZCs.

6.3. Principle of the CWE Fallback Arrangement

The principle of the proposed Fallback arrangement is to allocate the ATCs for shadow auctions derived from Flow Based parameters via a "shadow explicit auction" and a Partial/Full Decoupling of the PXs. This means isolated local auctions 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 (Fallback participants) may submit, amend or withdraw, bids for capacity. During normal operation, these bids are not used;
- should a Fallback situation be declared on a particular day in case of an incident during the daily session, the Shadow Auction System Operator (CASC) performs a Shadow Auction to allocate the Available Transmission Capacities based on the available valid bids; from the time of running the Fallback auction, the participants are not allowed to update their bids for the upcoming shadow auction.
- should a Fallback 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 Shadow Auction System Operator (CASC); the Shadow Auction System Operator (CASC) performs a Shadow Auction to allocate the available transmission capacities.

For the High-level Fallback Architecture, please refer to annex 16.9. The publication of Shadow Auction ATCs is described in chapter 10.

6.4. Description of explicit PTRs allocation

The Shadow Auction allocates Physical Transmission Rights (PTRs) for each oriented country border and for each hour of the day. Using the ATC, provided by TSOs, and the auction bids from the Shadow Auction System, the Shadow Auction System calculates 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 Fallback participants (UIOLI) if they are not nominated.

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

6.5. Bids

6.5.1. Content

A bid entered in the Shadow Auction System 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 capacity.

Bids inserted by the participants in the Shadow Auction System are unconditional and irrevocable once the Fallback mode has been declared in case of an unforeseen unavailability of the CWE FB MC or according to the new time schedule communicated in advance if an unavailability of the CWE FB 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 has 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.

6.5.2. Ticks and currency

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

6.6. Shadow Auction System tool and bid submitters

The Shadow Auction System enables participants to submit bids, according to the conditions set out in the documentation available on the Shadow Auction System Operator's (CASC) website. In par-

ticular, bids must be submitted in accordance with the formats defined in the relevant documentation.

6.7. Sequence of operations

The sequence of operations is applicable after a decision to resort to Fallback after the Partial/Full Decoupling deadline or in case a Fallback situation is announced in advance at 10:30. The process and contractual basis remains the same as under CWE ATC MC.

1. At any time, Market Parties are invited to register by means of entering into an agreement with the Shadow Auction System Operator (CASC) through the Rules for Capacity Allocation by Explicit Auctions within CWE Region. From then on, they become "Fallback participants".
2. At any time, Market Parties are invited to register by means of entering into an agreement with the TSOs for the nomination part (meaning that the Market Parties should sign a nomination contract or designate their nomination responsible according to each country's regulation).
3. Fallback participants are allowed to enter bids into the Shadow Auction System and amend or withdraw them.
4. TSOs provide the Shadow Auction System Operator (CASC) with ATCs.
5. Should a Fallback situation be declared, Market Parties will be informed and can update their bids according to the new time schedule communicated
6. The Shadow Auction System Operator (CASC) then performs the Shadow Auction: it determines the PTRs allocated to each Fallback participant and the corresponding programming authorizations.

7. The Shadow Auction System Operator (CASC) provides each Fallback participant with the results and prices resulting from the auction.
8. The Shadow Auction System Operator (CASC) provides each TSO/Fallback participant with all programming authorizations.
9. The Shadow Auction System Operator (CASC) publishes transparency data, as defined in chapter 10.4.
10. PX participants are allowed to change their position in the PX order books in function of the Fallback situation. The PXs then match and publish their results separately.
11. Fallback participants submit their nominations to TSOs according to the existing local processes.

6.8. Matching and price determination rules

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

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

5. If the capacity requested under the next highest bid price is equal to or greater than the residual available capacity, the bid is selected either in full, or partially up to the limit of the residual available capacity. The price of this bid constitutes the marginal price.

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

6.9. Daily schedule

A Fallback situation may be declared at any time before publication of FB 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 Fallback is triggered at the MC results publication deadline.

In the worst case, i.e. when the Fallback situation is declared at 13:50, the underlying hypotheses are:

- The delay between publication of the local PX market results and cross-border nominations is at least 45 minutes.
- 20 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 deadlines of the day ahead processes (e.g. ENTSO-E, Intra-day capacity calculation, margins calculation)

6.10. Opening hours

The access to the Shadow Auction System is open 24h a day and 365 days a year, except for system maintenance periods, announced by the Shadow Auction System Operator (CASC) generally 15 days in advance. In exceptional circumstances this notice may be shorter.

7 Rollback to solution existing prior to Flow Based Go Live

The launch of Flow Based Market Coupling (FB MC) is a major change including the introduction of new and/or adapted systems and new operational procedures; it is also a major change for the market. Even when tested thoroughly, there is still a risk of failure when switching from the ATC based systems to FB MC on the launch day itself as well as during the first period after the launch.

It is also possible that Flow Based results in unexpected and unacceptable market outcomes which were not detected during the external parallel run.

In order to mitigate this risk, the Project Partners will keep possible Rollback options as a Backup available for two months after launch of the Flow Based Market Coupling. The project keeps however the possibility to decide at the end of the Rollback period if two additional months are needed. The next paragraphs describe the Rollback solutions. They are devoted to:

- Rollback process
- Rollback solution

7.1. Rollback process

The decision to roll back from the FB MC to ATC based MC, will be a CWE Joint Steering Committee decision.

After such a decision of the CWE Joint Steering Committee, the Parties need at least 3 working days for the technical aspects of the Rollback, i.e. reinstall the Rollback systems, test the connections and run a couple of test scenarios. Parties have prepared procedures and checklists for such a Rollback situation before the launch

of FB MC and will make sure that the procedures are known internally.

