TenneT
Taking power further

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BETREFT Voorstel van CWE TSO's voor aangepaste flow-based capaciteitsberekeningsmethodologie

Geachte heer Don,

Conform uw besluit ACM/DE/2017/205360 van 15 september 2017 ontvangt u hierbij een gewijzigd voorstel voor de flow-based capaciteitsberekeningsmethodologie:

- "*Methodology for capacity calculation for ID timeframe*" d.d. 29 juni 2018.

Ter toelichting op dit voorstel ontvangt u tevens:

- "*Explanatory note for capacity calculation for ID timeframe*" d.d. 29 juni 2018;
- Een begeleidende, toelichtende brief van de CWE project partners.

Bijlage 2 bij de *Explanatory note* is vertrouwelijk en alleen bedoeld voor gebruik door de toezichthouders.

Een versie van de methodologie en de *Explanatory note* met daarin de wijzigingen ten opzichte van de vorige versie gemarkeerd ontvangt u per e-mail.

Anders dan gesteld als voorwaarde in het bovengenoemde besluit van 15 september 2017, zal de nieuwe methodologie nog niet op 1 oktober 2018 in werking kunnen treden. De voornaamste reden daarvoor is dat voor FB IDCC is voorzien om aan te sluiten op ENTSO-E niveau aangaande het uitwisselen van netmodellen gebaseerd op CGMES format. Aan de kant van ENTSO-E is er een vertraging bij de implementatie van CGMES, waar de invoering van FB IDCC dus afhankelijk van is.
Om de vertraging te beperken hebben de TSO's besloten om een UCTE-DEF - CGMES converter te laten ontwikkelen. Maar ook dat vergt een test- en implementatieperiode waardoor een vertraging onoverkomelijk is.

U wordt verzocht deze methodologie goed te keuren krachtens artikel 5, zesde lid, van de Elektriciteitswet 1998.

Verder verzoeken wij u de voorwaarde in het besluit van 15 september 2017 dat de start van de toepassing

van deze methodologie dient plaats te vinden voor 1 oktober 2018 te wijzigen in de voorwaarde dat de start van de toepassing van deze methodologie dient plaats te vinden voor 1 oktober 2019, de datum die in paragraaf 2.2.2 van de *Explanatory note* als uiterste implementatiedatum is opgenomen .

Hoogachtend,
TenneT TSO B.V.

[redacted]

[redacted]
Senior Manager Regulation NL

Methodology for capacity calculation for ID timeframe

For NRA approval

Version	Final version 2.0
Date	29-06-2018

Contents

1 Management summary

The purpose of this approval document is to provide all Regulators of the CWE region with a description of the Flow-Based Intraday Capacity Calculation (FB IDCC) methodology, in order for them to approve it in the framework of the Regulation 714/2009. This document is considered as a follow up of the CWE Flow-Based Day Ahead (FB DA) approval package dated August 1st, 2014 and in particular of the "*Position Paper of CWE NRAs on Flow-Based Market Coupling"* of March 2015, as well as the approval package on the methodology for capacity calculation for the ID timeframe submitted to NRAs on November 9th 2015. The present FB IDCC methodology is therefore to be seen as a third implementation step for the calculation of ID capacity after CWE FB DA market coupling and won't include the coordinated increase/decrease process applied since March 30th 2016.

For the avoidance of any doubts, this document does not cover FB ID allocation. For the purpose of the allocation of capacity, Available Transfer Capacities (ATC) (extracted from the FB domain) will be used. Additionally, the current design of the FB IDCC process is compliant with gate opening at 10PM. Any earlier gate opening time would be challenging in relation to design of the process and the implementation.

The remainder of the document is structured as follows: chapter two contains the glossary with the acronyms used in this paper. The FB ID CC methodology including a description of the inputs, the process and the outputs is presented in chapter three. The next chapter describes the back-up procedures and chapter five includes transparency procedures.

2 Glossary

- **DC calculations:** Direct current calculations. Calculations of unidirectional flow of electric charge.
- **CACM:** Regulation 1222/2015 - Capacity allocation and congestion management guideline
- **DA CGMs & ID CGMs**: Day Ahead & Intraday Common Grid Models which are the result of the merging of the Individual Grid Models provided by TSOs in day-ahead or in intraday as their best forecast of the topology, generation and load for a given hour of the Day D.
- **Day D**: Delivery day for which capacity increases or rejection are considered.
- **DACF**: Day-Ahead Congestion Forecast.
- **Explicit RAs**: Remedial actions taken into account in the capacity calculation process.
- **ID ATC**: Intraday Available Transfer Capacity.
- **IGM**: Individual grid models
- **FB DA ATC**: The left-over ATC values extracted from the FB DA domain.
- **FB ID ATC**: The ATC values extracted from the FB ID capacity calculation domain.
- **DA MCP**: Day-Ahead Market Clearing Point.
- **Net exchange program**: Netto exchanges in terms of cross-zonal flows between different bidding zones.
- **Net position**: netted sum of electricity exports and imports for each market time unit for a bidding zone.
- **PTDF**: Power Transfer Distribution Factor.
- **RA**: Remedial action. Measure applied to modify (increase) the FB domain in order to support the market, while respecting security of supply.
- **RAM**: Remaining available margins on critical network elements.
- **RSC**: Regional security coordinator.
- **Zone-to-hub PTDF**: Represent the variation of the physical flow on a critical network element induced by the variation of the net position of each zone.
- **Zone-to-zone PTDF**: The impact in terms of flows of a power exchange between two zones on a given critical network element.

3 Flow-Based Intraday capacity calculation Methodology

3.1 Inputs

To calculate the FB capacity domain for one timestamp of the business day, TSOs have to assess the following items which are used as inputs into the model:

- Critical Network Elements (CNEs)
- Contigency (C)
- Maximum current on a Critical Network Element (Imax) / Maximum allowable power flow (Fmax)
- Final Adjustment Value (FAV)
- DA Common Grid Model (CGM) and reference Programs
- Remedial Actions (RAs)
- Generation Shift Key (GSK)
- Flow Reliability Margin (FRM)
- Allocation/external constraints: specific limitations not associated with Critical Network Elements
- Data from previous flow-based capacity computations

As a general rule, if there is an agreement between NRAs and TSOs to update the method for the input generation for the D-2 CWE FB process, the consequences of the implementation of these changes for the ID timeframe will be analyzed and, if possible, the FB IDCC method will be adapted in order to align it with the updated D-2 method.

3.1.1 Critical Network Element (CNE) and Contingency (C)

3.1.1.1 Definitions

Definition of a Critical Network Element

A Critical Network Element (CNE) is a network element significantly impacted by CWE cross-border trades and/or by RAs. A CNE has the following parameters:

- An element: a line (tie-line or internal line) or a transformer
- An "operational situation": normal (N) or contingency cases (N-1, N-2 or busbar faults, depending on the applicable TSO risk policies). (See below for link between CNE and Cs)
- A set of Imax (See 3.1.2)
- A FAV (See 3.1.5)
- A FRM (See 3.1.7)

Definition of a Contingency

A Contingency (C) is an event that can occur in the network that will be monitored in the process. A C 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.

Definition of the Critical Network Element and Contingency (CNEC)

A CNEC (combination of Critical Network Element and Contingency) is defined by each CWE TSO who links one of his CNEs with one of the Cs.

3.1.1.2 CNEC list for Remedial Action Optimization

The Remedial Action Optimization is used to find a set of RAs that will be applied in the FB computation. Therefore, RAO must take into account at least all CNECs that will also be taken into account during FB computation (see section 3.1.1.3). The TSO may specify CNECs to be only taken into account during Remedial Action Optimization. This can be required in order to avoid Security of Supply effects on CNECs that are strongly influenced by RAs albeit only weakly influenced by cross-border exchanges. Consequently, the CNECs considered in the RAO can be a superset of the CNECs used in the FB computation and thus CNECs are not checked for their sensitivity to exchanges.

3.1.1.3 CNEC list for the FB computation

The CNECs with the agreed set of RAs that are monitored in the FB computation should be significantly impacted by CWE cross-border trades. This selection approach is identical to the approved and applied process for the day ahead flow-based capacity calculation.[1]

A set of PTDFs is associated to every CNEC after each FB parameter calculation, and gives the influence of the change of the net position of any bidding zone on the CNEC.

A CNE 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%.

For each CNEC, the following sensitivity value is calculated:

Sensitivity = max (PTDF (BE), PTDF (DE /LU), PTDF (AT), PTDF (FR), PTDF (NL)) - min(PTDF (BE), PTDF (DE/LU), PTDF (AT), PTDF (FR), PTDF (NL))

If the sensitivity is above the threshold value of 5%, then the CNEC is said to be significant for CWE trade. If a CNEC does not meet the pre-defined conditions, the concerned TSO then has to decide whether to keep the CNEC or to exclude it from the CNEC list.

Although the general rule is to exclude any CNEC which does not meet the threshold on sensitivity, exceptions on the rule are allowed: if a TSO decides to keep the CNEC in the CNE list, it has to justify this decision to the other TSOs, furthermore it will be systematically monitored by the NRAs as it is done today in the day ahead process.

If there is an agreement between NRAs and TSOs to update the method for the CNEC selection for the D-2 CWE FB process, the consequences of the implementation of these changes for the ID timeframe will be analyzed and, if possible, the FB IDCC method will be adapted in order to align it with the updated D-2 method.

3.1.2 Maximum current on a Critical Network Element (Imax) and Maximum allowable power flow (Fmax)

The maximum allowable current (Imax) is the physical limit of a CNE determined by each TSO in line with its operational criteria. Imax is the physical (thermal) limit of the CNE in Ampere, except when a relay setting imposes to be more specific for the temporary overload allowed for a particular CNEC.

As the thermal limit and relay setting can vary in function of weather conditions, Imax is usually defined at least per season.

[1] "Documentation of the CWE FB MC solution as basis for the formal approval-request", Brussels, 1st August 2014, http://jao.eu/support/resourcecenter/overview?parameters=%7B%22IsCWEFBMC%22%3A%22True%22%7D, pp. 18ff

When the Imax value depends on the outside temperature or wind conditions, its value can be reviewed by the concerned TSO if outside temperature or wind forecast is announced to be much higher or lower compared to the seasonal values.

Imax is not reduced by any security margin, as all margins have been covered by the calculation of the contingency by the Flow Reliability Margin (FRM, c.f. chapter 3.1.7) and Final Adjustment Value (FAV, c.f. chapter 3.1.5).

Some TSOs allow to overload lines after a contingency up to a temporary limit for a limited amount of time. As a result, two Imax values will be provided for one CNE.

- Temporary Imax
- Permanent Imax

The value Fmax describes the maximum allowable power flow on a CNEC in MW and is given by the formula:

Fmax = $\sqrt{3}$ * Imax * U * cos(φ) / 1000 [MW],

where Imax is the maximum permanent or temporary allowable current (in A [Ampere]) for a CNE. The value for cos(φ) is set to 1 (in case of DC calculations), and U is a fixed value for each CNE and is set to the reference voltage (e.g. 225kV or 400kV) for this CNE.

As several Imax may be provided for one CNE, several Fmax may exist for a CNEC.

3.1.3 Day ahead Common Grid Model

The day ahead Common Grid Model (DA CGM) is created by merging all individual Grid Models (IGMs) from all TSOs of continental Europe and is based on data from DA market coupling and a security assessment of the grid.

For intraday capacity calculation the latest available version of the day ahead Congestion Forecast process (DACF) will be used at the moment the capacity calculation process is initiated. This includes, according to the methodology developed in line with Regulation 1222/2015 Article 16 and 17 (CACM):

- Best estimation of Net exchange program
- Best estimation exchange program on DC cables
- Best estimation for the planned grid outages, including tie-lines and the topology of the grid
- Best estimation for the forecasted load and its pattern
- If applicable best estimation for the forecasted renewable energy generation, e.g. wind and solar generation
- Best estimation for the outages of generating units
- Best estimation of the production of generating units
- All agreed RAs during regional security analysis.

3.1.4 Remedial Actions (RA)

During FB parameter calculation, CWE TSOs take RAs into account to improve the FB domain where possible while ensuring a secure power system operation, i.e. N-1/N-k criterion fulfillment.

RAs used in capacity calculation can embrace the following measures a.o.:

- 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.
- Redispatching: changing the output of generators by ramping up and down certain power units.

The effect of these RAs on the CWE CNEs is directly determined in the calculation process to monitor the shift of load flow in the entire CWE grid.

There are several types of RAs, differentiated by the way they are used in the optimization of the domain:

- Preventive (pre-fault) and curative (post-fault) RAs: While preventive RAs are applied before any fault occurs, and thus to all CNECs of the flow-based domain, curative RAs are only used after a fault occurred. As such the latter RAs are only applied to those CNECs associated with this contingency. Curative RAs allow for a temporary overload of grid elements and reduce the load below the permanent threshold.
- Shared and non-shared RAs: Each TSO can define whether he wants to share the RA provided for capacity calculation or not. In case a RA is shared, it can be applied to increase the Remaining Available Margin (RAM) on ALL relevant CNEs. If it is a non-shared RA, the TSO shall determine the CNEs for which the RA can be triggered in the capacity optimization.

Each CWE TSO defines and checks the availability of their RAs in its responsibility area according to its operational principles. At least all RAs used for the DA capacity calculation and still available at the time of the ID capacity calculation have to be considered.

The CWE TSOs commit to include the DA MCP in the FB ID CC domain up to the FRM value – except in case of *force-majeure*. In order to do so CWE TSOs foresee to include costly RAs to avoid automatic DA MCP inclusion.

CWE TSOs will work on developing, testing and implementing this and seek for intermediate steps to reach this commonly agreed target with limited DA MCP inclusion.

Automatic DA MCP inclusion for values higher than FRM should only occur in very exceptional cases (aim to reach a pre-defined threshold).

3.1.5 Final Adjustment Value (FAV)

With the Final Adjustment Value (FAV), operational skills and experience that cannot be introduced into the FB-system can find a way into the FB-approach by increasing or decreasing the remaining available margin (RAM) on a CNE for very specific reasons which are described below. Positive values of FAV in MW reduce the available margin on a CNE while negative values increase it. The FAV can be applied by the responsible TSO during the validation phase to reduce the margin on a dedicated CNE, since the process is expected to be highly automated. 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 RAs which cannot be modelled and thus calculated in the FB parameter calculation.
- A positive value for FAV as a consequence of the validation phase of the FB domain, leading to the need to reduce the margin on one or more CNEs for system security reasons. The overload detected on a CNE during the validation phase is the value which will be put in FAV for this CNE in order to eliminate the risk of overload on the particular CNE.

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

3.1.6 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 zone. 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 FB domain, the GSK must be linear and items of the GSK cannot consider minimum or maximum values.

A GSK aims to deliver the best forecast of the impact on CNE of a net position change, taking into account on one hand the operational feasibility of the reference production program, projected market impact on units, market/system risk assessment and the characteristics of the grid; and on the other hand the model limitations.

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.

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 do not 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).

In order to take into account the characteristics of each TSO's network, individual GSKs are defined for each current bidding zone.

3.1.6.1 GSK for the German bidding zone

The German TSOs have to provide one single GSK-file for the whole German hub. Since the structure of the generation differs for each involved TSO, an approach has been developed, that allows the single TSO to provide GSKs that respect the specific character of the generation in their own control area and to create out of them a concatenated German GSK in the needed degree of full automation.

Every German TSO provides one file per business day. If one TSO does not provide a new GSK file for a business day the replacement strategy will take the latest valid file for working day, bank holiday or weekend day. Within this GSK file, the generators are listed with their estimated share within the specific control area for the different time-periods. Therefore, every German TSO provides within this GSK file the generators, according to TSO´s estimation, that participate to a net-position shift of the German hub. The generation-distribution among the defined generators inside its grid must sum up to 1.

In the process of the German merging, the FB ID system creates out of these four individual GSK-files, depending on the target day (working day / week-end or bank holiday), a specific GSK-file. The German TSOs defined generation share keys which represent the share of available power in a control area. The content of the individual GSK-files will be multiplied with the individual share of each TSO. This is done for all TSOs with the usage of the different share keys for the different target times. In that way a Common GSK file for German bidding zones is created on daily basis.

With this method, the knowledge and experience of each German TSO is incorporated in the process to obtain a representative GSK. With this structure, the generators named in the GSK are distributed over the whole German bidding zone in a realistic way, and the individual factor is relatively small.

The Generation Share Key for the individual control areas i is calculated according to the reported available market driven power plant potential of each TSO, divided by the sum of market driven power plant potential in the bidding zone.

$$\text{GShK TSO}_i = \frac{Available\ power\ in\ control\ area\ of\ TSO_i}{\sum_{k=1}^{4}(Available\ power\ in\ control\ area\ of\ TSO_k)}$$

Where k is the index for the four individual TSOs.

With this approach the share factors could be determined based on regular generation forecasts and will sum up to 1 forming the input for the common merging of individual GSKs.

TransnetBW

To determine relevant generation units TransnetBW takes into account most recent available information at the time when individual GSK-files are generated:

- Power plant availability
- Planned production

The GSK for every power plant i is determined as:

$$GSK_i = \frac{P_{max,i} - P_{min,i}}{\sum_{i=1}^{n}(P_{max,i} - P_{min,i})}$$

Where n is the number of power plants, which are considered for the GSK in the TransnetBW control area.

The following types of generation units connected to the transmission grid can be considered in the GSK:

- hard coal power plants
- hydro power plants
- gas power plants

Nuclear power plants as baseload units are excluded upfront because of their constant power output that does not change during normal operation.

Amprion

Amprion established a regularly 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 unit out of service. According to these changes in the grid Amprion updates its GSK.