7.2. Interim steps towards Rollback activation

During the interim period necessary to install the Rollback and according to the origin of the issue causing the Rollback decision, different solutions can be considered:

- In case the issue is on the TSO CS side: TSOs can still provide Flow Based parameters via a Backup tool. In this case, Flow Based parameters will not be computed as usual but “Fallback Flow Based parameters” will be used as it is the case in Backup mode. In this situation, FB MC will be continued as long as the issue in the TSO CS can be fixed within a reasonable number of days or until the ATC version of the CS has been reinstalled and Rollback to ATC MC can indeed be activated.
- In case the issue is on the Market Coupling side: TSOs can send ATC values to PXs which are derived from the Flow Based domain and initially calculated for Shadow Auction purposes. Market Parties will be informed that the coupling for the concerned day(s) will be performed with ATCs for Shadow Auctions instead of Flow Based parameters.

This interim process will be kept until all Rollback systems have been reinstalled and are operational for Market Coupling with “fully calculated ATC values” (3 working days).

All necessary information will be given to the Market Parties regarding the practical modalities of the Rollback, in particular, its potential duration, the time schedule of the explicit auctions etc.

7.3. Rollback solutions

In case a Rollback situation occurs, CWE parties will roll back to the solution used before the go-live of CWE FB MC, means ATC MC:

- CWE TSOs will roll back to the ATC based version of the TSO Common System
- CWE TSOs will roll back to the ATC processes and/or Back-end systems
- PX will still use the PMB as Market Coupling system
- PMB configuration will be switched to ATC mode
- Trading system interfaces will remain unchanged

All interfaces between TSOs, between PXs, and between TSOs and PXs will be re-established in case of Rollback.

The Rollback will continue to function until the re-launch of FB MC which is decided by the CWE Joint Steering Committee.

7.4. Possible reversion to ATC after the Rollback period

Flow Based Market Coupling is a major change for the market. While every effort is being made to ensure that the solution promotes efficient markets and optimal capacity utilisation and price formation, it will be important to monitor this and to review it with Market Parties (c.f. chapter 10.6). If unacceptable market outcomes emerge, and if other remedies are not immediately effective, it may be necessary to revert to ATCs until the issues can be resolved. In any case, such a decision needs to be made after regulatory dialogue and acceptance of all JSC members. .

For the avoidance of doubt, Project Partners commit to undertake any reasonable measures in order to mitigate any problems that may arise.

8 Requirements for and functioning of the Market Coupling algorithm

The introduction of Flow Based does not change the requirements for the Market Coupling algorithm (Euphemia). All details concerning the algorithm (except the intuitiveness constraint) can be found on NWE PXs' websites. Formal approval for using this specific and specified algorithm has been part of the approval of the NWE day-ahead MC project.

Intuitiveness constraint

Since the principle objective of the Market Coupling is to provide (day-ahead market) welfare maximizing solutions, such solutions need to fulfil optimality conditions. One can prove that under certain circumstances such optimal solutions exchange energy from high priced areas to low priced areas, i.e. the solution can be non-intuitive. This can be simply accepted and we label such a solution as "plain Flow Based solution".

However, from other perspectives, non-intuitive results may represent an unbalanced distribution of costs and benefits between markets, or even a perverse market. Consequently, in order to cope with the eventuality that such non-intuitive solutions may be determined to not be acceptable, the algorithm has an option to suppress non-intuitive solutions. More precisely when the "intuitive patch" is activated solutions should now fulfil an additional constraint:

For a solution that consists of net positions and market prices per bidding area a decomposition of the net positions into exchanges (following a pre-specified topology) should exist such that all exchanges are from a low priced area to a high priced area.

9 Economic Assessment

9.1. Results of the 2013 external parallel run

The economic impact of FB MC compared to ATC MC on market and prices was initially demonstrated in the feasibility report.

Based on the first year of the external parallel run an extensive study of the impact of FB(I) MC has been performed (annex 16.10). The study shows an approximate day-ahead market welfare increase of 79M€ (307 days simulated of 365) for 2013 with an average daily gain of 257 K€. Therefore a social welfare increase for the region of nearly 95M Euro on an annual basis can be expected (based on extrapolated results of the average daily welfare increase, during the external parallel run from January to December 2013).

The parallel run also showed some increases in price volatility and a limited correlation with prices under ATC Market Coupling, especially in the smaller markets.

Simulations comparing ATC, FB MC and FBI MC in 2013 gave furthermore the following results:

- Day-Ahead Market Welfare and Convergence indicators are significantly better with FB MC or FBI MC than with ATC MC.
- Non-intuitive situations were found. Enforcing intuitiveness through FBI MC deteriorates only very slightly the indicators. Moreover, non-intuitive situations represent a minor proportion of the analysed cases.

Notwithstanding the limitations mentioned in chapter 1.2.2 of the study in annex 16.10, the market impact analysis concludes that FB MC and FBI MC have a positive impact on welfare, compared to ATC MC.

It is premature to draw conclusions for 2014 as only results for Q1 2014 are currently available, which quarter made the transition to the NWE MC and the daily parallel run²³.

So far we observed that the average daily welfare increase compared to ATC was 26k€ which seems a tenfold decrease compared to the 2013 results. These effects mainly stem from a limited amount of days where the FB domain was smaller than the ATC domain. Pending more definitive explanations why this happened it would be unwise to extrapolate trends on this quarter and also because of the NWE go-live beginning of February that changed the welfare scope.

The number of non-intuitive situations also appears to have come down. Again because of the limited amount of data for now we cannot conclude this is a chance effect, or could be linked to systemic changes (e.g. start of NWE market coupling).

Finally the number of hours with full CWE price convergence did increase under FB MC, so this statistic remained on par with the 2013 result.

9.2. Sensitivity i.e. domain reduction study

The domain reduction study aims at providing some insights into the sensitivity of the market results to different FB parameters. The

²³ Please note that recent information will be available within the parallel run publications on CASC's website.

margin reduction is a simple tool to model impact, although it lacks a link with physical reality.

- The objective of this study was to answer what impact changes to the FB domain have on market results. A series of trivial qualitative results could be obtained by simple reasoning and was confirmed in our study: The level of price convergence increases with additional margin;
- The day-ahead market welfare increases with additional margin; We tried to quantify the impact.

Impact on price

The annual average prices are little affected by the margin reductions. However once the isolated case is being approached the effects, especially for BE become more noticeable (e.g. for BE the average price under FB is € 44.44, but this would increase to € 57.83 when margins are reduced to only 10% of the current level. When margin is reduced to 90% of the current level the BE would increase to € 44.92).

Impact on welfare

The difference in welfare between the 100% scenario and the infinite scenario is 383k€ average per day. This suggests that under the current market conditions welfare could be further increased with additional margin.

When we consider the relative increase in welfare (distance from isolated scenario over distance between infinite scenario and isolated scenario) we observe that 90.3% of the welfare potential is realized. This would increase to 92.8% when margin is increased to 110%, or drop to 87.03% when margin is decreased to 90%.

There are limitations too: diminishing return to scales: each subsequent increase in margin will increase welfare by less than it increased by earlier margin increases. This means that increasing margin from 10% to 20% raises average daily welfare by 470k€, whereas increasing margin from 20% to 30% only raises welfare an additional 380k€. The increase from 90% to 100% only added 119k€ and from 100% to 110% 93k€. Realizing the full remaining welfare potential with the infinite scenario would likely require vast increases in margin.

Overall

Comparing the results from this study with the results from ATC, it appears that as long as margins are at least 90% of their current values the FB methodology still outperforms the ATC approach, both in terms of welfare and price convergence.

The domain reduction study can be found in Annex 16.11.

9.3. Decision on Intuitiveness

Buying at low(er) prices and selling at high(er) prices is an intuitive fundamental for all kinds of trading and business activities. However, for maximising total day-ahead market welfare under FB MC, it can happen that there is an exchange from a higher price area to a lower price area, which is non-intuitive.

Related to FB MC, a situation (a combination of market clearing prices and Net Export Positions) is said to be (bilateral-)intuitive, if there exists at least one set of bilateral exchanges that satisfies the following property: "exchanges on each interconnector occur from the low price area to the high price area".

In October 2013 the Project Partners published an update of the CWE Enhanced Flow Based MC Intuitiveness Report to explain all

details related to intuitiveness. This version of this Intuitiveness Report is annexed to this approval document (c.f. Annex 16.12).

The economic assessment for the complete year 2013 of external parallel run indicates

421 non intuitive hours (5,7% of all hours and 8,2% of the congested hours).

The main outcome of the project’s assessment whether to go-live with plain or intuitive CWE Flow Based market coupling is presented in the following overview, assessing the differences between FB and FBI against a set of criteria.

The exhaustive study can be found in Annex 16.13.

Criterion	In favour of FB “plain”	In favour of FB “intuitive”
Volatility	inconclusive	
Price Signal	Negligible difference	
Liquidity	resilience analysis: inconclusive	
Welfare (global)	Unknown	Unknown
Welfare (DAMW)	X (though relatively small)	
Welfare repartition	No statistically significant difference	
ID	X (considering DA capacity should not be allocated to ID)	X (considering ID capacity is higher; mitigates DA welfare loss)
Investment	inconclusive	
SoS	inconclusive	
Communication to general public	Arguments against either alternative exist	

Based on the inconclusive outcome of the study, the Project is not yet in a position to make a recommendation whether to start with FB or FBI. The outcome of the public consultation will hopefully bring additional guidance for the decision.

Regardless of the decision made, the Project will monitor the other option and keep the possibility to reassess the decision after go-live.

10 Publication of data

This paragraph describes how the Project aims to provide the necessary data towards Market Parties of the CWE Flow Based Market Coupling, in order to facilitate the market and to comply with EU-legislation.

The issue of data publication (transparency) has been a key issue in the responses of the first public consultation in May-June 2013 (c.f. annex16.14). The results have been discussed with the CWE NRAs in expert meetings afterwards. Additionally there have been exchanges with MPs about transparency needs in Flow Based User Group meetings and Market Fora. To keep business secrets and confidentiality, the Project furthermore had bilateral discussions with some MPs to better understand processes and data needs on MPs' side.

As a result, an approach for data-supply and transparency, which covers the main needs of MPs is available for go-live.

For monitoring purposes the National Regulatory Authorities get additional (confidential) data and information (further described in chapter 11). Based on national and EU-legislation, on reasonable request from the NRAs, the Project will provide all Project related data for monitoring purposes. Publications of monitored information can be commonly agreed from case to case.

10.1.Relation to EU Regulations

Transparency obligations related to congestion management are currently mainly regulated by Regulation (EC) No 714/2009 and its Annex 1 § 5, but will soon be largely replaced by the Commission Regulation on submission and publication of data in electricity markets and amending Annex I to Regulation (EC) No 714/2009 of the

European Parliament and of the Council (entered into force in June 2013).

After the entry into force of transparency regulation 543/2013, points 5.5 to 5.9 of the annex to the EC Regulation 714/2009 (also known as Congestion Management Guidelines) remain valid for transparency obligations until 5th January, 2015. The transparency regulation and the abovementioned paragraphs of these CM-Guidelines oblige TSOs to publish a broad variety of data related to congestion management in general, and implicit FB MC in specific. Specifically for Flow Based, the transparency regulation foresees in its article 11 §1 that TSOs, for their control areas or, if applicable, transmission capacity allocators, shall calculate and provide the following information to the ENTSO for Electricity sufficiently in advance of the allocation process:

"b) The relevant flow based parameters in case of flow based capacity allocation".