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 in changes in the production.

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 part of the GSK. This list is updated regularly. The individual GSK factors are calculated by the available potential of power plant i (Pmax-Pmin) divided by the total potential of all power plants in the GSK list of TTG.

3.1.6.2 GSK for the Austrian bidding zone

APG's method to select GSK nodes is analogue to the German TSOs. So only market driven power plants are considered in the GSK file which was done with statistical analysis of the market behaviour of the power plants. In that case APG pump storages and thermal units are considered . Power plants which generate base load (river power plants) are not considered. Only river power plants with daily water storage are considered in the GSK file. The list of relevant power plants is updated regularly in order to consider maintenance or outages.

3.1.6.3 GSK for the Dutch bidding zone

The Dutch GSK will dispatch the main generators in a manner which avoids extensive and unrealistic under- and overloading of the units for foreseen extreme import or export scenarios. The GSK is directly adjusted in case of new power plants. Also unavailability of generators due to planned outages are considered in the GSK.
All GSK units are re-dispatched pro rata on the basis of predefined maximum and minimum production levels for each active unit in order to prevent infeasible production levels of generators. The total production level remains the same.
The maximum production level is the contribution of the unit in a foreseen extreme maximum production scenario. The minimum production level is the contribution of the unit in a foreseen extreme minimum production scenario. Base-load units will have a smaller difference between their maximum and minimum production levels than start-stop units.
For the intraday timeframe, a proportional GSK based on the results of FB DA CC will initially be used, using the same set of GSK units. It is to be expected that, for relatively small volumes of additional capacity given in intraday, this will not result in less reliable results. In the future, a more sophisticated GSK method for intraday may be introduced respecting the GSK description as given in this paragraph.

3.1.6.4 GSK for the Belgian bidding zone

Elia will use in its GSK a fixed list of nodes based on the locations where most relevant flexible and controllable production units (market oriented generating units) are connected. This list will be determined in order to limit as much as possible the impact of model limitations on the loading of the CNEs.
The variation of the generation pattern inside the GSK is the following: For each of these nodes, the sum of the generation which are in operations in the base case of each of these nodes will follow the change of the Belgian net position on a pro-rata basis. That means, if for instance one node is representing n% of the sum of the generation on all these nodes, n% of the shift of the Belgian net position will be attributed to this node.

3.1.6.5 GSK for the French bidding zone

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.

3.1.7 Flow Reliability Margin (FRM)

The intraday capacity calculation methodology is based on forecast grid models of the transmission system (the DA CGMs). The inputs are created the day before the delivery date of energy with available knowledge at that point in time. Therefore, the outcomes are subject to inaccuracies and uncertainties. The aim of the Flow Reliability Margin (FRM) is to cover a level of risk induced by these forecast errors.

For each oriented CNEC, a FRM has to be defined. Inevitably, the FRM reduces the remaining available margin (RAM) on the CNEC because a part of the transmission capacity - that is provided to the market to facilitate cross-border trading - must be reserved to cope with these uncertainties.

As a first step, for each hour of a one-year observatory period, the DA CGMs are updated in order to take into account the real-time tap position of the PSTs that are considered in the intraday capacity calculation. These PSTs are controlled by CWE TSOs and thus not considered as an uncertainty. This step is undertaken by copying the real-time tap position of the PSTs and applying them into the historical DA CGM. The power flows of the latter modified CGM are re-computed and then adjusted to realised commercial exchanges inside the CWE region with the PTDFs calculated based on the historical GSK and the modified DA CGM. Consequently, the same commercial exchanges in the CWE region are taken into account when comparing the power flows resulting from the intraday capacity calculation with flows in the real-time situation. The power flows on each CNEC are then compared with the real-time flows observed on the same CNEC, by means of a contingency analysis. All differences for all hours of a one-year observation period are statistically assessed and a probability distribution is obtained.

As a second step, the 90^{th} percentiles of the probability distributions of all CNECs are calculated. This means that the CWE TSOs apply a common risk level of 10%, i.e., the FRM values cover 90% of the historical errors. The FRM values are computed for all oriented CNECs from the distribution of flow differences between forecast and real-time observation.

This basic idea is illustrated in Figure 1.

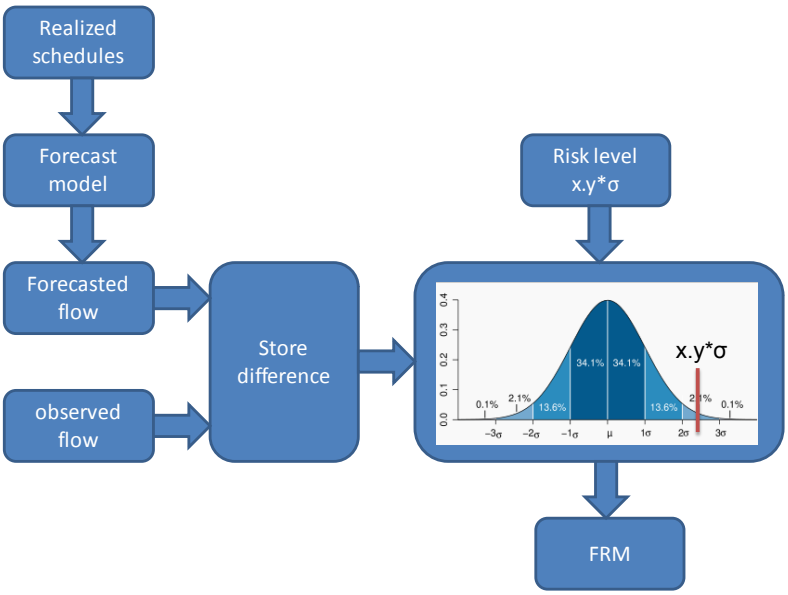


Figure 1: FRM Assessment Principle

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
- 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 CNEC definition. The rationale behind this is that TSOs remain critical towards the outcome of the calculation in order to ensure the implementation of parameters which make sense operationally. For any reason (e.g. data quality issues or significant grid topology changes in the past year), it can occur that the calculated FRM is not consistent with the TSO's experience on a specific CNEC. Should this case arise, the TSO will proceed to an adjustment of the calculated FRM values. The differences between operationally adjusted and calculated FRM values shall be systematically monitored and justified in a dedicated report to the NRA of the particular TSO applying the operational adjustment. The calculated values remain a "reference", especially with respect to any methodological change, which would be monitored through FRM.

The general FRM computation process can then be summarized by figure 2.

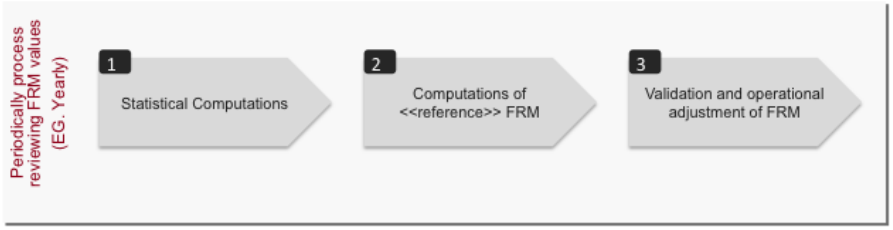


Figure 2: FRM computation process

Step 1: Elaboration of statistical distributions, for all CNECs (i.e. N and N-1 situations).
Step 2: Calculated (reference) FRM computed by applying a common risk level on the statistical distributions.
Step 3: Validation and potentially operational adjustment of the FRM values.

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 re-computing FRM values, following the same principles but using updated input data, on a regular basis and at least once a year.

3.1.8 External constraints (EC)

Besides the limitations on CNEs, other specific limitations may be necessary to guarantee a secure grid operation. Import/Export limits for bidding zones declared by TSOs are taken into account as "special" constraints, in order to guarantee that the market outcome does not exceed these limits. For these constraints the term "external constraints" was introduced in the days of implementing DA FB in CWE. In CACM guidelines the term "allocation constraints" is introduced, meaning constraints that need "to be respected during capacity allocation to maintain the transmission system within operational security limits and have not been translated into cross-zonal capacity or that are needed to increase the efficiency of capacity allocation". These allocation constraints are a superset of the external constraints used in CWE as they may also contain other constraints such as technology-driven ramping constraints on HVDC connections. For intraday capacity calculation in CWE the use of the well-known external constraints is deemed sufficient. Therefore, the respective terminology will be used in the remainder of this document.

External constraints can be used for two different reasons. Firstly, they can be justified if market results beyond such constraints would lead to stability and/or voltage management problems. Such issues have to be detected via dedicated system studies. Secondly, market results which are too far from reference flows, and might have unexpected impact due to linearization errors, can be avoided by the external constraints. This aspect is of particular importance during the introduction of FB allocation because new flow patterns may arise. The definition of external constraints is a responsibility of each individual TSO. It is important to understand that these constraints do not limit transit flows.

TSOs remind here that these constraints are not new, since they are already being successfully applied in DA FB capacity calculation. As the physics behind the external constraints remain the same irrespective of the market time period under investigation, the same constraints in the intraday stage as in the day ahead allocation shall be applied in the intraday allocation.

3.2 FB Intraday Capacity Calculation

3.2.1 Operational process

Figure 3 illustrates an overview of the process divided in several steps. Each step is described in the next paragraphs.

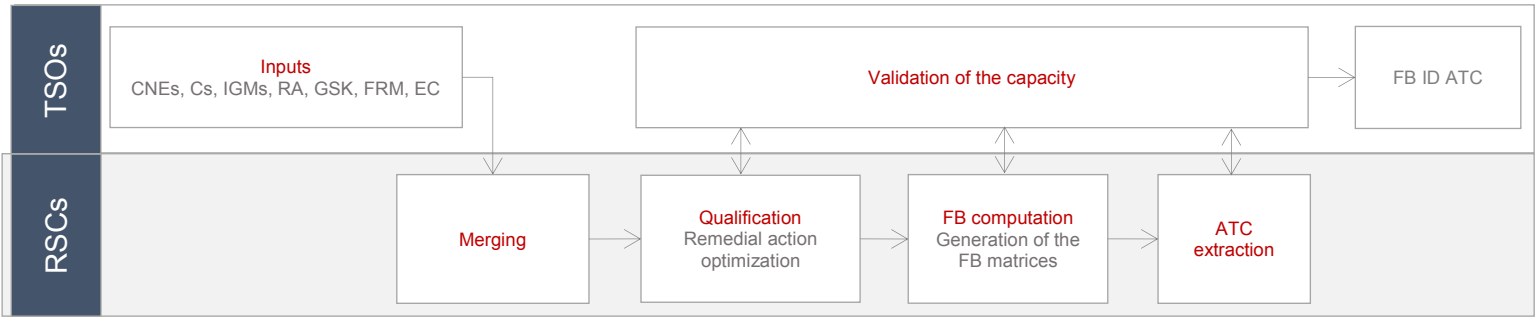


Figure 3: Operational process for FB IDCC.

3.2.2 Inputs

The aim of the input phase is to gather all the necessary inputs decribed in the previous section. The responsibility of the delivery and the quality of the inputs lies with the TSOs.

3.2.3 Merging

The aim of the merging process is to define a common set of data based on the data provided by the TSOs. During this merging process, quality checks are performed.
Concerning the grid model, the merging entity will be in charge to generate the common grid model (CGM) reflecting the best forecast of infeeds, flows and topology of continental Europe at the time of the merge.

The output of the merging process is a clean merged dataset to be used in the next steps:

- Common list of CNECs with associated parameters (Fmax, FRM…)
- Common list of RAs and condition of use
- Common grid model
- Merged GSK file

3.2.4 Qualification

The aim of the qualification phase is firstly to include the already allocated capacity and secondly to increase the capacity around the already allocated capacity.
In order to achieve this goal, a branch-and-bound optimizer is used in order to associate RAs to constraints creating an additional margin that can be offered to the market participants. The risk policy of each TSO has to be respected during the association and the impact of the RA on CNECs has also to be assessed in order not to create unsecure grid situations.

In particular, the optimizer determines a set of RAs that improve the flow-based domain according to a defined objective function. In the CWE FB IDCC framework, this objective function aims to increase the minimum relative margin in MW, around the DA MCP. The relative margin is defined as the RAM divided by the absolute sum of the commercial bilateral CWE zone-to-zone PTDF. In case one of the CNECs has a negative RAM, the relative margin will be equal to the RAM.

In this process, the optimizer tries to maximize the RAM of the CNECs relatively to their sensitivity to exchanges, without market assumption (i.e. without a preference to any particular exchange direction so as not to discriminate any border).

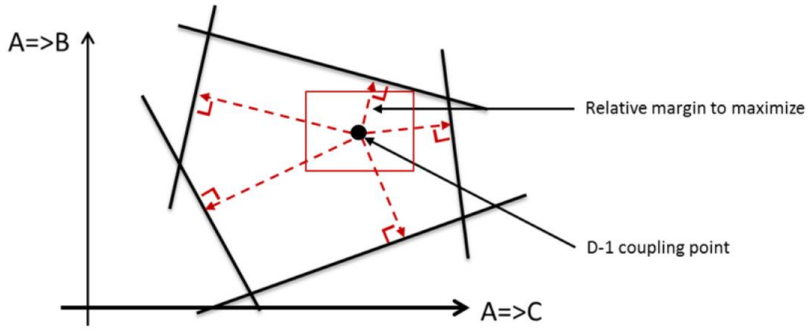


Figure 4: Illustration of the non-discriminatory approach to increase the space around the DA MCP.

The output of this part of the process is:

- A coordinated set of preventive RAs
- A coordinated set of curative RAs for contingencies

3.2.5 FB computation

The aim of the FB computation is to deliver the flow-based matrix. The FB parameters computation is a centralized computation.

The outputs of the FB computation process are:

1. PTDF for each hub of the CWE area

The PTDFs are calculated by varying the exchange of a zone, taking the zonal GSK into account. For every single zone-variation the effect on the load of every CNE 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 CNE => PTDF = 10%).
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 CNEs by multiplication with the PTDFs.

2. Margin for each considered CNEC (RAM)

As the reference flow (Fref) is the physical flow computed from the common base case, it reflects the loading of the CNE. Out of the formula:
RAM = Fmax – Fref – FRM - FAV
The calculation delivers, with respect to the other parameters, the free margin for every CNE. This RAM is one of the inputs for the subsequent process steps.

3. List of CNEC limiting the domain

Not all CNECs are relevant for the market as only a few limit the exchanges. The pre-solve sub-process removes the redundant CNECs to create the pre-solved domain.

4. Power Shift Distribution Factors (PSDF) for special grid element

These PSDFs aim at representing the influence of special grid elements on CNECs like cross zonal HVDC links in a Capacity Calculation Region which may be used to redistribute the flows in the region.

3.2.6 Validation of capacity

Ideally multiple FB calculations in intraday should be performed. However, currently there is only one FB calculation possible without the possibility to re-assess extracted ID ATC during the day. As a result, with current means available, potential SoS issues during intraday cannot be avoided. This may result in the application of additional costly RAs to ensure grid security. Availability of these RAs should not be seen as self-evident.

The aim of validation is to verify whether the computed flow-based domains are deemed secure enough according to TSO risk policy. For example, the TSOs can verify voltage/transient stability and perform AC load flows. In case the TSOs detect a constraint, they have several instruments at their disposal to reduce the flow-based or ATC domains:

- Providing one or more additional CNEs, to be taken into account
- Editing or adding external constraints
- Using FAV on a specific CNE
- Updating the availability status of the RAs
- Reduce the ATCs

The use of any of the above mentioned instruments has to be monitored, and is not dedicated to enlarge the flow-based or ATC domain, as it would become too large, thus unsecure. The output of this process is the amended flow-based and/or ATC domain.

3.3 Outputs

The output of FB capacity calculation for the intraday timeframe can be separated in two parts:

- A FB domain resulting from the capacity calculation which can be described by domain indicators;
- Intraday ATCs extracted from the FB domain, as long as the capacity allocation for the intraday market is based on ATC.

Both kinds of output are briefly discussed in the two subsequent subsections.

3.3.1 FB capacity domain

The FB parameters that have been computed indicate which net positions, given the CNEs that are specified by the TSOs in CWE, can be facilitated under the continuous intraday

trading without endangering the grid security. As such, the FB parameters are able to act as constraints in the allocation of cross-zonal capacity. Only those FB constraints that are most limiting to the net positions need to be respected in the capacity allocation: the non-redundant constraints. The redundant constraints are identified and removed by the TSOs by means of the so-called pre-solve. This pre-solve step is schematically illustrated in the two-dimensional example in Figure 5 below.

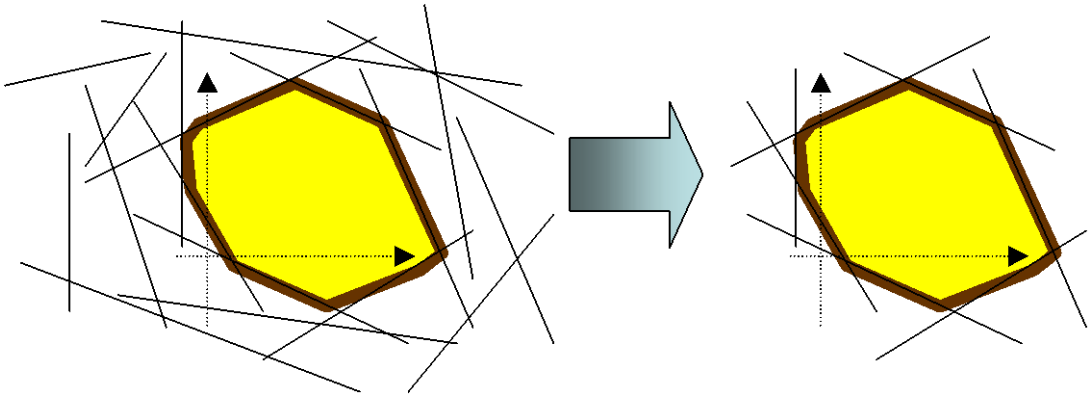


Figure 5: Pre-solve illustration

In the two-dimensional example shown in Figure 5, each straight line in the graph reflects the FB parameters of one CNE. A line indicates for a specific CNE 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 CNE and endanger the grid security. As such, the non-redundant, or pre-solved, FB parameters define the FB capacity domain that is indicated by the yellow region in the two-dimensional figure above.