Next, for transparency issues, there is the EC Regulation 1227/2011 on wholesale energy market integrity and transparency (REMIT) and the competition law, the Project has to comply with. To the opinion of the Project Partners, it is the responsibility of the individual PXs and TSOs to fulfil the requirements of all EU-regulations.

In this chapter we especially present the data which will facilitate the Market Parties in their bidding behaviour, as far as it concerns data produced by the common MC system and commonly published by the Project Partners.

10.2. General information to be published

The following general information is already covered within this document and will be updated and published when needed:

- Description of the coordinated Flow Based capacity calculation methodology,
- High-level business process of Flow Based capacity calculation
- A description of the CWE FB MC solution,
- Fallback arrangements in case of decoupling,
- Rollback arrangements.

Furthermore, a description of the market coupling algorithm Euphemia is published by the NWE Project²⁴. -

10.3. Daily publication of Flow Based Market Coupling data

It is the obligation of ENTSO-E to publish relevant data related to the cross border exchanges on the ENTSO-E platform. TSOs can mandate a third party, like CASC, to deliver the data on their behalf to the ENTSO-E Transparency platform. For the time being, the Project Partners have decided to provide easily accessible data as set out in the next two subsections on common websites (www.CASC.eu and www.Europeanpricecoupling.eu).

10.3.1. Daily publication of data before GCT

Initial Flow-Based parameters (without LT-nominations)

Based on requests from MPs' side, the Project provides for information and analysing purposes initial Flow-Based parameters at D-1 (8:00 target time) with random anonymized CBCOs.

²⁴ This information is published on PXs' websites of the NWE region.

For this set of FB-parameters all long term nominations at all CWE-borders are assumed as zero (LT-noms=0).

The technical provision is similar to the below mentioned, via the Utility Tool.

Final Flow-Based parameters

The TSOs will publish for each hour of the following day the Flow-Based parameters i.e. the random, anonymized Critical Branches, Power Transfer Distribution Factors (PTDFs) and the Remaining Available Margin (RAM) on Critical Branches. This publication shall comply with the obligations of Art. 11 (1b) of the transparency regulation.

The Flow Based parameters will be available at D-1 (10:30 CET – target time) via the Utility Tool, daily fed with new input data of the next day from the CASC website. The Utility Tool can be downloaded from CASC website.

The look and main features of the Utility Tool are presented in Annex 16.15.

Content	Where/ Who	When	Unit
Anonymized Critical Branches (CBs)	CASC/ ENTSO-E	D-1 (10:30 CET)	Anonymized names
PTDFs	CASC/ ENTSO-E	D-1 (10:30 CET)	-
RAMs	CASC/ ENTSO-E	D-1 (10:30 CET)	MW

Final Shadow Auction ATCs

The final Shadow Auction ATCs (border and direction) per market time unit will be published at D-1 (10:30 CET – target time) together with the FB parameters. The form of publication can be found in Annex 16.16.

10.3.2. Publication of data after Market Coupling calculation

The Project will comply with the respective obligations of Art. 12 (a) & (e) of the transparency Regulation.

Additionally, in the framework of separate CWE FB MC publications, the following data is published:

On CASC Website:

- Capacity allocated (being defined as the sum of the used margins on the tie-lines of a bidding zone border)
- The total congestion income in the CWE area

On Europeanpricecoupling.eu Website:

- Scheduled Bilateral Exchanges
- Indication of economic capacity value, given by the price difference between two hubs in implicit allocation schemes

In addition to the data above, it is the aim of the Project Partners to publish the following data:

- PX market prices: the market prices for each market time unit of the day will be published on daily basis on the common CWE website (Europeanpricecoupling.eu) and by the individual PXs for their hub.
- Aggregated supply and demand curves for each market time unit of the day will be published by the individual PX for their hub.

These data will be published after Flow Based allocation for each market time unit (presently an hour) of the day.

The standard timing for publication of these data is one hour after the capacity allocation (Target time for publication: 14:00 CET). Of course deviations are possible in case of exceptional circumstances or re-opening of markets.

Content	Where/ Who	When	Unit
Capacity allocated (used margin on Critical Branches)	CASC/ ENTSO-E	14:00 CET	MW
Congestion income	CASC/ ENTSO-E	14:00 CET	€
Individual Hub prices	PXs' websites	14:00 CET	€/MWh
Aggregated supply and demand curves for each market time unit	PXs' websites	14:00 CET	-
Overview CWE-Hub prices	www.europeanpricecoupling.eu	14:00 CET	€/MWh
Hubs net positions	CASC / ENTSO-E	14:00 CET	MW

10.3.3. Ex-post publication of additional CBCO information

CWE partners will publish, for each day with an hourly resolution, the list of pre-solved Critical Branches, disclosing the location aggregated by country or border ("BE", "DE", "FR", "NL", "DE-NL", "FR-BE", "FR-DE", "BE-NL").

In other words, CWE partners will publish the equivalent of the PTDF sheet of the utility tool, but will indicate the location of the CB per country/border instead of a general "CB x" naming. Moreover, the labelling of CBs will be fixed.

Additionally active, means limiting, branches will be highlighted.

This additional publication will be realized 2 days ex-post.

The content and style of this additional data supply related to the Critical Branches is the outcome of intensive exchange with Market Parties and NRAs. It somehow balances interests and demands of the MPs, obligations and restrictions of the TSOs related to critical infrastructure-protection and remaining risks of market abuse.

Day d / Hour h					
Location	BE-hub	DE-hub	FR-hub	NL-hub	RAM (MW)
CB2 (BE - NL)	-0,00751	0,03839	-0,02333	0,04863	248
CB44 (BE - NL)	-0,00751	0,05327	-0,02333	0,04863	341
CB78 (DE)	0,01825	0,24165	0,16244	-0,00478	1246
CB7 (DE - FR)	0,03219	-0,12462	0,06965	-0,09202	846
CB87 (DE - FR)	0,03219	-0,12462	0,06965	-0,09202	846
CB34 (FR)	-0,0934	-0,17882	-0,30739	-0,10358	955
CB25 (DE - FR)	-0,01121	0,03316	0,04949	0,02056	241
CB12 (BE - NL)	0,15894	0,01178	-0,10359	0,08035	1069
CB 13 (BE - FR)	0,07409	0,00339	-0,0138	0,02669	371
CB19 (BE - FR)	0,08865	-0,13143	-0,07653	-0,14152	823
CB71 (BE)	-0,06486	0,09981	0,18421	0,04557	1030
CB56 (NL)	-0,04593	0,20901	0,09448	0,25008	1143
CB97 (NL)	-0,04593	0,20901	0,09448	0,25008	1143
CB4 (BE - FR)	0,03743	-0,04985	-0,05299	-0,03277	377
CB5 (DE - FR)	-0,10814	-0,31978	-0,18941	-0,4588	1366
CB20 (DE - NL)	-0,02438	-0,14392	-0,07175	-0,31532	1079
CB21 (DE - NL)	-0,02438	-0,14392	-0,07175	-0,31532	1079
BE	-1	0	0	0	4220
FR	0	0	1	0	6406
FR	0	0	-1	0	4123
DE	0	-1	0	0	4470
DE	0	1	0	0	6930
NL	0	0	0	-1	3838
NL	0	0	0	1	4462

Figure 10-1: Proposed publication (ex-post), red: active branch (Example)

10.4. Publication of data in Fallback mode

The Fallback solution for CWE FB MC is coordinated with the NWE-/PCR Fallback arrangements. It will be ATC based explicit shadow auctions. These explicit auctions will be performed by the Shadow Auction System Operator (CASC).

The Shadow Auction System Operator (CASC) will publish and update when necessary the following general information on its website:

- Shadow auction rules;
- names, phone and fax numbers and e-mail addresses of persons to be contacted at the Shadow Auction System Operator (CASC);
- the forms to be sent by participants;
- the information related to the time schedule of the shadow auctions when they are decided in advance (auction specifications);
- the shadow auction results, including the anonymous complete Bid curves (amongst others the requested capacity, the capacity allocated, the auction clearing price and the auction revenue); the results should be published 10 min after the allocation.
- Data of past days will be archived

10.5. Additional market needs addressed, position and planning of the Project

Based on the intensive exchanges with Market Parties and NRAs, CWE project partners fully acknowledge the importance of the

transparency question in terms of acceptability of the Flow Based method.

Transparency contributes to the broader requirement that the Flow Based Market Coupling contributes to a fair and orderly market that participants have confidence in.

There are, however, other considerations regarding data publication. There is the potential risk of market manipulation, and TSOs have identified possible conflicts with the security of critical infrastructures as well as concerns about the costs of supporting extensive data publication. The challenge TSOs face is to find the right balance between the needs of Market Parties versus the risks.

The set of transparency arrangements might be reviewed in the future in the light of operational experience.

As the current proposal for data publication does not completely meet Market Parties' expectations, TSOs explain in the following section the reasoning behind their current position.

10.5.1. Market Parties' expectations

Market Parties strongly highlighted during the first consultation, Flow Based User Group meetings, Market Fora and bilateral meetings that they need detailed publication of exhaustive Flow Based related data in order to cope with the sophistication of this new method, for their full range of activities: from long-term investment decisions to daily dispatch optimization, from long-term hedging on the derivatives to daily trading tactics on the spot markets. The exchange especially emphasized uniform requests stemming from big national utilities to smaller players, as well as from representative associations.

In short, Market Parties requested the additional publication of the following data:

- Common Grid Model: the so-called D2CF or “day minus two congestion forecast” elaborated by TSOs, containing assumptions on load, topology, generation pattern and reference exchanges between countries, as well as all electrotechnical characteristics of the grid (line capacities and impedances, transformer characteristics etc.)
- Technical inputs specific to Flow Based: detailed GSK, detailed Critical Branches description, with access to all related fields: location of the lines on an ex-ante hourly basis, Remedial Actions, individual FRM, FAV, Fref, Fmax, etc.
- Regarding the ex-post publication of CBCOs: Earlier publication than D+2
- Full transparency related to TSO operational procedures: detailed internal process and timings, procedure for Remedial Actions deployment etc.
- Long term grid models and yearly PTFDs; Typical Flow Based Parameters (standard set)

10.5.2. Reasons for not meeting market expectations listed above

- Common Grid model: These files are the results of a complex process which crystallises much effort, expertise and experience. It is identified a risk of market abuse, and TSOs have identified possible conflicts with the security of critical infrastructures. Moreover, the CGM contains information far beyond CWE area and CWE TSO cannot decide to publish dataset of non-CWE TSOs.
- Providing detailed location of Critical Branches raises an issue associated to the European directive on critical infrastructures 2008 - 114. These infrastructures actually entail specific protection measures, including the interdiction to publish infor-

mation related to their localization. Not respecting these obligations can trigger a penal process. As it is already identified that for some countries Flow Based Critical Branches can belong to the set of critical infrastructures, publication of the former cannot be considered lightly. However based on the intensive exchange with MPs, a compromise (ex-post, fixed anonymous publication) could be found. One remaining discussion point is the point of time of publication. MPs request a publication close after gate closure (D-1, 13:00). For mainly protection reasons of critical infrastructure TSOs could commonly agree on a publication in D+2.