3.3.2 ID ATC

As described above the following procedure is an intermediate step to make the ID FB method compatible with the current ID ATC process for capacity allocation. The aim is to assess ID ATC values deduced from the FB parameters. The ID ATCs can be considered as a coordinated ATC model of the FB capacity domain. The procedure of ATC computation equals the approved methodology for computing leftover ATCs from FB DA. As a result a set of ATC for each border in each direction is given.

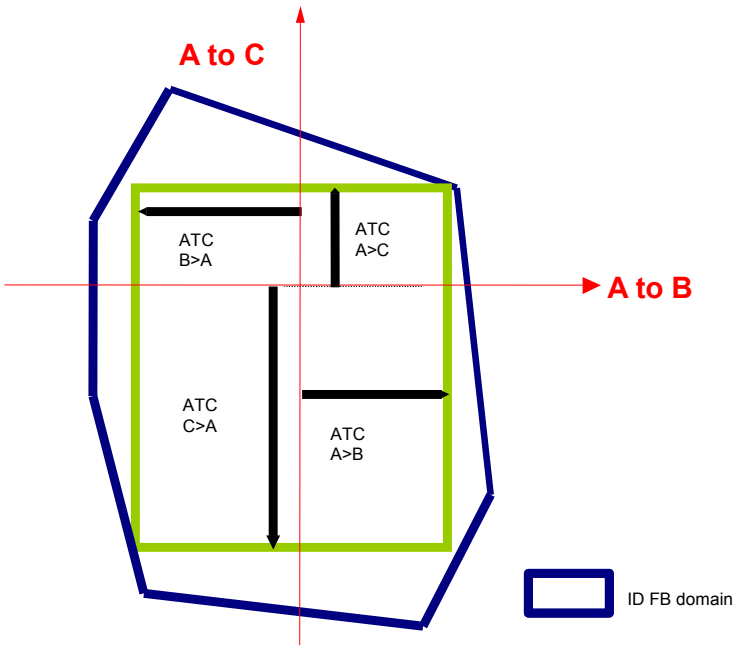


Figure 6: Illustration of ID ATC computation

In the following paragraphs the input and output parameters are described and the iterative method is explained using a pseudo-code and an example calculation.

Input data

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

- Already allocated capacities
- Pre-solved FB parameters

Output data

The calculation leads to the following outputs for each timestamp:

- ID ATC
- Number of iterations that were needed for the ID ATC computation
- CNEs with zero margin after the ID ATC calculation

Algorithm

The ID ATC calculation is an iterative procedure. First, the remaining available margins (RAM) of the pre-solved CNEs have to be adjusted to the net positions at the time of computation. In other words, the ΔID nominations, being the ID nominations between creation of the network model for ID capacity calculation and the timestamp where the ATCs are computed, need to be reflected in the FB domain. The adjustment is performed using the net position shift between both timestamps 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 FB domain from which the ID ATC domain is determined.

From the non-anonymized pre-solved zone-to-hub PTDFs ($PTDF_{z2h}$), zone-to-zone PTDFs ($pPTDF_{z2z}$) are computed, where only the positive numbers are stored[2]:

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

with $A, B = DE, FR, NL, BE, AT$ 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 until the first interconnection of these bidding zones has been commissioned).

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 CNEC, the remaining margin is equally shared between the CWE internal borders that are positively influenced.
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 CNECs.
4. Update the margins on the CNECs using new bilateral exchanges from step 3 and go back to step 1.

This iteration continues until the maximum value over all CNEs 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 CNEs with no remaining available margin left. These are the limiting elements of the ID ATC computation.

[2]Negative PTDFs would relieve CBs, which cannot be anticipated for the ID ATC computation

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

```
While max(abs(margin(i+1) - margin(i))) >StopCriterionIDATC
        For each CNE
                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 CNE
                margin(i+1) = margin(i) – pPTDF_z2z * 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 5.

Special cases

In case the already allocated capacity is not included in the FB domain, the algorithm of market clearing point coverage is used to include the already allocated capacity. The algorithm of capacity extraction can then be performed. In any case the necessity and extent of Market Clearing Point (MCP) inclusion will be tracked in order to allow for potential counter measures.

3.4 Providing ID ATCs for allocation

After the validation process, the responsible TSOs provide the capacity to the available allocation platform.

4 Back-up procedures

The back-up process has to be reliable in order to ensure that capacity will always be delivered to the market players. In case the process fails, the last computed capacity will be provided to the allocation platform. For example, in case the intraday capacity calculation fails, the TSOs will provide to the allocation platforms the leftover of the day ahead capacity.

5 Transparency

The level of transparency of the process will be at least the transparency decided for the CWE day ahead process.

Methodology for capacity calculation for ID timeframe

For NRA approval

Version	Final version 2.0
Date	~~09-05-2017~~29-06-2018

Contents

1 Management summary

The purpose of this approval document is to provide all Regulators of the CWE region with a description of the Flow-Based Intraday Capacity Calculation (FB IDCC) methodology, in order for them to approve it in the framework of the Regulation 714/2009. This document is considered as a follow up of the CWE Flow-Based Day Ahead (FB DA) approval package dated August 1st, 2014 and in particular of the "*Position Paper of CWE NRAs on Flow-Based Market Coupling"* of March 2015, as well as the approval package on the methodology for capacity calculation for the ID timeframe submitted to NRAs on November 9th 2015. The present FB IDCC methodology is therefore to be seen as a third implementation step for the calculation of ID capacity after CWE FB DA market coupling and won't include the coordinated increase/decrease process applied since March 30th 2016.

For the avoidance of any doubts, this document does not cover FB ID allocation. For the purpose of the allocation of capacity, Available Transfer Capacities (ATC) (extracted from the FB domain) will be used. Additionally, the current design of the FB IDCC process is compliant with gate opening at 10PM. Any earlier gate opening time would be challenging in relation to design of the process and the implementation.

The remainder of the document is structured as follows: chapter two contains the glossary with the acronyms used in this paper. The FB ID CC methodology including a description of the inputs, the process and the outputs is presented in chapter three. The next chapter describes the back-up procedures and chapter five includes transparency procedures.

2 Glossary

- **DC calculations:** Direct current calculations. Calculations of unidirectional flow of electric charge.
- **CACM:** Regulation 1222/2015 - Capacity allocation and congestion management guideline
- **DA CGMs & ID CGMs**: Day Ahead & Intraday Common Grid Models which are the result of the merging of the Individual Grid Models provided by TSOs in day-ahead or in intraday as their best forecast of the topology, generation and load for a given hour of the Day D.
- **Day D**: Delivery day for which capacity increases or rejection are considered.
- **DACF**: Day-Ahead Congestion Forecast.
- **Explicit ~~remedial actions~~RAs**: Remedial actions taken into account in the capacity calculation process.
- **ID ATC**: Intraday Available Transfer Capacity.
- **IGM**: Individual grid models
- **FB DA ATC**: The left-over ATC values extracted from the FB DA domain.
- **FB ID ATC**: The ATC values extracted from the FB ID capacity calculation domain.
- **DA MCP**: Day-Ahead Market Clearing Point.
- ~~**MTP**: Market Time Period. A group of consecutive hours within the Day D.~~
- **Net exchange program**: Netto exchanges in terms of cross-zonal flows between different bidding zones.
- **Net position**: netted sum of electricity exports and imports for each market time unit for a bidding zone.
- **PTDF**: Power Transfer Distribution Factor.
- **RA**: Remedial action. Measure applied to modify (increase) the FB domain in order to support the market, while respecting security of supply.
- ~~**RSC**: Regional security coordinator.~~
- **RAM**: Remaining available margins on critical network elements.
- **RSC**: Regional security coordinator.
- **Zone-to-hub PTDF**: Represent the variation of the physical flow on a critical ~~branch~~network element induced by the variation of the net position of each ~~hub~~zone.
- **Zone-to-zone PTDF**: The impact in terms of flows of a power exchange between two zones on a given critical network element.

3 Flow-Based Intraday capacity calculation Methodology

3.1 Inputs

To calculate the FB capacity domain for one timestamp of the business day, TSOs have to assess the following items which are used as inputs into the model:

- Critical Network Elements (CNEs)
- Contigency (C)
- Maximum current on a Critical Network Element (Imax) / Maximum allowable power flow (Fmax)
- Final Adjustment Value (FAV)
- DA Common Grid Model (CGM) and reference Programs
- Remedial Actions (RAs)
- Generation Shift Key (GSK)
- Flow Reliability Margin (FRM)
- Allocation/external constraints: specific limitations not associated with Critical Network Elements
- Data from previous flow-based capacity computations

As a general rule, if there is an agreement between NRAs and TSOs to update the method for the input generation for the D-2 CWE FB process, the consequences of the implementation of these changes for the ID timeframe will be analyzed and, if possible, the FB IDCC method will be adapted in order to align it with the updated D-2 method.

3.1.1 Critical Network Element (CNE) and Contingency (C)

3.1.1.1 Definitions

Definition of a Critical Network Element

A Critical Network Element (CNE) is a network element significantly impacted by CWE cross-border trades and/or by RAs. A CNE has the following parameters:

- An element: a line (tie-line or internal line) or a transformer
- An "operational situation": normal (N) or contingency cases (N-1, N-2 or busbar faults, depending on the applicable TSO risk policies). (See below for link between CNE and Cs)
- A set of Imax (See 3.1.2)
- A FAV (See 3.1.5)
- A FRM (See 3.1.7)

Definition of a Contingency

A Contingency (C) is an event that can occur in the network that will be monitored in the process. A C 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.

Definition of the Critical Network Element and Contingency (CNEC)

A CNEC (combination of Critical Network Element and Contingency) is defined by each CWE TSO who links one of his CNEs with one of the Cs.

3.1.1.2 CNEC list for Remedial Action Optimization

The Remedial Action Optimization is used to find a set of ~~Remedial Actions (RA)~~RAs that will be applied in the FB computation. Therefore, RAO must take into account at least all CNECs that will also be taken into account during FB computation (see section 3.1.1.3). The TSO may specify CNECs to be only taken into account during Remedial Action Optimization. This can be required in order to avoid Security of Supply effects on CNECs that are strongly influenced by RAs albeit only weakly influenced by cross-border exchanges. Consequently, the CNECs considered in the RAO can be a superset of the CNECs used in the FB computation and thus CNECs are not checked for their sensitivity to exchanges.

3.1.1.3 CNEC list for the FB computation

The CNECs with the agreed set of RAs that are monitored in the FB computation should be significantly impacted by CWE cross-border trades. This selection approach is identical to the approved and applied process for the day ahead flow-based capacity calculation.[1]

A set of PTDFs is associated to every CNEC after each FB parameter calculation, and gives the influence of the change of the net position of any bidding zone on the CNEC.

A CNE 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%.

For each CNEC, the following sensitivity value is calculated:

Sensitivity = max (PTDF (BE), PTDF (DE~~/AT~~ /LU), PTDF (AT), PTDF (FR), PTDF (NL)) - min(PTDF (BE), PTDF (DE/LU), PTDF (AT~~/LU~~), PTDF (FR), PTDF (NL))

If the sensitivity is above the threshold value of 5%, then the CNEC is said to be significant for CWE trade. If a CNEC does not meet the pre-defined conditions, the concerned TSO then has to decide whether to keep the CNEC or to exclude it from the CNEC list.

Although the general rule is to exclude any CNEC which does not meet the threshold on sensitivity, exceptions on the rule are allowed: if a TSO decides to keep the CNEC in the CNE list, it has to justify this decision to the other TSOs, furthermore it will be systematically monitored by the NRAs as it is done today in the day ahead process.

If there is an agreement between NRAs and TSOs to update the method for the CNEC selection for the D-2 CWE FB process, the consequences of the implementation of these changes for the ID timeframe will be analyzed and, if possible, the FB IDCC method will be adapted in order to align it with the updated D-2 method.

3.1.2 Maximum current on a Critical Network Element (Imax) and Maximum allowable power flow (Fmax)

The maximum allowable current (Imax) is the physical limit of a CNE determined by each TSO in line with its operational criteria. Imax is the physical (thermal) limit of the CNE in Ampere, except when a relay setting imposes to be more specific for the temporary overload allowed for a particular CNEC.

[1] "Documentation of the CWE FB MC solution as basis for the formal approval-request", Brussels, 1st August 2014, http://jao.eu/support/resourcecenter/overview?parameters=%7B%22IsCWEFBMC%22%3A%22True%22%7D, pp. 18ff

As the thermal limit and relay setting can vary in function of weather conditions, Imax is usually defined at least per season.

When the Imax value depends on the outside temperature or wind conditions, its value can be reviewed by the concerned TSO if outside temperature or wind forecast is announced to be much higher or lower compared to the seasonal values.

Imax is not reduced by any security margin, as all margins have been covered by the calculation of the contingency by the Flow Reliability Margin (FRM, c.f. chapter 3.1.7) and Final Adjustment Value (FAV, c.f. chapter 3.1.5).

Some TSOs allow to overload lines after a contingency up to a temporary limit for a limited amount of time. As a result, two Imax values will be provided for one CNE.

- Temporary Imax
- Permanent Imax

The value Fmax describes the maximum allowable power flow on a CNEC in MW and is given by the formula:

Fmax = $\sqrt{3}$ * Imax * U * cos(φ) / 1000 [MW],

where Imax is the maximum permanent or temporary allowable current (in A [Ampere]) for a CNE. The value for cos(φ) is set to 1 (in case of DC calculations), and U is a fixed value for each CNE and is set to the reference voltage (e.g. 225kV or 400kV) for this CNE.

As several Imax may be provided for one CNE, several Fmax may exist for a CNEC.

3.1.3 Day ahead Common Grid Model

The day ahead Common Grid Model (DA CGM) is created by merging all individual Grid Models (IGMs) from all TSOs of continental Europe and is based on data from DA market coupling and a security assessment of the grid.

For intraday capacity calculation the latest available version of the day ahead Congestion Forecast process (DACF) will be used at the moment the capacity calculation process is initiated. This includes, according to the methodology developed in line with Regulation 1222/2015 Article 16 and 17 (CACM):

- Best estimation of Net exchange program
- Best estimation exchange program on DC cables
- Best estimation for the planned grid outages, including tie-lines and the topology of the grid
- Best estimation for the forecasted load and its pattern
- If applicable best estimation for the forecasted renewable energy generation, e.g. wind and solar generation
- Best estimation for the outages of generating units
- Best estimation of the production of generating units
- All agreed ~~remedial actions~~RAs during regional security analysis.

3.1.4 Remedial Actions (RA)

During FB parameter calculation, CWE TSOs take ~~Remedial Actions (RA)~~RAs into account to improve the FB domain where possible while ensuring a secure power system operation, i.e. N-1/N-k criterion fulfillment.

~~Remedial Actions~~RAs used in capacity calculation can embrace the following measures a.o.:

- 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.
- Redispatching: changing the output of generators by ramping up and down certain power units.

The effect of these RAs on the CWE CNEs is directly determined in the calculation process to monitor the shift of load flow in the entire CWE grid.

There are several types of RAs, differentiated by the way they are used in the optimization of the domain:

- Preventive (pre-fault) and curative (post-fault) RAs: While preventive RAs are applied before any fault occurs, and thus to all CNECs of the flow-based domain, curative RAs are only used after a fault occurred. As such the latter RAs are only applied to those CNECs associated with this contingency. Curative RAs allow for a temporary overload of grid elements and reduce the load below the permanent threshold.
- Shared and non-shared RAs: Each TSO can define whether he wants to share the RA provided for capacity calculation or not. In case a RA is shared, it can be applied to increase the Remaining Available Margin (RAM) on ALL relevant CNEs. If it is a non-shared RA, the TSO shall determine the CNEs for which the RA can be triggered in the capacity optimization.

Each CWE TSO defines and checks the availability of their RAs in its responsibility area according to its operational principles. At least all RAs used for the DA capacity calculation and still available at the time of the ID capacity calculation have to be considered.

The CWE TSOs commit to include the DA MCP in the FB ID CC domain up to the FRM value – except in case of *force-majeure*. In order to do so CWE TSOs foresee to include costly ~~remedial actions~~RAs to avoid automatic DA MCP inclusion.

CWE TSOs will work on developing, testing and implementing this and seek for intermediate steps to reach this commonly agreed target with limited DA MCP inclusion.

Automatic DA MCP inclusion for values higher than FRM should only occur in very exceptional cases (aim to reach a pre-defined threshold).

3.1.5 Final Adjustment Value (FAV)

With the Final Adjustment Value (FAV), operational skills and experience that cannot be introduced into the FB-system can find a way into the FB-approach by increasing or decreasing the remaining available margin (RAM) on a CNE for very specific reasons which are described below. Positive values of FAV in MW reduce the available margin on a CNE while negative values increase it. The FAV can be applied by the responsible TSO during the validation phase to reduce the margin on a dedicated CNE, since the process is expected to be highly automated. 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)~~RAs which cannot be modelled and thus calculated in the FB parameter calculation.
- A positive value for FAV as a consequence of the validation phase of the FB domain, leading to the need to reduce the margin on one or more CNEs for system security reasons. The overload detected on a CNE during the validation phase is the value which will be put in FAV for this CNE in order to eliminate the risk of overload on the particular CNE.

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

3.1.6 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 zone. 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 FB domain, the GSK must be linear and items of the GSK cannot consider minimum or maximum values.

A GSK aims to deliver the best forecast of the impact on CNE of a net position change, taking into account on one hand the operational feasibility of the reference production

program, projected market impact on units, market/system risk assessment and the characteristics of the grid; and on the other hand the model limitations.

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.

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 do not 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).

In order to take into account the characteristics of each TSO's network, individual GSKs are defined for each current bidding zone.

3.1.6.1 GSK for the German ~~-Austrian~~ bidding zone

The German TSOs ~~and APG~~ have to provide one single GSK-file for the whole German~~/Austrian~~ hub. Since the structure of the generation differs for each involved TSO, an approach has been developed, that allows the single TSO to provide GSKs that respect the specific character of the generation in their own control area and to create out of them a concatenated German~~/Austrian~~ GSK in the needed degree of full automation.