- Operational procedures: CWE TSOs see a priori no operational risk of publishing detailed procedures in an informal manner and for information purposes. However these procedures integrate complex, sophisticated, built over years of experience of TSOs in relation with their risk management policies. Thus, providing in an understandable and concise form all the knowledge related to congestion management is simply impossible.
- "Long term Flow Based grid models" do not exist as such, as TSO perform their long term studies by using complex hypotheses and multiple scenarios.
- As a consequence of the previous statement, "LT PTDF", which would therefore be computed on the basis on a LT grid model, cannot exist. Flow Based is computed on day-ahead, it is not feasible to publish additional "days-ahead" information. Flow Based takes into account parameters which change on a daily basis and which are very difficult to predict. The TSOs did perform a test already some time ago on calculating a longer period of Flow Based parameters which showed that this resulted in unrealistic values

- Together with the Flow Based User Group the Project tried to develop useful typical Flow Based Parameters (standard sets). Based on the intensive discussion with MPs it became clear, that suchlike approach could not really support MPs and needs much more research and therefore time.

Notwithstanding the specific reasons explained above, TSOs wants to highlight:

1. The TSOs' approach complies with current legislation
2. There has been and still is significant development regarding transparency outside the scope of the CWE FB MC Project:
 - a. Go-live of the central transparency platform at ENTSO-E on 5.1.2015 with significant steps forward
 - b. ENTSO-E publications regarding the "ENTSO-E Interconnected Network Grid Map" and the TYNDPs
 - c. Provision of the ENTSO-E Study Model (STUM) on demand (in case a NDA is signed), already covering most of the demands needed for FB calculation

10.6. Cooperation with the Market Parties after go-live

In the first year of CWE FB MC operation a Flow Based User Group meeting or call will be held on a regular basis (e.g. bimonthly), to discuss all relevant issues related to FB MC operation from MPs' perspective and to further improve the FB MC solution.

11 Monitoring

11.1. Monitoring and information to the NRAs only

For monitoring purposes the CWE Project provides the following additional data-items on a monthly basis to the NRAs only:

Items related to the FB capacity calculation

1. Results of the hourly LTA checks
2. Results of the hourly NTC checks
3. Line Sensitivity Check
4. Hourly Min/Max Net Positions
5. Hourly Intraday ATCs for all CWE borders
6. BE - Max Bilateral Exchanges (hourly)
7. FR - Max Bilateral Exchanges (hourly)
8. DE - Max Bilateral Exchanges (hourly)
9. NL - Max Bilateral Exchanges (hourly)
10. Volume of the Flow-Based domains (hourly)
11. Usage of the Final Adjustment Value FAV
12. External Constraints
13. Hourly Shadow Auction ATCs for all CWE-borders
14. Overview of timestamps where spanning is applied (per month)
15. Overview of timestamps for which default FB parameters were applied (per month)
16. Hourly non-anonymized presolved CBCOs, disclosing
PTDF, FMAX, FRM, FAV, RAM and FREF
17. Key aggregated figures per country and border (weekly aggregations)

Number of presolved CBs
Number of precongested cases

- Number of CBs exceeded by LTA
- Number of CBs exceeded by ATC
- Number of of presolved CBs with RAs applied
- Number of presolved CBs without RAs applied
- Number of presolved CBs, breaching the 5% rule
- Number of hours using the FAV
- Number of hours, spanning technology was applied
- Number of hours, default FB parameters were applied
- 18. In case of occurrence: justification when FAV is used
- 19. In case of occurrence: justification when 5% is breached (of pre-solved CBs)

Items related to the FB capacity allocation (after market coupling)

1. Active CBs (Hourly)
2. Shadow prices (Hourly)
3. Monthly top 10 of active constraints
4. Number of days or hours, allocation used Shadow Auction ATCs instead of FB parameters
5. Number of congested CBs
6. Number of congestions in the timestamps with non-intuitive prices (pending technical feasibility)
7. Price convergence indicator
8. Price convergence indicator: border-per-border price differences diagrams
9. Welfare loss compare to infinite capacity
10. Comparison FB-intuitive and FB-plain
11. CIA-Reporting (congestion income allocation)

The templates for the foreseen reporting towards the CWE NRAs are presented in in Annex 16.17.

12 Bilateral Exchange Computation and Net Position Validation

Bilateral Exchange Computation

As a result of the Market Coupling process one gets several sets of net positions (one net position value for each participating Market Area per hour).

The net positions have to be transformed into bilateral exchange data in order to support the daily nomination process. This transformation is called the 'bilateral exchange computation' (BEC). In the course of the BEC, the routes and time series of all CWE cross-border schedules (reflecting the MC volumes) are determined.

In principle, an infinite number of solutions exist to determine these Bilateral Exchanges, so it was decided to take the same formula as in BEC for ATC, without the major constraint used in this case (respect of NTC on all borders).

This formula reads (with B = NetPosition of one country):

$$\begin{aligned} \text{BEC}_{\text{ma}_{\text{BE} \Rightarrow \text{FR}}} &= -\frac{1}{4} * (3B_{\text{FR}} + 2B_{\text{DE}} + B_{\text{NL}}) \\ \text{BEC}_{\text{ma}_{\text{FR} \Rightarrow \text{DE}}} &= -\frac{1}{4} * (3B_{\text{DE}} + 2B_{\text{NL}} + B_{\text{BE}}) \\ \text{BEC}_{\text{ma}_{\text{DE} \Rightarrow \text{NL}}} &= -\frac{1}{4} * (3B_{\text{NL}} + 2B_{\text{BE}} + B_{\text{FR}}) \\ \text{BEC}_{\text{ma}_{\text{NL} \Rightarrow \text{BE}}} &= -\frac{1}{4} * (3B_{\text{BE}} + 2B_{\text{FR}} + B_{\text{DE}}) \end{aligned}$$