Every German TSO ~~as well as APG~~ provides one file per business day. If one TSO does not provide a new GSK file for a business day the replacement strategy will take the latest valid file for working day, bank holiday or weekend day. Within this GSK file, the generators are listed with their estimated share within the specific control area for the different time-periods. Therefore, every German TSO ~~as well as APG~~ provides within this GSK file the generators, according to TSO´s estimation, that participate to a net-position shift of the German~~/Austrian~~ hub. The generation-distribution among the defined generators inside its grid must sum up to 1.

In the process of the German~~/Austrian~~ merging, the FB ID system creates out of these ~~five~~four individual GSK-files, depending on the target day (working day / week-end or bank holiday), a specific GSK-file. The German TSOs ~~and APG~~ defined generation share keys which represent the share of available power in a control area. The content of the individual GSK-files will be multiplied with the individual share of each TSO. This is done for all TSOs with the usage of the different share keys for the different target times. In that way a Common GSK file for German~~/Austrian~~ bidding zones is created on daily basis.

With this method, the knowledge and experience of each German TSO ~~and APG~~ is incorporated in the process to obtain a representative GSK. With this structure, the generators named in the GSK are distributed over the whole German ~~Austrian~~ bidding zone in a realistic way, and the individual factor is relatively small.

The Generation Share Key for the individual control areas i is calculated according to the reported available market driven power plant potential of each TSO, divided by the sum of market driven power plant potential in the bidding zone.

$$\text{GShK TSO}_i = \frac{Available\ power\ in\ control\ area\ of\ TSO_i}{\sum_{k=1}^{54}(Available\ power\ in\ control\ area\ of\ TSO_k)}$$

Where k is the index for the ~~five~~four individual TSOs.

With this approach the share factors could be determined based on regular generation forecasts and will sum up to 1 forming the input for the common merging of individual GSKs.

TransnetBW

To determine relevant generation units TransnetBW takes into account most recent available information at the time when individual GSK-files are generated:

- Power plant availability
- Planned production

The GSK for every power plant i is determined as:

$$GSK_i = \frac{P_{max,i} - P_{min,i}}{\sum_{i=1}^{n}(P_{max,i} - P_{min,i})}$$

Where n is the number of power plants, which are considered for the GSK in the TransnetBW control area.

The following types of generation units connected to the transmission grid can be considered in the GSK:

- hard coal power plants
- hydro power plants
- gas power plants

Nuclear power plants as baseload units are excluded upfront because of their constant power output that does not change during normal operation.

Amprion

Amprion established a regularly 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 unit out of service. According to these changes in the grid Amprion updates its GSK.

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 in changes in the production.

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 part of the GSK. This list is updated regularly. The individual GSK factors are calculated by the available potential of power plant i (Pmax-Pmin) divided by the total potential of all power plants in the GSK list of TTG.

~~APG~~

3.1.6.2 GSK for the Austrian bidding zone

APG's method to select GSK nodes is analogue to the ~~same as for the other~~ German TSOs. So only market driven power plants are considered in the GSK file which was done with statistical analysis of the market behaviour of the power plants. In ~~the~~that case ~~of~~ APG pump ~~storage~~storages and thermal units are considered. Power plants which ~~produce band energy~~generate base load (river power plants) are not considered. Only river power plants with daily water storage are ~~also~~ considered in the GSK file. The list of relevant power plants is updated regularly in order to consider maintenance or outages. ~~Furthermore will the GSK file be also updated seasonally because in the summer period the thermal units will be out of operation.~~

~~3.1.6.2~~3.1.6.3 GSK for the Dutch bidding zone

The Dutch GSK will dispatch the main generators in a manner which avoids extensive and unrealistic under- and overloading of the units for foreseen extreme import or export scenarios. The GSK is directly adjusted in case of new power plants. Also unavailability of generators due to planned outages are considered in the GSK.
All GSK units are re-dispatched pro rata on the basis of predefined maximum and minimum production levels for each active unit~~.~~ in order to prevent infeasible production levels of generators. The total production level remains the same.
The maximum production level is the contribution of the unit in a ~~predefined~~foreseen extreme maximum production scenario. The minimum production level is the contribution

of the unit in a ~~predefined~~foreseen extreme minimum production scenario. Base-load units will have a smaller difference between their maximum and minimum production levels than start-stop units.
For the intraday timeframe, a proportional GSK based on the results of FB DA CC will initially be used, using the same set of GSK units. It is to be expected that, for relatively small volumes of additional capacity given in intraday, this will not result in less reliable results. In the future, a more sophisticated GSK method for intraday may be introduced respecting the GSK description as given in this paragraph.

~~3.1.6.3~~3.1.6.4 GSK for the Belgian bidding zone

Elia will use in its GSK a fixed list of nodes based on the locations where most relevant flexible and controllable production units (market oriented generating units) are connected. This list will be determined in order to limit as much as possible the impact of model limitations on the loading of the CNEs.
The variation of the generation pattern inside the GSK is the following: For each of these nodes, the sum of the generation which are in operations in the base case of each of these nodes will follow the change of the Belgian net position on a pro-rata basis. That means, if for instance one node is representing n% of the sum of the generation on all these nodes, n% of the shift of the Belgian net position will be attributed to this node.

~~3.1.6.4~~3.1.6.5 GSK for the French bidding zone

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.

3.1.7 Flow Reliability Margin (FRM)

~~For each CNE, a~~ The intraday capacity calculation methodology is based on forecast grid models of the transmission system (the DA CGMs). The inputs are created the day before the delivery date of energy with available knowledge at that point in time. Therefore, the outcomes are subject to inaccuracies and uncertainties. The aim of the Flow Reliability Margin (FRM) is to cover a level of risk induced by these forecast errors.

For each oriented CNEC, a FRM has to be defined~~, that quantifies at least how the uncertainty impacts the flow on the CNE.~~. Inevitably, the FRM reduces the remaining available margin (RAM) on the ~~CNE~~CNEC because a part of ~~this free space~~the transmission capacity - 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 FB model to the observation of the corresponding timestamp in real time. More precisely, the base case, which is the basis of the FB parameters computation, is compared with a snapshot of the transmission system on the respective 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 1.~~

As a first step, for each hour of a one-year observatory period, the DA CGMs are updated in order to take into account the real-time tap position of the PSTs that are considered in the intraday capacity calculation. These PSTs are controlled by CWE TSOs and thus not considered as an uncertainty. This step is undertaken by copying the real-time tap position of the PSTs and applying them into the historical DA CGM. The power flows of the latter modified CGM are re-computed and then adjusted to realised commercial exchanges inside the CWE region with the PTDFs calculated based on the historical GSK and the modified DA CGM. Consequently, the same commercial exchanges in the CWE region are taken into account when comparing the power flows resulting from the intraday capacity calculation with flows in the real-time situation. The power flows on each CNEC are then compared with the real-time flows observed on the same CNEC, by means of a contingency analysis. All differences for all hours of a one-year observation period are statistically assessed and a probability distribution is obtained.

As a second step, the 90th percentiles of the probability distributions of all CNECs are calculated. This means that the CWE TSOs apply a common risk level of 10%, i.e., the FRM values cover 90% of the historical errors. The FRM values are computed for all oriented CNECs from the distribution of flow differences between forecast and real-time observation.

This basic idea is illustrated in Figure 1.

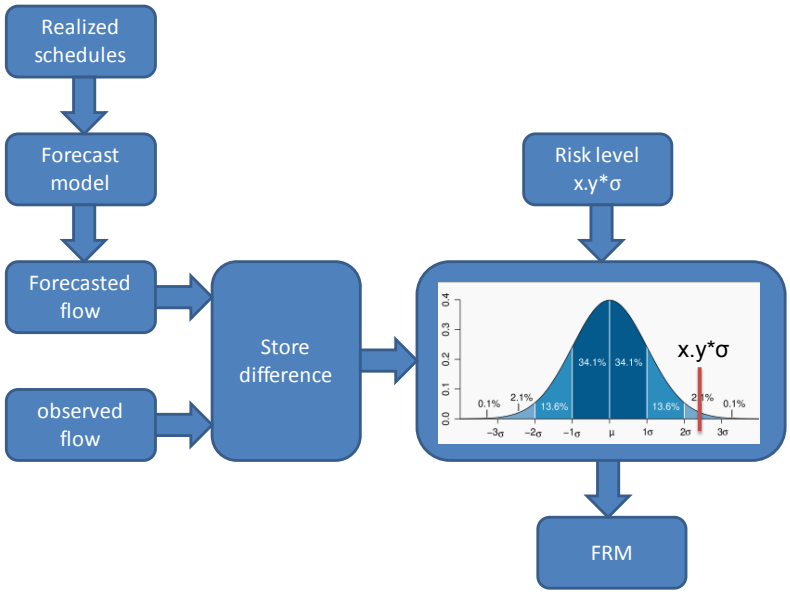


Figure 1: FRM Assessment Principle

~~The differences between the observed and predicted flows 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 level[2], 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
- 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 ~~CNE~~CNEC definition. The rationale behind this is that TSOs remain critical towards the outcome of the ~~pure theoretical approach~~calculation in order to ensure the implementation of parameters which make sense operationally. For any reason (e.g~~.~~., data quality ~~issue~~issues or significant grid topology changes in the past year), it can occur that the ~~"theoretical~~calculated FRM" is not consistent with the TSO's experience on a specific ~~CNE~~CNEC. Should this case arise, the TSO will proceed to an adjustment~~.~~

of the calculated FRM values. The differences between operationally adjusted and ~~theoretical~~calculated FRM values shall be systematically monitored and justified~~, which will be formalized~~ in a dedicated report~~.~~

~~[2]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.~~

to the NRA of the particular TSO applying the operational adjustment. The ~~theoretical~~calculated values remain a "reference", especially with respect to any methodological change, which would be monitored through FRM.

The general FRM computation process can then be summarized by figure 2.

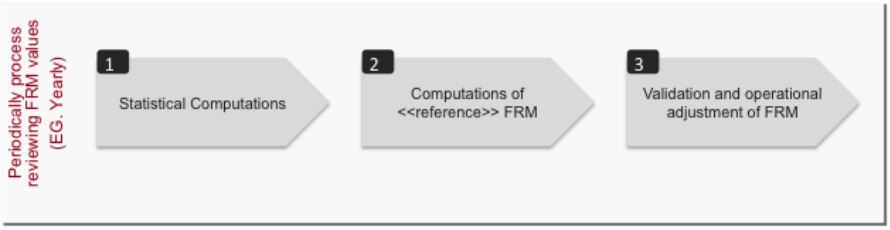


Figure 2: FRM computation process

Step 1: Elaboration of statistical distributions, for all ~~CNE, in~~CNECs (i.e. N and N-1 situations~~.~~).
Step 2: ~~Computation of theoretical (or~~ Calculated (reference) FRM computed by applying ~~of~~ a common 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 CNE, and systematically justified and documented after bilateral agreement.~~ of the FRM values.

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 re-computing FRM values, following the same principles but using updated input data, on a regular basis and at least once a year.

3.1.8 External constraints (EC)

Besides the limitations on CNEs, other specific limitations may be necessary to guarantee a secure grid operation. Import/Export limits for bidding zones declared by TSOs are taken into account as "special" constraints, in order to guarantee that the market outcome does not exceed these limits. For these constraints the term "external constraints" was introduced in the days of implementing DA FB in CWE. In CACM guidelines the term "allocation constraints" is introduced, meaning constraints that need "to be respected during capacity allocation to maintain the transmission system within operational security limits and have not been translated into cross-zonal capacity or that are needed to increase the efficiency of capacity allocation". These allocation constraints are a superset of the external constraints used in CWE as they may also contain other constraints such as technology-driven ramping constraints on HVDC connections. For intraday capacity calculation in CWE the use of the well-known external constraints is deemed sufficient. Therefore, the respective terminology will be used in the remainder of this document.

External constraints can be used for two different reasons. Firstly, they can be justified if market results beyond such constraints would lead to stability and/or voltage management problems. Such ~~stability~~ issues have to be detected via dedicated system ~~dynamics~~ studies. Secondly, market results which are too far from reference flows, and might have unexpected impact due to linearization errors, can be avoided by the external constraints. This aspect is of particular importance during the introduction of FB allocation because new flow patterns may arise. The definition of external constraints is a responsibility of each individual TSO. It is important to understand that these constraints do not limit transit flows.

TSOs remind here that these constraints are not new, since they are already being successfully applied in DA FB capacity calculation. As the physics behind the external constraints remain the same irrespective of the market time period under investigation, the same constraints in the intraday stage as in the day ahead allocation shall be applied in the intraday allocation.

3.2 FB Intraday Capacity Calculation

3.2.1 Operational process

Figure 3 illustrates an overview of the process divided in several steps. Each step is described in the next paragraphs.

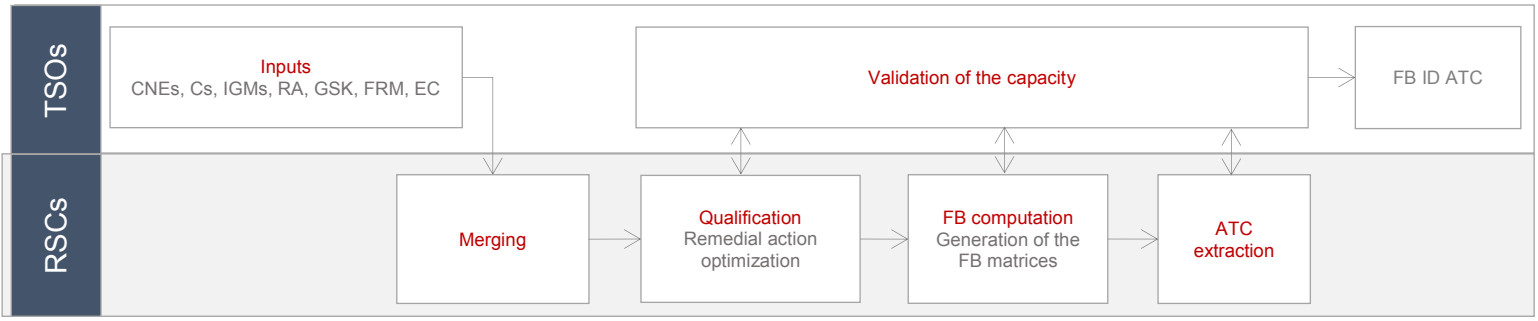


Figure 3: Operational process for FB IDCC.

3.2.2 Inputs

The aim of the input phase is to gather all the necessary inputs decribed in the previous section. The responsibility of the delivery and the quality of the inputs lies with the TSOs.

3.2.3 Merging

The aim of the merging process is to define a common set of data based on the data provided by the TSOs. During this merging process, quality checks are performed.
Concerning the grid model, the merging entity will be in charge to generate the common grid model (CGM) reflecting the best forecast of infeeds, flows and topology of continental Europe at the time of the merge.

The output of the merging process is a clean merged dataset to be used in the next steps:

- Common list of CNECs with associated parameters (Fmax, FRM…)
- Common list of ~~remedial actions~~RAs and condition of use
- Common grid model
- Merged GSK file

3.2.4 Qualification

The aim of the qualification phase is ~~first~~firstly to include the already allocated capacity and ~~second~~secondly to increase the capacity around the already allocated capacity.
In order to achieve this goal, a branch-and-bound optimizer is used in order to associate ~~remedial actions~~RAs to constraints creating an additional margin that can be offered to the market participants. The risk policy of each TSO has to be respected during the association and the impact of the RA on CNECs has also to be assessed in order not to create unsecure grid situations.

In particular, the optimizer determines a set of RAs that improve the flow-based domain according to a defined objective function. In the CWE FB IDCC framework, this objective function aims to increase the minimum relative margin in MW, around the DA MCP. The relative margin is defined as the RAM divided by the absolute sum of the commercial bilateral CWE zone-to-zone PTDF. In case one of the CNECs has a negative RAM, the relative margin will be equal to the RAM.

In this process, the optimizer tries to maximize the RAM of the CNECs relatively to their sensitivity to exchanges, without market assumption (i.e. without a preference to any particular exchange direction so as not to discriminate any border).

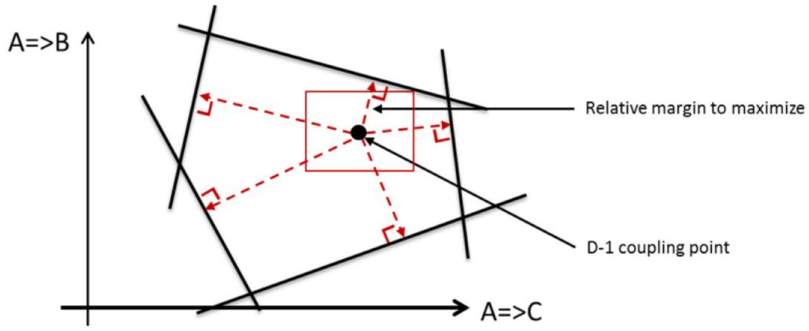


Figure 4: Illustration of the non-discriminatory approach to increase the space around the DA MCP.

The output of this part of the process is:

- A coordinated set of preventive ~~remedial actions~~RAs
- A coordinated set of curative ~~remedial actions~~RAs for contingencies

3.2.5 FB computation

The aim of the FB computation is to deliver the flow-based matrix. The FB parameters computation is a centralized computation.

The outputs of the FB computation process are:

1. PTDF for each hub of the CWE area

The PTDFs are calculated by varying the exchange of a zone, taking the zonal GSK into account. For every single zone-variation the effect on the load of every CNE 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 CNE => PTDF = 10%).
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 CNEs by multiplication with the PTDFs.

2. Margin for each considered CNEC (RAM)

As the reference flow (Fref) is the physical flow computed from the common base case, it reflects the loading of the CNE. Out of the formula:
RAM = Fmax – Fref – FRM - FAV
The calculation delivers, with respect to the other parameters, the free margin for every CNE. This RAM is one of the inputs for the subsequent process steps.

3. List of CNEC limiting the domain

Not all CNECs are relevant for the market as only a few limit the exchanges. The pre-solve sub-process removes the redundant CNECs to create the pre-solved domain.

4. Power Shift Distribution Factors (PSDF) for special grid element

These PSDFs aim at representing the influence of special grid elements on CNECs like cross zonal HVDC links in a Capacity ~~Calcualtion~~Calculation Region which may be used to redistribute the flows in the region.

3.2.6 Validation of capacity

Ideally multiple FB calculations in intraday should be performed. However, currently there is only one FB calculation possible without the possibility to re-assess extracted ID ATC during the day. As a result, with current means available, potential SoS issues during intraday ~~due to unforeseen market behaviour (e.g. change of market direction) and/or severe grid changes (e.g. loss of generator / HVDC cable)~~ cannot be avoided ~~and will be handled as *force majeure*.~~ This may result in the application of additional costly ~~remedial actions~~RAs to ensure grid security. Availability of these ~~remedial actions~~RAs should not be seen as self-evident.

The aim of validation is to verify whether the computed flow-based domains are deemed secure enough according to TSO risk policy. For example, the TSOs can verify voltage/transient stability and perform AC load flows. In case the TSOs detect a constraint, they have several instruments at their disposal to reduce the flow-based or ATC domains:

- Providing one or more additional CNEs, to be taken into account
- Editing or adding external constraints
- Using FAV on a specific CNE
- Updating the availability status of the RAs
- Reduce the ATCs

The use of any of the above mentioned instruments has to be monitored, and is not dedicated to enlarge the flow-based or ATC domain, as it would become too large, thus unsecure. The output of this process is the amended flow-based and/or ATC domain.

3.3 Outputs

The output of FB capacity calculation for the intraday timeframe can be separated in two parts:

- A FB domain resulting from the capacity calculation which can be described by domain indicators;
- Intraday ATCs extracted from the FB domain, as long as the capacity allocation for the intraday market is based on ATC.

Both kinds of output are briefly discussed in the two subsequent subsections.

3.3.1 FB capacity domain

The FB parameters that have been computed indicate which net positions, given the CNEs that are specified by the TSOs in CWE, can be facilitated under the continuous intraday trading without endangering the grid security. As such, the FB parameters are able to act as constraints in the allocation of cross-zonal capacity. Only those FB constraints that are most limiting to the net positions need to be respected in the capacity allocation: the non-redundant constraints. The redundant constraints are identified and removed by the TSOs by means of the so-called pre-solve. This pre-solve step is schematically illustrated in the two-dimensional example in Figure 45 below.

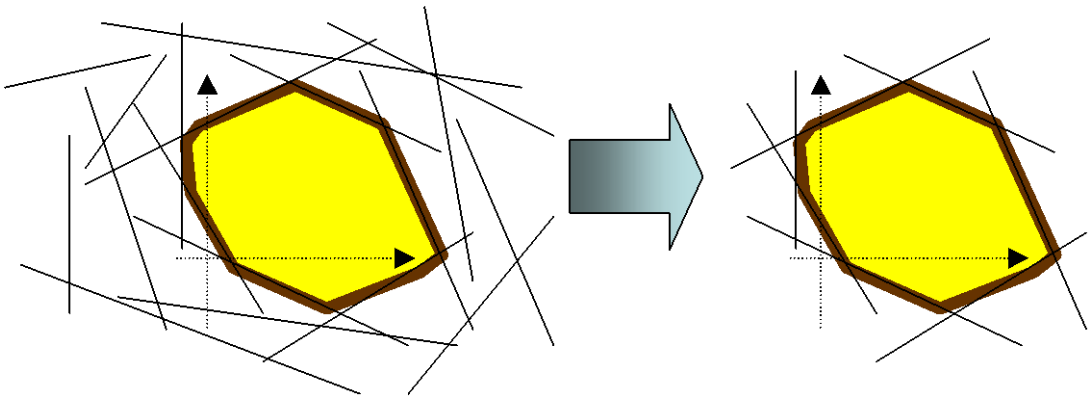


Figure 45: Pre-solve illustration

In the two-dimensional example shown in Figure 45, each straight line in the graph reflects the FB parameters of one CNE. A line indicates for a specific CNE 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 CNE and endanger the grid security. As such, the non-redundant, or pre-solved, FB parameters define the FB capacity domain that is indicated by the yellow region in the two-dimensional figure above.

3.3.2 ID ATC

As described above the following procedure is an intermediate step to make the ID FB method compatible with the current ID ATC process for capacity allocation. The aim is to assess ID ATC values deduced from the FB parameters. The ID ATCs can be considered as a coordinated ATC model of the FB capacity domain. The procedure of ATC computation equals the approved methodology for computing leftover ATCs from FB DA. As a result a set of ATC for each border in each direction is given.

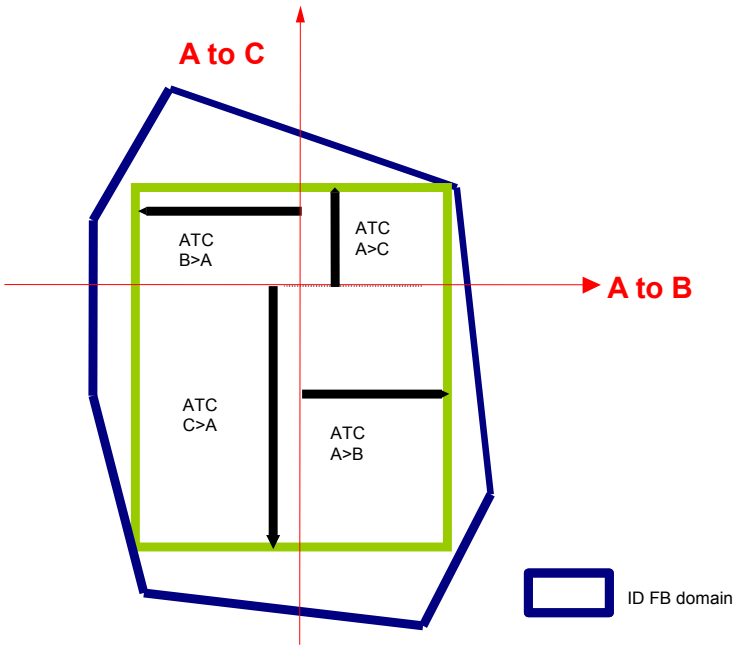


Figure ~~5~~6: Illustration of ID ATC computation

In the following paragraphs the input and output parameters are described and the iterative method is explained using a pseudo-code and an example calculation.

Input data

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

- Already allocated capacities
- Pre-solved FB parameters

Output data

The calculation leads to the following outputs for each timestamp:

- ID ATC
- Number of iterations that were needed for the ID ATC computation
- ~~Branches~~CNEs with zero margin after the ID ATC calculation

Algorithm

The ID ATC calculation is an iterative procedure. First, the remaining available margins (RAM) of the pre-solved CNEs have to be adjusted to the net positions at the time of computation. In other words, the ΔID nominations, being the ID nominations between creation of the network model for ID capacity calculation and the timestamp where the ATCs are computed, need to be reflected in the FB domain. The adjustment is performed using the net position shift between both timestamps 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 FB domain from which the ID ATC domain is determined.

From the non-anonymized pre-solved zone-to-hub PTDFs ($PTDF_{z2h}$), zone-to-zone PTDFs ($pPTDF_{z2z}$) are computed, where only the positive numbers are stored[3]:

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

with $A, B = DE, FR, NL, BE, AT$ 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 until the first interconnection of these bidding zones has been commissioned).

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 CNEC, the remaining margin is equally shared between the CWE internal borders that are positively influenced.
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 CNECs.
4. Update the margins on the CNECs using new bilateral exchanges from step 3 and go back to step 1.

This iteration continues until the maximum value over all CNEs 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 CNEs 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(abs(margin(i+1) - margin(i))) >StopCriterionIDATC
        For each CNE
                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 CNE
                margin(i+1) = margin(i) – pPTDF_z2z * 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~~5.

Special cases

In case the already allocated capacity is not included in the FB domain, the algorithm of market clearing point coverage is used to include the already allocated capacity. The algorithm of capacity extraction can then be performed. In any case the necessity and extent of Market Clearing Point (MCP) inclusion will be tracked in order to allow for potential counter measures.

[3]Negative PTDFs would relieve CBs, which cannot be anticipated for the ID ATC computation

3.4 Providing ID ATCs for allocation

After the validation process, the responsible TSOs provide the capacity to the available allocation platform.

4 Back-up procedures

The back-up process has to be reliable in order to ensure that capacity will always be delivered to the market players. In case the process fails, the last computed capacity will be provided to the allocation platform. For example, in case the intraday capacity calculation fails, the TSOs will provide to the allocation platforms the leftover of the day ahead capacity.

5 Transparency

The level of transparency of the process will be at least the transparency decided for the CWE day ahead process.

Explanatory note for capacity calculation for ID timeframe

For additional information

Version	Final version 2.0
Date	29-06-2018

Contents

1 Management summary

1.1 Purpose of the document

The purpose of this explanatory note is to describe the concept of the Flow-Based Intraday Capacity Calculation (FB IDCC) and thereby to complete the Methodology for capacity calculation for intraday timeframe that is provided for approval to the CWE NRAs in the framework of Regulation 714/2009. It provides in particular a more detailed explanation of the methodology, the experimentation results and the further improvements foreseen.

In order to ensure a manageable implementation of the FB IDCC within a reasonable timeframe, TSOs focused on a set of requirements to be covered by the present concept as a first step towards a CACM enduring solution. These are the following:

- At least one FB ID computation should be performed for each time stamp (TS).
- Concerning the network model, focus is mainly on DA CGM, possibility of the applicability of ID CGM will be analysed and potentially implemented.
- For the remaining inputs, the methodology should be close to the day ahead (DA) method.
- All Remedial Actions (RA) coordinated in DA should be considered if still available, and possible additional RAs should be considered.
- In order to increase the coordination and ease the operational process, taking into account the time constraints, an optimizer will be developed to link RAs to Critical Network Element Contingency (CNEC) in a way to optimize capacities.
- At the end of the capacity calculation process, ATCs will be extracted from the flow-based domains.

This paper provides a detailed description of the inputs and processes. The major change compared to the FB DA method relates to RA optimization including usage of CNECs. Due to the time constraints in intraday, a highly automated process is needed.

Particular attention has been taken in order to provide a clear objective function and ensure that the inputs allow to apply this new methodology. The other needed inputs, processes and outputs are also described in a similar way as in the FB DA approval package.

The remainder of this document is structured as follows: chapter two contains an introduction. A description of the FB IDCC process is defined in chapter three and the partial results of the internal parallel run with assessments and learnings are presented in chapter four. The next chapter describes the improvements on the inputs and the process for the future FB IDCC and chapter six provides technical and quality criteria for the parallel run.

2 Introduction

2.1 Background of FB IDCC

2.1.1 Recalculation of the existing Flow-Based Day-Ahead Capacity Values

Due to the structural change in the electricity sector, mainly due to the increase of intermittent renewable energy sources, liquid and efficient intraday markets become more and more important. Cross border capacities are of major importance for the liquidity by increasing trade and balancing opportunities for the market players between market areas. While guarantying security of supply, TSOs have the obligation to deliver to the market as much available capacity as possible.

With the implementation of the FB Market Coupling, CWE TSOs developed a flow-based capacity calculation for the day ahead timeframe. Using the latest available information on grid, demand and supply TSOs compute the available capacity before the day ahead allocation (12 am D-1). As this information is supposed to change over time, a recalculation of the available capacity after the day ahead timeframe might lead to additional capacity for the intraday allocation, supporting cross border trade and balancing opportunities for market parties. However, it has to be noted that a recalculation taking into account the latest available information on grid, demand and supply could also result in less available capacity for the intraday timeframe. In any case, the already allocated capacity will be ensured.

According to the CACM Guideline the target model used in the capacity calculation methodologies shall be a flow-based approach and should ensure that cross-zonal capacity is recalculated within the intraday market timeframe based on the latest available information. Moreover, the frequency of this recalculation shall take into consideration efficiency and operational security. On the way towards a CACM compliant capacity calculation methodology CWE TSOs will apply a step-wise approach on the basis of the current intraday ATC solution and under consideration of the target model to be developed and implemented in the Core region.

2.1.2 Current solution is an ID ATC calculation after FBMC process

The current capacity calculation methodology for the intraday timeframe is based on an ATC approach (intraday ATC calculation). This solution is an outcome of a step-wise evolution from a bilateral increase/decrease process to a coordinated increase/decrease process.

The intraday ATC calculation process was inspired by the process that was implemented before FB Go Live on the DE-NL and BE-NL borders and the CWE ATC day ahead process, which also combined different local processes with coordination on CWE level in consecutive steps. Starting point for the intraday ATC calculation methodology are the initial intraday ATC values, which result from the FB day ahead process. The initial intraday ATC is computed out of the day ahead FB domain around the day ahead market clearing point and is the result of a unique and common centralized computation. The first step is followed by a local assessment by CWE TSOs evaluating a possible increase or decrease on their own borders. The third step is a merging step by a common system. A Central Matching Tool (CMT) consolidates the increase requests and the decrease notifications. Based on this consolidated input, all CWE TSOs perform a local analysis that enables them to accept, partially accept or reject the requested capacity increases in a justified manner. Finally, the acceptance or rejection messages are handled in a common way by the CMT.

2.2 Context of FB IDCC

2.2.1 Request from CWE NRAs to design a Flow-Based IDCC process

According to Regulation EC 714/2009, TSOs shall establish a congestion management method for the different timeframes taking into account the electrical and physical realities of the network.

After receiving the "Position Paper of CWE NRAs on Flow-Based Market Coupling" of March 2015, CWE TSOs implemented a bilateral increase/decrease process starting from initial intraday ATC values, which was extended to a coordinated increase/decrease process by November 2015. This process allows for more capacity at the intraday timeframe, taking stock of recent information on grid, consumption, generation parameters and renewables.
In February 2016 CWE NRAs communicated their position regarding the implementation of the coordinated intraday ATC calculation to CWE TSOs. CWE NRAs stressed that the proposed method is not in line with the request made in the Position Paper, since the proposed method is seen as a reassessment but not as a recalculation of the intraday ATC values by CWE NRAs.

CWE NRAs and TSOs discussed the development of a flow-based capacity calculation for the intraday timeframe during 2016. In May 2016 a workshop was held in order to discuss the FB IDCC concept foreseen to be implemented in CWE, the challenges compared to FB day ahead and the implementation approach. Also the aim of the workshop was to provide detailed explanations and receive direct feedback from the regulators.

After the decision taken by ACER on CCRs on November 17th 2016, CWE NRAs have communicated to CWE TSOs on January 4th 2017 a letter officially requesting CWE TSOs to continue with the development and implementation of a Flow-Based Intraday Capacity Calculation Methodology in CWE, as an extension of the original and already approved CWE FB DA MC. This letter also reminds that the Flow-Based Intraday Methodology has to be compliant with the general and content-related objectives of the CACM Regulation.

2.2.2 Planning for implementation

CWE TSOs are working towards the implementation of FB IDCC, which will replace the current coordinated bilateral increase/decrease process. The FB IDCC implementation planning, up-to-date as of the submission of this document, can be found in Figure 1.

CWE TSOs would like to highlight that this is a challenging planning reflecting the earliest go-live date seen as feasible as of this submission, but that high uncertainties remain, including:

- progress in the central and local implementation of industrialized IT tools;
- the need for significant testing and validation of these tools, as this is the first CC process running in CGMES format and using an automated RAO;
- the potential need for further optimization of system performance, considering the shorter duration of the FB IDCC process when compared to the FB DA process.
- the approval by NRAs of the FB IDCC methodology and potential requests for additional ammendments.

TSOs plan the go-live of FB IDCC on BD 20190619, but note that, considering the elements above, the go-live could be delayed until the end of September 2019.

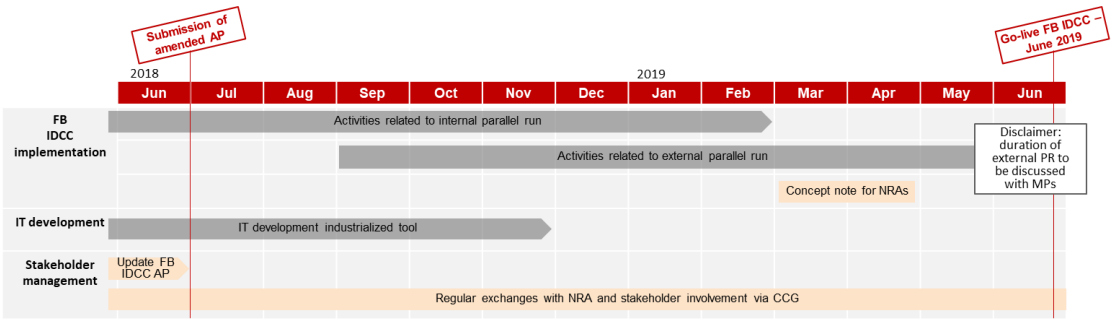


Figure 1: Planning for implementation FB IDCC.

During meetings with NRAs and the CCG, the project will inform stakeholders of additional updates and next steps.

3 General principles of Flow-Based Intraday Capacity Calculation

3.1 Inputs

Each time intraday capacity will be computed, the TSOs will have first to provide all the required input data: Individual Grid Models (IGMs) aiming at representing the best forecast of his control area for the computed timestamps, especially for what concern the latest consumption forecast, topology, latest RES forecast, operating schedules of generators and exchange schedules, the list of Critical Network Elements (CNEs), Contingencies (Cs), Flow Reliability Margins (FRMs), available Remedial Actions (RAs), the Generation Shift Key (GSK) and the External Constraints (ECs). These inputs will be provided for each remaining hour of the day.

3.1.1 ECs

The following sections will depict in detail the method used by each TSO[1] to design and implement external constrains. These methods were already approved together with the DA FB methodology.