The output of the computation has to be provided per directed border, so the missing borders in the previous calculation are determined as follows:

$$\begin{aligned} \text{BEC_ma}_{FR \Rightarrow BE} &= - \text{BEC_ma}_{BE \Rightarrow FR} \\ \text{BEC_ma}_{DE \Rightarrow FR} &= - \text{BEC_ma}_{FR \Rightarrow DE} \\ \text{BEC_ma}_{NL \Rightarrow DE} &= - \text{BEC_ma}_{DE \Rightarrow NL} \\ \text{BEC_ma}_{BE \Rightarrow NL} &= - \text{BEC_ma}_{NL \Rightarrow BE} \end{aligned}$$

Net Position Validation

After completing the Market Coupling Process, the MC System sends the net positions for validation to the TSO Common System, for formal approval.

As the MC system and the TSO CS use the same algorithm for validation of the net positions (with the only difference in the tolerance levels), the results will normally be the same. The output of this verification is a full acceptance or full rejection of results of the Market Coupling process.

Validation performed is based on simple principles:

- $\text{Abs}(\text{NPout} * \text{NPin}) < \text{Tolerance Margin}$

2 Net Position per Market Area are produced by the process: one in and one out. Only one can be non-zero.

- $(\text{NPout} - \text{NPin}) < \text{Tolerance Margin}$

Global CWE Net position is zero.

- $((\text{NPout}_i - \text{NPin}_i) * \text{PTDF}_i) < \text{Margin} (\text{CB}_j) + \text{Tolerance margin}_i$

All CBs, adjusted to NetPosition to be validated, are safe

The tolerance margins are parameters with small positive values.

If all these inequalities are correct, the result of the validation process is a "Go" message to the MC System as the confirmation of the acceptance of Net Positions.

13 Contractual scheme

In this chapter the contractual scheme put in place for the operation of CWE FB MC is presented.

CWE FB MC shall be seen in the context of the European Price Coupling. To that extend, the CWE agreements as regional arrangements of the CWE region shall be compliant with the principles set forth in the Day-Ahead Operations Agreement (DAOA).

In this chapter, we will focus in particular on the:

- Principles of the CWE Framework agreement
- Parties involved in the daily operation and their tasks
- Risk management

13.1. Principles of the Framework Agreement

The daily operation and maintenance of the CWE FB MC is governed by a number of contracts between subsets of parties. These contracts are governed by the CWE Framework Agreement: the overall contract between CWE PXs and CWE TSOs. The subsidiary agreements between subsets of parties must be compliant with the principles of the CWE Framework Agreement. The principles of the CWE Framework Agreement have already been discussed with regulators for the ATC MC and will remain the same under FB MC.

13.2. 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 this section 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.

13.2.1. Roles of the individual/joint TSOs

The individual TSOs are responsible to calculate on a daily basis the day-ahead Cross-Zonal Capacities (CZCs) for the operation of Market Coupling. In the context of FB MC, CZCs are Flow Based parameters. Flow Based parameters are determined by the joint TSO pre-coupling system according to the method described in chapter 3.1 on capacity calculation. After their determination, the joint TSO pre-coupling system sends the Flow Based parameters to the local PX trading system which forwards them to the PMB. The joint TSO pre-coupling system is operated by all TSOs taking weekly shifts.

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 joint TSO post-coupling system. CASC is the operator of that system on behalf of the TSOs.

13.2.2. 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 PMB, a joint PX system part of the PCR solution. The 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 APX 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.

13.2.3. Roles of the joint PXs

The joint CWE PXs are responsible for building, operation and maintenance of the PMB system together with PXs of the PCR cooperation. The PMB system is the system on which the price coupling algorithm, Euphemia, 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 PMB system according to a rotation scheme.

13.2.4. Roles of joint Parties

The CWE PXs and TSOs are together responsible for the management of the CWE FB MC solution. Decisions regarding the solution will be taken by all the parties. In order to perform this task, the Parties will set up a joint steering committee, an operational committee and an incident committee.

13.2.5. Roles of external service providers

In order to operate an efficient Market Coupling, the CWE Parties have decided to outsource a number of tasks to external service providers (e.g. CASC and Coreso). 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 APX: ECC for the French and German hub and APX for the Belgium and Dutch hub.
- Reception of congestion rents and distribution to the individual TSOs. This task will be operated by CASC.

13.2.6. Summary of operational roles

Entity	Role
TSOs	<ul style="list-style-type: none">• Determine CZCs• Operate the TSO pre-coupling system (determination of Flow Based parameters and their sending to the local PX trading systems by taking weekly shifts)
Coreso	<ul style="list-style-type: none">• Operate the TSOs pre coupling system on behalf of RTE and Elia

Amrion and TenneT staff organised in SSC²⁵	<ul style="list-style-type: none"> • Operate the TSO pre-coupling system on behalf of Amrion and TenneT
PXs	<ul style="list-style-type: none"> • Collection of bids and offers from their participants in their hub, and submission of their aggregated and anonymous order books to the PMB. • Operation of the PMB in shift
ECC	<ul style="list-style-type: none"> • Financial clearing and settlement in the EPEX SPOT French and German hub, nomination of cross border exchanges
APX	<ul style="list-style-type: none"> • Financial clearing and settlement in the Dutch and Belgium hub, nomination of cross border exchanges
CASC	<ul style="list-style-type: none"> • Operation of the TSO post-coupling system (calculation of bilateral exchanges) • Congestion revenue distribution among TSOs

Operational roles at the time of submission of the approval document.

13.3. 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, e.g.

²⁵ In fact, SSC is not a legal entity. It is cooperation between Amrion and TenneT.

systems, procedures and interfaces, the Parties have implemented a change control procedure (c.f. chapter 141).