3.1.1.1 German External Constraint

Amprion, TransnetBW and TenneT Germany do not apply External Constraints for the German Market area.

3.1.1.2 Dutch External Constraint

TenneT NL determines the maximum import and export constraints for the Netherlands based on off-line studies, which include voltage collapse analysis, stability analysis and an analysis on the increased uncertainty introduced by the GSK, 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.

3.1.1.3 Belgian External Constraint

To ensure operational security, Elia uses an import limit constraint as an additional FB constraint which is related to the voltage control and dynamic stability of the network. The value is set to be the global constraint minus the allocated capacities after Market Coupling (in relevant import or export direction) on non-CWE borders and the capacity calculated on non CWE borders. This limitation is estimated with offline studies which are performed on a regular basis.

3.1.1.4 French External Constraint

RTE will not use any External Constraint in most cases.
In some specific cases (cold front for example) though, RTE could use an import/export limit constraint related to the voltage control and dynamic stability of the network. If required, these limitations will be calculated with a dynamic study performed on the afternoon of D-1. The use of External Constraints will be systematically reported to the NRA.

3.1.1.5 Austrian External Constraint

APG will not use an External Constraint in most cases.

In some situations APG would use an import/export limit constraint to address specific load flow situations (e.g. change of the likely market direction). The EC would be based on offline studies which are performed on a regular basis and after first operational

[1]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.

experience is gained with the bidding zone border split DE/AT. The use of External Constraints will be systematically reported to the NRA.

3.2 FB ID CC Process

On an abstract level, the Flow-based Intraday Capacity Calculation process can be described by the following flow chart in Figure 2.

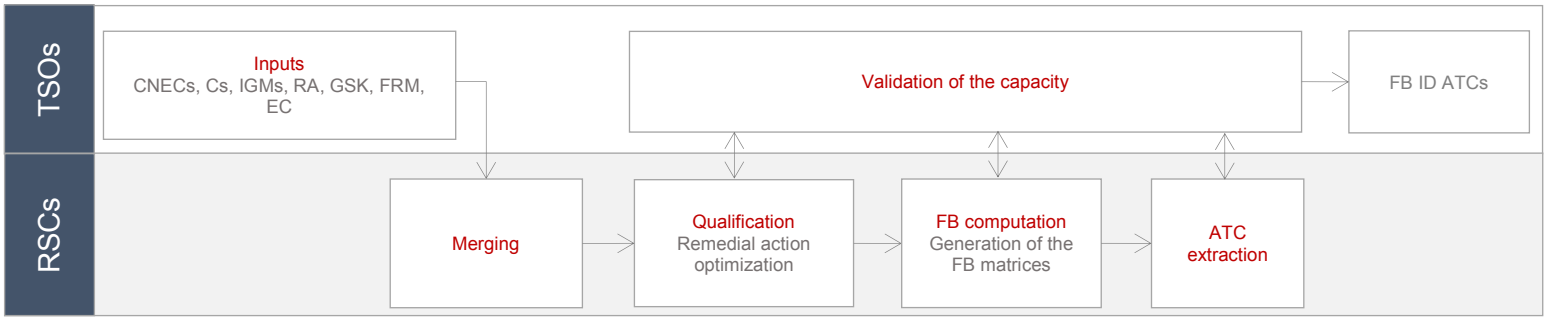


Figure 2: FB IDCC process.

Once the inputs have been provided, the Regional Security Coordinators (RSCs) in charge of the merging and computation will merge the IGMs. The aim of the merging process is to define a common set of data based on the data provided by the TSOs. This will result in Common Grid Models (CGMs). During the merging process quality checks are performed.
For the construction of the CGMs the IGMs of CWE TSOs but also of every continental European TSO will be used. At the time of the merge this CGM is the best forecast of the infeeds and flows in Continental Europe.

Once the CGMs are generated the qualification phase starts. The aim of the qualification phase is first to include the already allocated capacity and second to increase the capacity around the already allocated capacity.

In order to achieve this goal, a branch-and-bound optimizer is used in order to associate remedial actions to constraints creating an additional margin that can be offered to the market participants. The objective of the optimization is to maximize the relative margin of the CNEC that has the lowest relative margin using available RAs, which means to optimize those RAMs that can be effectively optimized and yield the highest impact on capacities. The relative margin is the RAM divided by the absolute sum of the commercial bilateral CWE zone to zone PTDF. If a CNEC has a negative RAM, its relative margin will be equal to the RAM.

The aim is to introduce a gain in terms of capacity and not absolute Ampere. Presently the PTDFs are computed before and after the choice of the preventive remedial actions. The risk policy of each TSO has to be respected during the association and the impact of the RA on CNECs has also to be assessed in order not to create an insecure grid situation. The outputs of this part of the process is, for each remaining hour of the day:

- A coordinated set of preventive remedial actions,
- A coordinated set of curative remedial actions for contingencies.

Based on these outputs, the FB computation will be performed with the aim to deliver the flow-based parameters just like in the DA FB computation.
The outputs of the FB computation process are for each remaining hour of the day:

- a PDTF per hub and CNEC
- a margin per CNEC
- a list of limiting CNEC (pre-solved domain)
- and, optionally, Power Shift Distribution Factors (including virtual hubs) per special grid element (Eg. HVDC links)

In case the day ahead market clearing point is not included in the FB domain (at least one CNEC has negative margin after the Remedial Action Optimization and flow-based computation), the day ahead market clearing point will be automatically included in the domain (Annex 6.1).

The resulting FB domain will then be used to extract the available transfer capacities (ATCs) for each remaining hour of the day, for each border and direction. Remedial Action Optimization, FB computation and ATC extraction will be performed in a central place by RSCs.

As in any capacity calculation process, the results of Remedial Action Optimization, FB computation and ATC extraction will be subject to validation by TSOs. The aim of this validation is to verify if the computed flow-based domains and extracted ATCs are still secured after computation. The proposed methodology foresees different ways to perform a validation after Remedial Action Optimization and FB computation like using FAV, changing EC, modifying CNECs and/or change of RAs. However, it has to be noticed that for the time being no TSO intends to use one of these possibilities. Currently, only a validation of the ATCs after ATC extraction is foreseen.
After the validation, the ATCs will be made available to the market players on the allocation platforms for the 24 hours.

4 Flow-Based IDCC internal parallel run Results Flow-Based IDCC Experimentation Results

TSOs in collaboration with RSCs are performing an internal parallel run in several phases in order to develop, test and verify a new capacity calculation process for the intraday timeframe. The new capacity calculation process is based on a Flowbased approach using ATC extraction to determine the final capacities to be provided to the market.

The main focus of the internal parallel run is on implementing a new operational process on RSC and TSO side, and improving the Remedial Action Optimizer in accordance with TSO's business requirement, while developing the final IT environment in parallel.

During the parallel run, the results are monitored and analyzed in order to constantly improve the quality and development of the Intraday Flowbased process.

Results for the timespan from **29/05/2017** to **31/03/2018** are analyzed.

4.1 Approach

The process of the internal parallel run is designed to be as close as possible to the later operational process. Nevertheless, due to the challenges for the introduction of a new operational process like IT development and operator availability, different process timings and increased expert involvement is required.

Five main steps of the internal parallel run process can be identified:

- Initial data preparation, mapping & checks
- Remedial Action Optimization
- Flowbased computation
- ATC extraction
- Validation of capacities

1. Initial data preparation, mapping & checks

The main objective is to prepare the input for the daily RA optimization and Flowbased computation. The following input is required:

- Initial DA CGM (containing corrections on tie-lines inconsistencies, balance mismatch, correction of loadflow parameters etc.)
- Reference program
- Critical Network Elements, Contingencies and Remedial Actions (CNE, C, RA)
- Generation Shift Key (GSK)
- External Constraints (EC)
- Initial and increased ID ATC domain (for comparison)

2. Remedial Action Optimization

In this step ID capacities are optimized by a set of shared remedial actions (see section 3.1.4. of Methodology). TSOs define the remedial actions that are available for the Remedial Action Optimization and the set of considered CNECs.

3. Flowbased computation

The main objective of step is to perform a Flowbased computation considering all Remedial Action determined by the Remedial Action Optimization.

4. ATC extraction

ATCs are extracted from the Flowbased Domains of step 3 for each hour.

5. Validation of capacities

Before the ATCs are considered as final, each TSO has the opportunity to validate the calculated capacities.

4.2 Intraday Flowbased Key Performance Indicators

In order to assess and monitor the performance and the impact of the new intraday capacity calculation process, CWE TSOs developed four main indicators, the Intraday Flowbased Key Performance Indicators (KPI), that are more detailed below:

- Computed Business Days
- MCP indicator
- ATC indicator
- Minimum ATCs

Results from **29/05/2017** to **31/03/2018** are analyzed.

4.2.1 Computed Business Days

The percentage of all successfully computed timestamps or business days during the parallel run indicates the reliability of the current process from an IT and operational point of view.

The overall results for the internal parallel run and the 30 days moving average can be seen below.

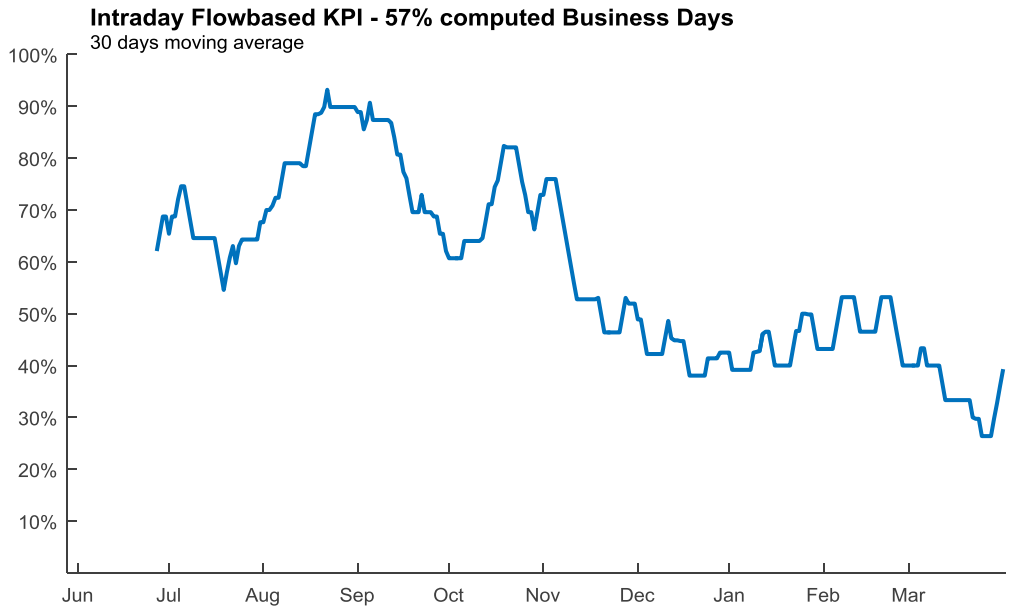


Figure 1: Computed Business Days (29/05/2017 to 31/03/2018)

Overall, 57% of all business days are successfully computed. Main reasons for non-computed days are issues with the IT prototypes being used for the parallel run and challenges of a new daily operational process.

Starting in November 2017 re-occurring IT issues prevent more computed business days. However, the problems could be fixed in April 2018 and a higher rate of computed business days is expected for the remaining parallel run.

4.2.2 MCP indicator – percentage of the DA Market Clearing Point (MCP) Inclusion without FRM

This indicator looks at the minimum absolute margin on the CNECs that will be monitored during the FB computation after Remedial Action Optimization. If this value is above or equal to 0 MW, the MCP is considered as included and all congestions could be removed before the Flowbased calculation starts. In order to have an indicator reflecting the flows in the gridmodels, the security margins (ID FRM) are not considered for this indicator.

The following figure shows the behavior of the MCP indicator (30 days moving average) from 29/05/2017 to 31/03/2018.

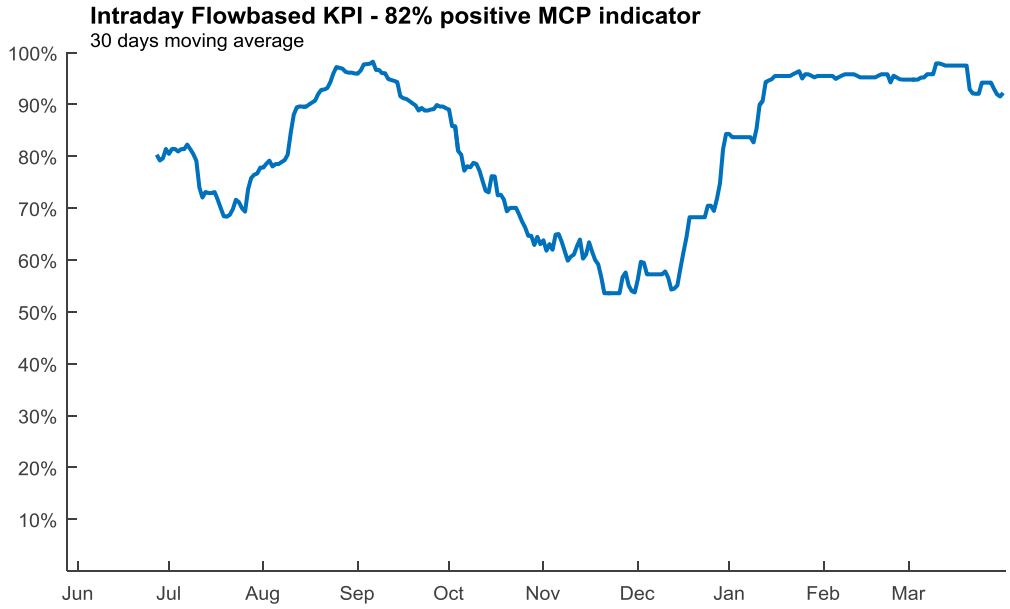


Figure 2: MCP indicator (29/05/2017 to 31/03/2018)

The DA MCP inclusion indicator without FRM averages at 82% for the internal parallel run. It surpasses values of 95% or higher in August and September, before it decreases below 55% during autumn due to a stressed grid situation and planned outages. At the end of 2017 several improvements in the grid and in the process were implemented that positively affected this indicator.

In December, the positive MCP indicator values raises and remains at approximately 95% for the 30 days moving average in January, February and March.

4.2.3 ATC indicator

The resulting ATCs per border and direction extracted from the ID FB domain are compared to the ATCs from the current Intraday ATC after FBMC increase/decrease process and a reference ATC obtained from a statistical analysis on the intraday behavior of the market participants and cross border nominations.

For each hour, the differences for all borders are summed. If the sum is equal to or higher than zero, the value is counted as positive.

The results are shown below:

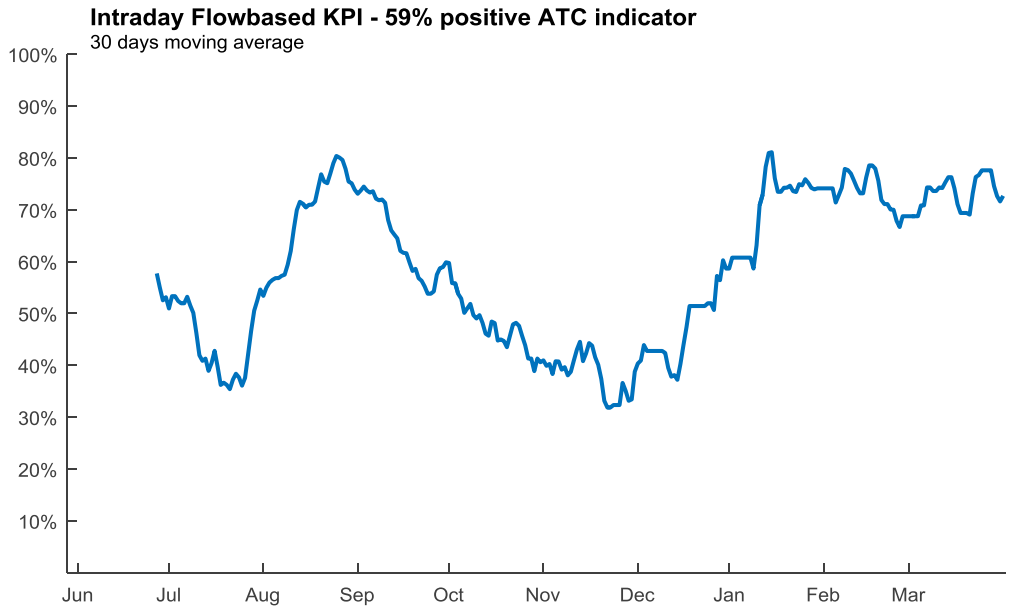


Figure 3: ATC indicator (29/05/2017 to 31/03/2018)

On average, 59% of the timestamps show positive values which means that more frequently capacities similar or better fitting the historical market use, when compared to the ID ATC after FBMC increase/decrease process, can be offered to the market.

Similar to the MCP indicator, constant high positive values can be seen starting in January, while low values occur during the stressed grid situations in autumn.

In the figure below, the ATC indicator is shown for each border.

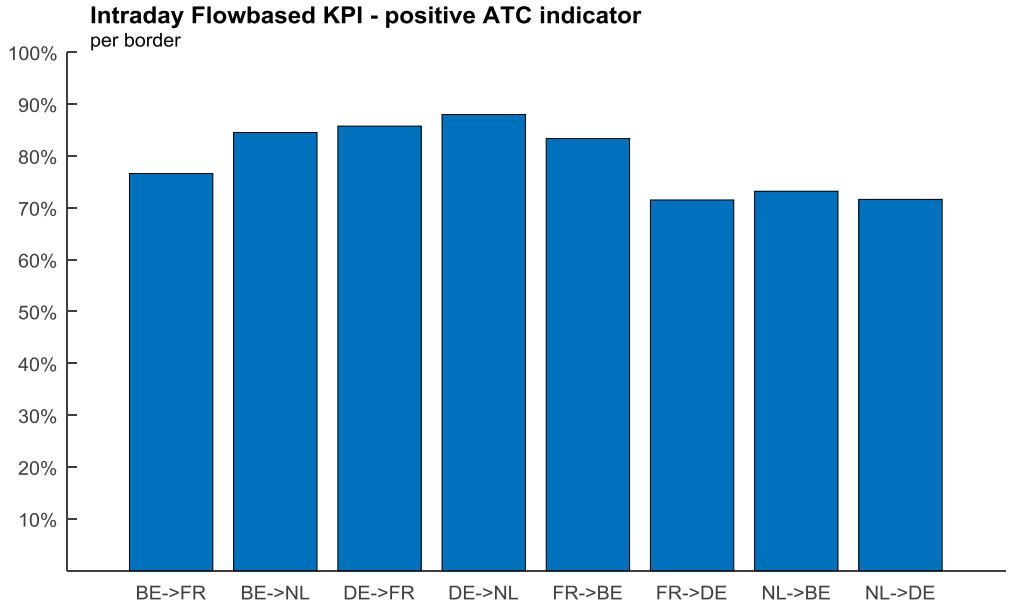


Figure 4: ATC indicator per border (29/05/2017 to 31/03/2018)

The ID ATC indicator reaches at least 70% for each individual border for the parallel run. The most positive impact can be observed for the German export capability with values over 85%.

4.2.4 Minimum ATC

This indicator compares the minimum ATC for the Intraday Flowbased process and the actual values of the ID ATC after FBMC increase/decrease process. The minimum ATC is the lowest ATC value of all commercial borders for each timestamp. In case the difference between the Intraday Flowbased process and the current process is zero or higher, the timestamp is counted as positive.

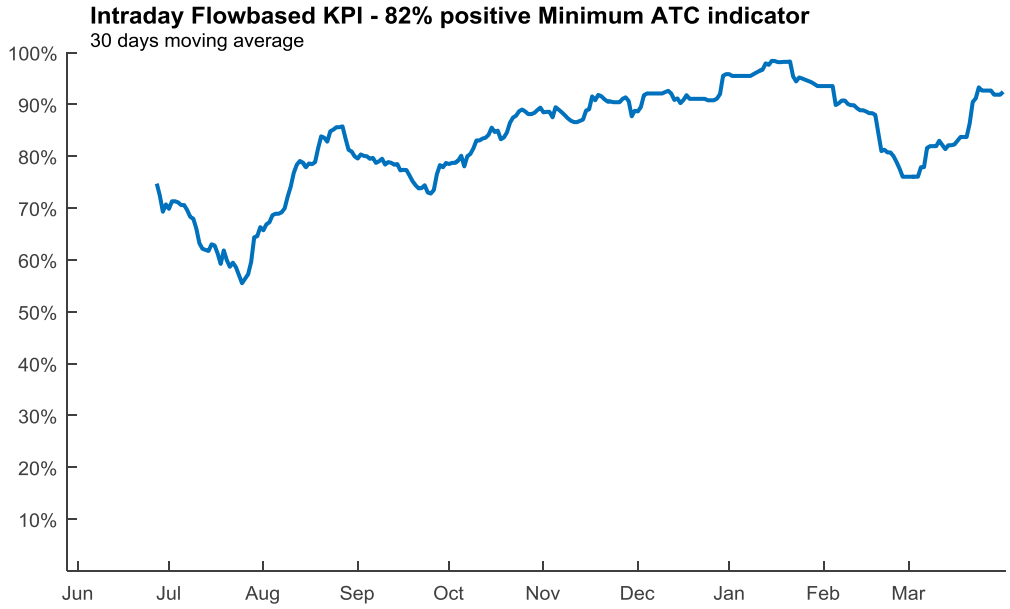


Figure 5: Minimum ATC indicator (29/05/2017 to 31/03/2018)

On average, a value of 82% is observed for the minimum ATCs. In particular, during the more stressed grid situation in autumn and winter, constant high values can be seen, although the MCP inclusion and ATC indicator show decreased values for this period. This is caused by low initial ATC values of the current process during that period. The new calculated ATC are able to match or surpass them most of the time.

The following figure gives a more detailed look of the actual values of the minimum ATCs. The differences between the current process and the IDCC process can be seen.

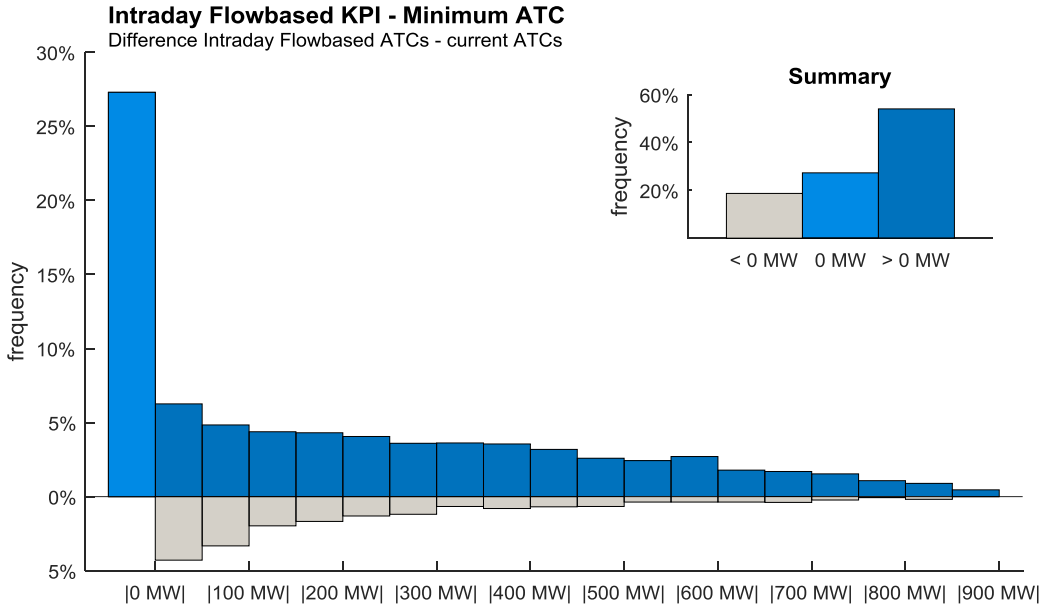


Figure 6: Minimum ATC indicator – values in MW (29/05/2017 to 31/03/2018)

The FB IDCC process shows higher minimum capacities when compared to the current ID ATC after FBMC incr/decr. process in 54% of all timestamps, and lower minimum capacities in around 19% of all timestamps.

A noticeable positive effect on the minimum ATC occur for the range from 0 MW to 900 MW for positive values (dark blue bars). The frequency for higher delta of positive minimum ATCs slightly decreases with higher delta values.

For negative values (grey bars), frequent decreases mainly occur for the range between 0 MW and 100 MW.

One of the main drivers for the positive results of this indicator is the Remedial Action Optimization that defines the ideal set of Remedial Action to improve the capacities around the Market Clearing Point.

4.3 Conclusion

Results in terms of capacities show positive elements.

Furthermore, there are additional benefits to the process that justify an implementation of FB IDCC:

- A better coordinated process;
- A more secure grid, as accuracy of forecasts is improved when compared to FB DA CC;
- More transparency regarding results.

However, more capacities for all directions compared to FB DA and the ATC increase/decrease process cannot be guaranteed with the new process as the simultaneous optimization of FB domains in all market directions is not possible.

The main challenges are to improve reliability of the process and the frequency of MCP inclusion. CWE TSOs commit to include the DA MCP in the FB ID CC domain up to the FRM value – except in case of force-majeure. Automatic DA MCP inclusion for values higher than FRM should only occur in very exceptional cases.

5 Developments for future FB IDCC

The current FB IDCC method has been developed in the CWE area. The new capacity calculation region is now the Core CCR and subsequently a FB IDCC method will be developed in that CCR as set forth in CACM. The following improvements of the CWE FB IDCC methodology will therefore need to be coordinated at Core level. Hereafter is a list of possible future improvements to be implemented in that context:

5.1 Additional recomputations in ID

In the current process, only one recomputation is coordinated with all TSOs. This recomputation is performed in the evening of the D-1. In the future, additional recomputations (i.e. after IDCZGOT) could be implemented based on the updated set of data: IGMs, but also remedial actions, in order to assess more efficiently the capacity that can be provided to the market players.

5.2 Developments foreseen in order to cope with the evolution of the system in the region

In the case of new HVDC interconnectors within the CWE area that will be operated in parallel with the AC system, the following is presenting possible adaptations to the capacity calculation process which would allow considering the influence of this grid element:

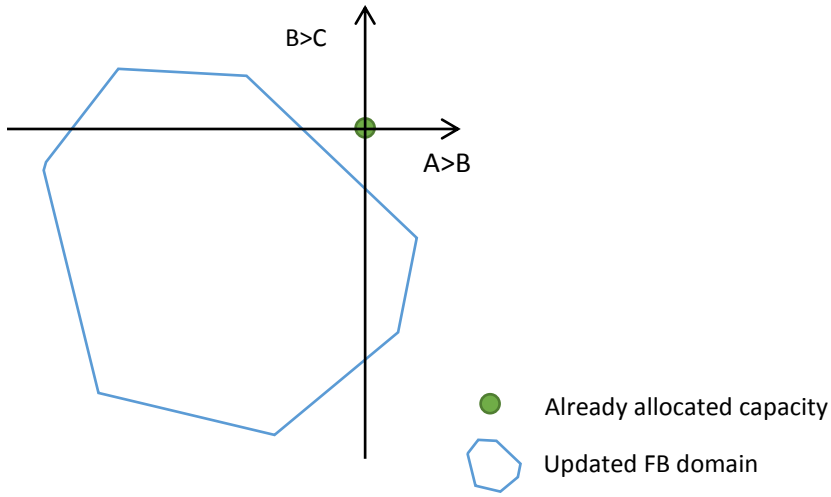
The impact of an exchange over the HVDC is considered for all relevant Critical Network Elements Contingencies (CNECs).

The outage of the HVDC interconnector is considered as a contingency for all relevant CNEs in order to simulate a zero flow over the interconnector, since this is becoming the n-1 state.

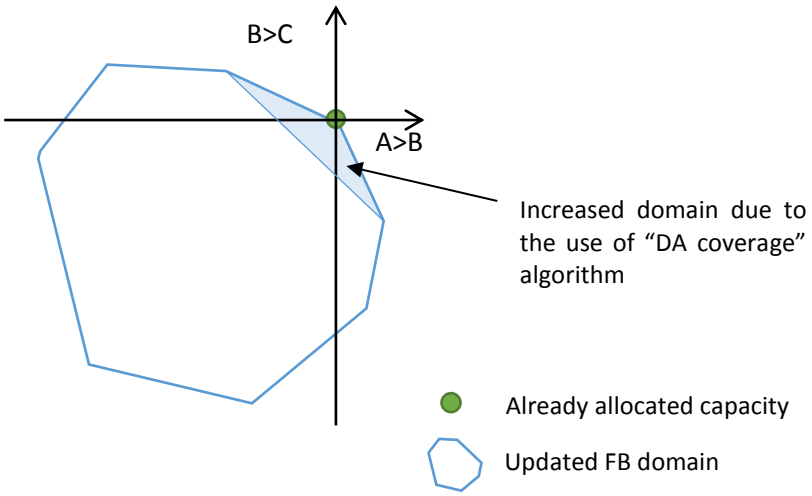
In order to achieve the integration of the HVDC interconnector into the FB process, two "virtual hubs" at the converter stations of the HVDC are added. These hubs represent the impact of an exchange over the HVDC interconnector on the relevant CNE/Contingency combinations. By placing a GSK value of 1 at the location of each converter station the impact of a commercial exchange can be translated into an equivalent PTDF value which will be called PSDF for Power Shift Distribution Factor. This action adds two columns to the existing PTDF matrix.