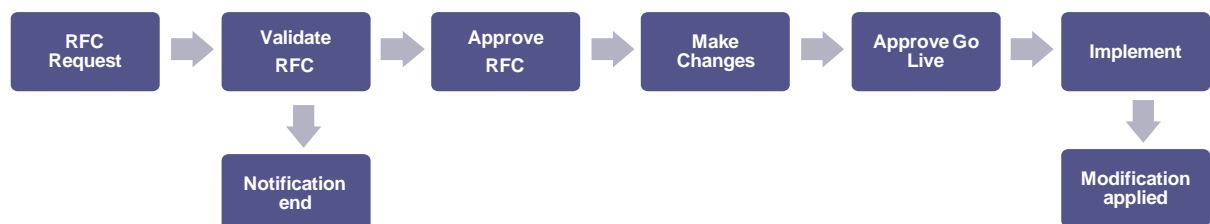
14 Change control

14.1. Internal change control processes of the Project

The change control procedure aims at tracking any change, small and large, in software, systems, procedures and in documents. Whilst the majority of changes are likely to be simple operational changes or small textual changes, it is still important that the procedure is robust to the processing of more complex changes. The relevant Steering Committee (e.g. CWE TSO Steering Group, CWE Joint Steering Committee) shall decide on the final approval of changes. Changes in the NWE coupling or PCR arrangements fall under the responsibility of the respective NWE Steering Committee or PCR Steering Committee.

In case a change is needed, a request for change document is filled. This document shall contain the details, the consequences such change could have for the other parties and any other relevant information on the requested change. Then, an impact assessment is performed in order to determine whether the requested change will have a material impact on the common operations and systems. The proposal is checked to see if it is correct. After approval, the change is performed.

Example given of a RFC Procedure control



Simple changes with a low-risk solution affect a small number of components owned by a single or joint party, and change only local items with no identified impact on common items. Project Partners are informed of such changes, with a fast track procedure if required.

All other changes which are more complex, of a higher risk category, affecting multiple components or components which are the responsibility of more than one project party are handled as real modifications, but can be managed in fast track if needed.

For simple changes, the change will be recorded on just one form. This will contain all the information required including the cause of the change, the proposed solution, its impact and the way in which the change will be implemented. In this case no other forms will be required to be completed.

14.2. Approval of changes of the CWE FB MC solution

For all major changes in the CWE FB MC solution, having a significant market impact, a formal approval request towards the NRAs will be started to be commonly approved. All changes will be documented and attached to the initial approval document.

15 Glossary

AC	Active constraint
ATC	Available Transfer Capacity
ATC MC	ATC Market Coupling
CASC	Capacity Allocating Service Company
CB	Critical Branch
CBCO	Critical Branch Critical Outage
CCP	Cross Clearing Party
CEE	Central Eastern Europe
CET	Central European Time
CEWE	Central East West Europe
CGM	Common Grid Model
CO	Critical Outage
CS	Common System
CWE	Central Western Europe
CZCs	Cross Zonal Capacities
D	Delivery Day
D-1	Day Ahead
D-2	Two-Days Ahead
D-2CF or D2CF	Two-Days Ahead Congestion Forecast
DA	Day Ahead
DACF	Day-Ahead Congestion Forecast
EC	External Constraints
ENTSO-E	European Network of Transmission System Operators for Electricity
FAV	Final Adjustment Value
FB	Flow Based
FB MC	Flow Based Market Coupling
FBI MC	Flow Based Intuitive Market Coupling
Fmax	Maximum allowable flow on a given Critical Branch
FRM	Flow Reliability Margin

GCB	German control block
GCT	Gate Closure Time
GSK	Generation Shift Key
HLA	High Level Architecture
IC	Incident Committee
ID	Intraday
IFA	Interconnexion France Angleterre
Imax	Maximum current on a Critical Branch
LT	Long Term
LTA	Allocated capacity from LT auctions
LTN	Long Term Nominations
MC	Market Coupling
MoU	Memorandum of Understanding
MP	Market Party
NA	Not applicable
NRA	National Regulatory Authority
NWE	North Western Europe (CWE countries + Denmark, Finland, Norway, Sweden, United Kingdom)
PCR	Price Coupling of Regions
PLEF	Pentalateral Energy Forum
PMB	PCR Matcher and Broker (Joint PX IT System which embeds the PCR Algorithm calculating the NWE Net Positions, Prices and Scheduled Exchanges on the non CWE interconnectors)
PCR Coordinator	PX operating the PMB system
PTDF	Power Transfer Distribution Factor
PST	Phase-Shifting Transformer
PX	Power Exchange
RA	Remedial Action
RAM	Remaining Available Margin
SAS	Shadow Auction System

SoS	Security of Supply
SSC	Security Service Center
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
UCTE	(formerly Union for the Coordination of Transmission of Electricity (today integrated into ENTSO-E))

16 Annexes

16.1. Documentation of all methodological changes during the external parallel run

16.2. Educational example "How does Flow Based capacity calculation work?"

16.3. High level business process FB capacity calculation

16.4. Examples of different types of Remedial Actions (will be provided later)

16.5. Dedicated report on FRM (confidential, will be provided later)

16.6. Information regarding LTA inclusion

16.7. CWE High level architecture (confidential)

16.8. Technical Procedures (confidential)

16.9. CWE High level Fallback architecture (confidential)

16.10. Economic assessment

16.11. Domain reduction study

16.12. Intuitiveness report

16.13. Intuitiveness, Analysis for the FB/FB(I) selection

16.14. Results of the survey/ consultation in May/June 2013

16.15. Presentation of the Utility Tool

16.16. Publication of Shadow ATCs

16.17. Monitoring templates (will be provided later)