6 Annexes

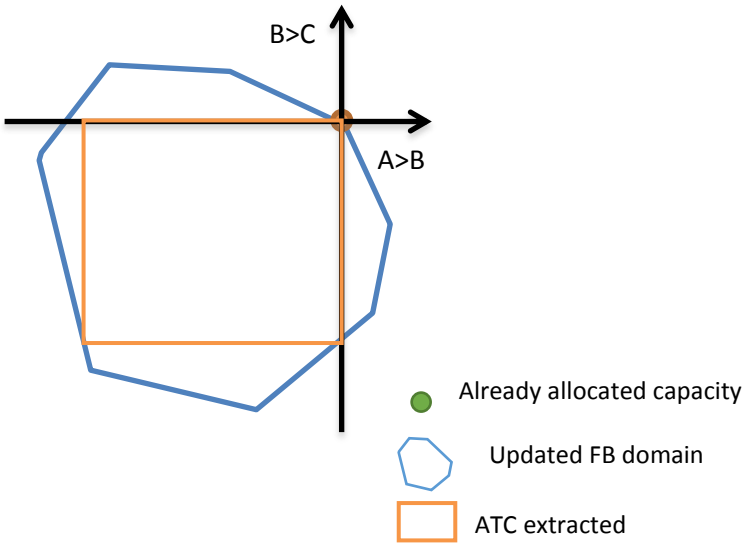
6.1 Annex 1: Example for automatic market clearing inclusion



Step 1: Shift the FB domain according to the market clearing point



Step 2: Add the origin (zero NPs) as a vertex when it is not part of the FB domain



Step 3: Run the ATC extraction module to assess the ID ATCs

6.2 Annex 2: Current behavior of the remedial action tool

In the following part, the remedial actions optimizer that is used in the internal parallel run is presented.

The RAO tool determines a set of RAs that improve the flow-based domain according to a defined objective function. In the CWE FB IDCC framework, this function aims to increase the minimum relative margins in MW, around the DA MCP.

RAO needs several inputs: merged CNEC with the Remedial Actions to be used by the RAO tool, merged GSK, and merged CGM. The output of the RAO service is a coordinated set of RAs.RAs can be split into two different categories: Preventive Remedial Actions (PRA) and Curative Remedial Actions (CRA) (cf. 3.1.4). The aim of the RAO tool is to find the optimal set of PRAs and CRAs in order to enlarge the Flow-Based domain.

6.2.1 Determining the PRAs and CRAs

The RAO algorithm explores solutions through a sequential approach made of two sub-problems:

1. Preventive problem for all CNECs
2. Curative problems for every Contingency (C)

In the proposed method, all CNECs are considered during RAO in order to take into account the influence of remedial actions.

It can be set as a constraint of the optimisation that the margins of certain CNECs shall not be optimised but only respect a certain value:

- If the initial margin of such element is positive, it should not become negative.
- If the initial margin is negative, it should not become even smaller than initially, or if smaller, not more than a defined threshold.

On both preventive and curative steps, the available remedial actions are tested: the most efficient RA according to the objective function (see Section 1.1.2) is selected , which are then implemented. RAs are selected, tested and implemented one by one. The iterations are managed through a search tree. Once the preventive optimization is finished, the set of preventive actions is fixed and implemented as starting point for all curative optimizations. For CRAs, approach is different, and is made C per C.

→ Algorithm keeps applying RA until one of the following conditions is fulfilled:

In preventive :

- All available preventive remedial actions have been evaluated
- At a certain step of optimization, no preventive remedial actions improve the objective function more than a defined threshold

In curative:

- The maximum number of curative actions have been reached
- All available curative remedial actions have been evaluated
- At a certain step of optimization, no curative actions improve the objective function more than a defined threshold

The two figures below illustrate the sequential approach and the search tree approach for RA selection (some names of CNECs are provided as an example):

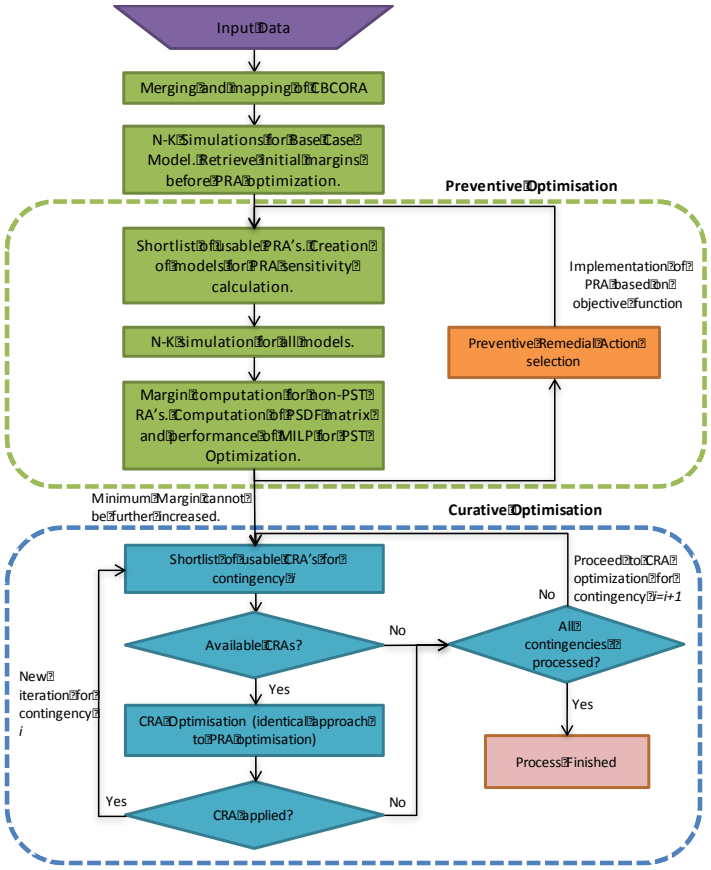


Figure 1: Presentation of PRA and CRA process selection.

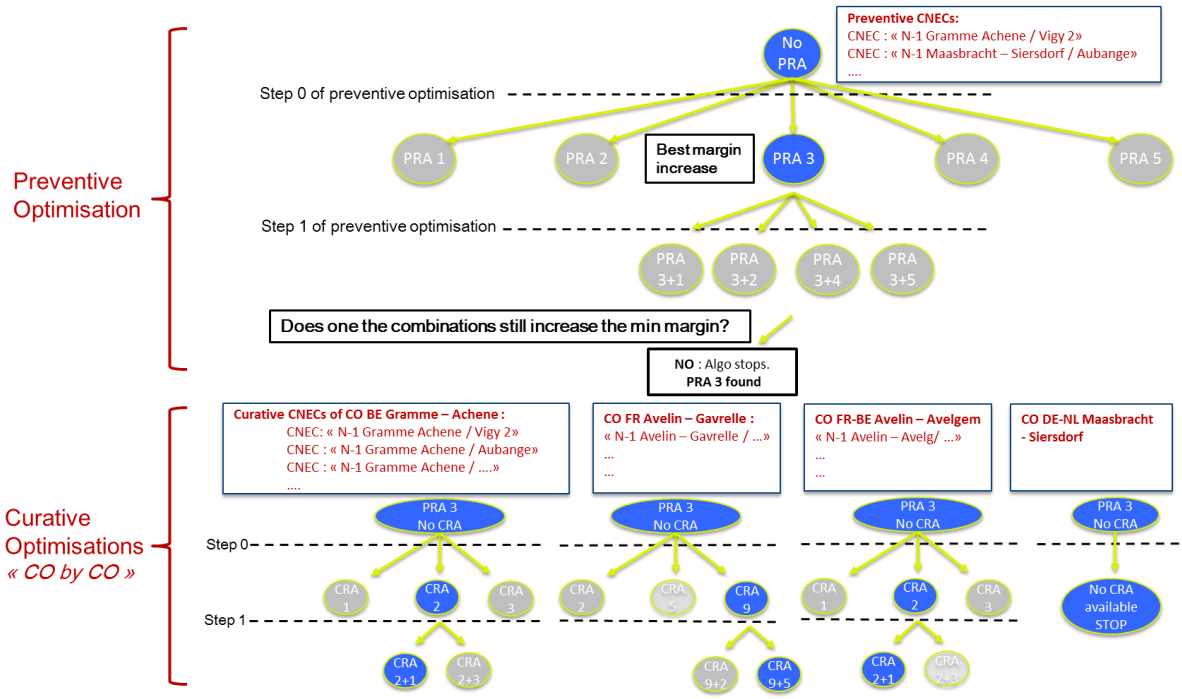


Figure 2: Presentation of the search tree approach for PRA and CRA process selection.

6.2.2 Objective Function

The present objective function is to **increase the minimum relative margin by finding remedial actions that aim at improved capacities based on the day-ahead market results**. The RAO tries to maximize the RAM of elements to be optimized **relatively to their sensitivity to exchanges**, without market assumption (i.e. without a preference to any particular exchange directions). This can be explained as increasing the space around the market clearing point of the day-ahead market as illustrated in figure 3 below.

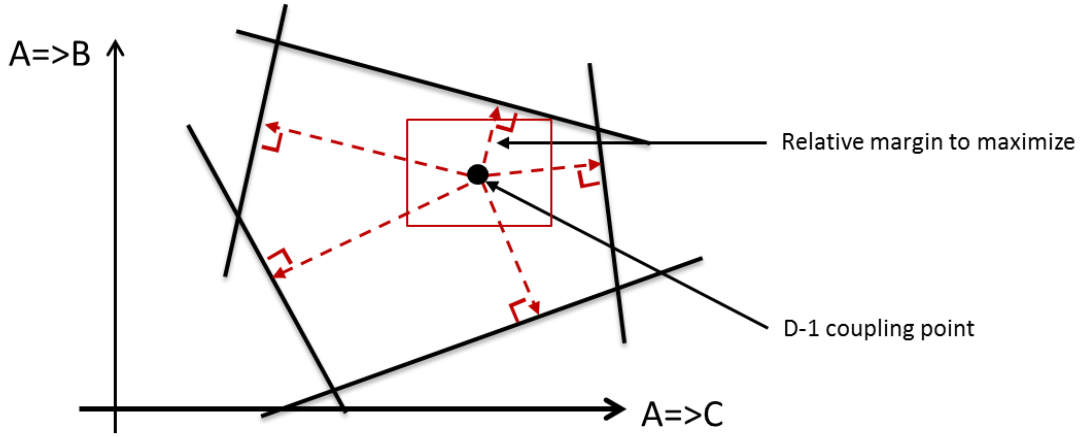


Figure 3: Illustration of the non-discriminatory approach to increase the space around the market clearing point of day-ahead without one border being advantaged over another.

This means that a remedial action will be selected and implemented if it increases the margin on the limiting branch (among the CNECs to be optimized) considering the already achieved minimum margin.

Margins are assessed through DC loadflows in order to enable faster optimization and to get results, which are compliant with the current flow based capacity calculation processes. The borders for PTDF computation in the objective function are the commercial bilateral borders of CWE.

The output of the RAO is a coordinated set of PRAs and CRAs linked to each C.

Found remedial actions are then applied for the final flowbased computation at each hour:

- The set of preventive actions is applied on each and every CNEC.
- For each contingency, the corresponding set of curative actions is applied on all CNECs linked with this contingency.

6.3 Annex 3: List of remedial actions

In the following part, the remedial actions that were used in the experimentation phase 3 are presented.

6.3.1 Amprion

The list of RAs that are currently used for FB IDCC activities by Amprion is the following:

PST

PST Gronau 380kV

6.3.2 APG

Topological Remedial Action

Bus bar coupler in St. Peter 220kV

PST

PST Ernsthofen 220kV (*)

PST Tauern 220kV (*)

PST Ternitz 220kV (*)

(*) APG PSTs are going to be used in a range of max. + - 6 steps.

6.3.3 Elia

The list of RAs that are currently used for FB IDCC activities by Elia is the following:

PST 380 Zandvliet 1
PST 380 Zandvliet 2
PST 380 Van Eyck 1
PST 380 Van Eyck 2

Opening of Bus-bar coupler in Avelgem 380
Opening of Bus-bar coupler in Horta 380
Opening of Bus-bar coupler in Courcelles 380
Open Line 220.513 Aubange-Moulaine
Open Line 220.514 Aubange-Mont-Saint-Martin

6.3.4 RTE

The list of RAs that are currently used for FB IDCC activities by RTE is the following:

Modification of the topology

Avelin 400kV
Beautor 225kV
Bezaumont 400kV
Chevalet 400kV
Gavrelle 400Kv
Lonny 400kV
Mambelin 400kV
Mastaing 400kV
Moulaine 225kV
Muhlbach 400kV

Revigny 400kV
Sierentz 400kV
Vigy 400kV
Vogelgrun 225kV

Opening of line

Trois Domaines-Vandière 225kV
Muhlbach-Scheer 400kV

Modification of the dispatch

Hydro power plant in Revin

6.3.5 TNG

The list of RAs that are currently used for FB IDCC activities by TNG is the following:

PST

Bürs 380/225kV

Topological Remedial Action

Dellmensingen 380kV

6.3.6 TTG

The list of RAs that are currently used for FB IDCC activities by TTG is the following:

PST

Diele 380kV

Topological Remedial Action

Opening of bus-bar coupler in Grafenrheinfeld 380kV

Opening of bus-bar coupler in Doerpen West 380kV

6.3.7 TTN

The list of RAs that are currently used for FB IDCC activities by TTN is the following:

PST

PST Meeden W 380kV

PST Meeden Z 380kV

Topological Remedial Action

Opening of bus-bar coupler in Lelystad 380kV

Opening of bus-bar coupler in Ens 380kV

Opening of bus-bar coupler in Doetinchem 380kV

Opening of bus-bar coupler in Hengelo 380kV

Opening of bus-bar coupler in Geertruidenberg 380kV

Opening of bus-bar coupler in Diemen 380kV

Opening of bus-bar coupler in Eindhoven 380kV

Opening of bus-bar coupler in Zwolle 380kV

Opening of bus-bar coupler in Borssele 380kV

Opening of bus-bar coupler(s) in Maasbracht 380kV

Opening of bus-bar coupler in Krimpen 380kV

Opening of bus-bar coupler in Dodewaard 380kV

The availability of remedial actions for the RAO from the list above will be determined on daily basis and are related to the gridconditions.

6.4 Annex 4: CWE Flow-based Intraday Capacity Calculation Consultation Report

Results of the consultation in March 2017

CWE Flow-Based Intraday Capacity Calculation Survey results: Executive Summary of answers received from the Market Parties

The online survey was available for Market Parties from 1st March 2017 to 15th March 2017. In total, 4 Stakeholders (Market Participants and Associations) submitted their answers.

The public consultation process is anonymous, therefore the identity of respondents will not be disclosed with the publication of this consultation's outcome. Please note that it was however disclosed to the CWE National Regulatory Authorities together with the complete responses.

Main market views and recurring comments have been summed up in this report. The CWE TSOs wish to clarify that the contents of this document are intended to summarize the results obtained in the public consultation. This also means that the report should not be interpreted as the CWE TSOs' position on the concerned topics. The CWE partners will do their best to reply to all comments and concerns. However before engaging in more in-depth discussions within the project and with market parties, CWE TSOs cannot commit to comply with all reported concerns and requests.

In addition to specific observations (see below), market parties provided TSOs with general comments. Some market parties raised concerns over the fact that TSOs do not include countertrading as a possible remedial action. In addition, the consideration of different FRM values for cross-zonal capacity calculation and security assessmenst is perceived as discriminatory behavior. All responses by market parties expressed concerns over TSOs' ability to re-assess ID ATCs, and generally, over TSOs' possibilities to manually influence available capacities.

Even though this consultation focuses on the capacity calculation process, some market parties further criticize that capacity allocation is based on ATC values, which are extracted from the flow based intraday domain. Market parties express that they see a need for a fully flow based capacity allocation system, which from their point of view is a prerequisite for the full exploitation of possible welfare gains.

6.4.1 Section 1: Survey Questions

6.4.1.1 A.) Introduction

1. After studying the consultation document, do you have a clear view on the challenges and benefits of the implementation of Flow Based intraday capacity calculation?

Three market parties explicitely answered this question.

Two market parties express their satisfaction with the overview that is provided in the consultation document. However, TSOs are asked to provide exact numerical values for the parameters they plan to apply in the FB IDCC calculation process. In addition, two market parties express their fear that welfare gains of FB IDCC might be underestimated because of an inaccurate impact assessment.

One market party states that the one calculation approach is acceptable as a first step for the implementation of FB IDCC, but urges for multiple recomputations during the day in the future.

One market party states that the evidence provided by the experimentation results is insufficient. Furthermore, this market party is worried that an increase of available capacities compared to the current approach cannot be guaranteed. In addition, the market party fears that TSOs do not properly take into account the improvements in the quality of information in D-1 compared to D-2.

Feed-back of the TSOs:

The economic assessment of the capacity in intraday is more difficult than in DA, indeed no agreed indicator as the social welfare exists. In the current version of the Explanatory Note, TSOs proposed two economic indicators. TSOs will investigate the feasibility of additional indicators as proposed by the market parties.

In parallel, TSOs will perform an internal and external parallel run and the outcomes will allow for MPs and regulators to get a better view on the benefits and drawbacks of the FB IDCC methodology.

The TSOs propose as a first step a recomputation based on updated information in the evening of the DA, after DA allocation but before gate opening. In future versions of the FB ID capacity calculation, TSOs will develop multiple recomputations in the ID timeframe to take into account the latest information of the market.

Transparency topics (parameters and use of costly remedial actions) are further developed in the following question number 16.

6.4.1.2 B.) Coordinated Flow Based intraday capacity calculation process

One market party provided a combined comment on answers 2 to 9, which states that there seem to be too many opportunities for TSOs to intervene in the algorithm and to manually reduce capacities. From the point of view of this market party, this makes it impossible for market parties and regulators to determine how available capacities have been calculated, resulting in inefficient bidding strategies and, consequently, in welfare losses.

2. Are the inputs for the capacity calculation clearly described and understandable (see M chapter 3.1 and EN chapter 3.1)[2]?

Two market parties explicitely answered this question.

Market parties advocate that TSOs compare historical forcasted flows with realized flows in order to set values for FRM. In addition, market parties wish to receive more information on TSOs' risk policy, especially with regard to the assessment of FRMs and external constraints.

Furthermore, market parties urge TSOs to demonstrate that their approach to determine GSKs is representative. Also, it is asked to review the CNEC selection criteria.

Feed-back of the TSOs:

Regarding the lack of information for the risk policy per TSO, the new ID FRM values will be published by the end of 2017 after the ID FRM assessment has been performed.

CWE TSOs are convinced that the DA GSK approach used is representative. The method to generate the GSK in ID is the same as in DA. Furthermore, TSOs are updating the GSK with the new ID assumption. Moreover, the current use of ID capacity is smaller than the DA capacity, therefore the inevitable error made by the needed linearization of the GSK will be lower.

In ID, most CWE TSOs are using the same method to determine their EC as in DA.

The CNEC selection criteria are presently being investigated in the Core region.

3. Is the capacity calculation process clearly described and understandable (see M chapter 3.2 and EN 3.2)?

Two market parties explicitely answered this question.

Market parties consider the description of the capacity calculation as insufficient and incomprehensible. More transparency is requested on the underlying parameters for capacity calculation. Additionally, the RAO algorithm is considered as not clearly described. Market parties state that costly remedial actions should only be taken into account if economically relevant.

Feed-back of the TSOs:

[2] M = Methodology, EN = Explanatory note.

The CWE FB ID capacity calculation process relies on the same principle as the DA capacity calculation process. The main change in the process is the introduction of the optimizer to choose the remedial actions in order to cover the already allocated capacity and increase the space around the day-ahead market clearing point for every hour. In DA, this activity is performed manually by the operators.

Transparency topics (parameters and use of costly remedial actions) are further discussed in the following question number 16.

4. Are the outputs of the capacity calculation process clearly described and understandable (see M chapter 3.3 and EN chapter 3.2)?

Two market parties explicitely answered this question.

Market parties feel sufficiently informed regarding the outputs of the capacity calculation process.

Feed-back of the TSOs:

The TSOs will remain available to the market parties through the CWE Consultative Group to continue the discussion on the outputs of the process.

5. Which sections of the capacity calculation process should be more clearly described (see M chapter 3 and EN chapter 3)?

Two market parties explicitely answered this question.

Market parties ask for more information on the capacity validation process.

Feed-back of the TSOs:

For validation, it is planned to directly validate extracted ATC values instead of validating the ID FB domain. Therefore, each TSO can check the impact of the newly calculated ATCs on the grid and redetermine ATC values, if necessary, but only in order to ensure security of supply in exceptional cases.

6. Is the re-assessment of ID ATCs for allocation process clearly described and understandable (see M chapter 3.4 and EN chapter 3.3)?

Two market parties explicitely answered this question.

Market parties recommend that the MCP can be updated to account for potential cross border redispatching actions. In addition, one market party is concerned that TSOs have the option to oppose the new ID ATC domain.

Feed-back of the TSOs:

No feed-back from the TSOs as the re-assessment process is not part of the methodology anymore.

7. Do you feel sufficiently informed about the method of Remedial Action Optimisation and their influences for cross-border capacity (see M chapter 3.1 and 3.2)?

Two market parties explicitely answered this question.

Market parties ask for more detailed information on the method of remedial action optimization, especially with regard to alternative objective functions and the list of remedial actions under consideration.

Additionally, one market party asks for more information about the impact of remedial action optimisation on capacity increase, and generally for more transparency regarding this process.

Feed-back of the TSOs:

CWE TSOs acknowledge that a certain level of transparency is required for market parties in order to gain confidence in the FB process and make the process as a whole more understandable.

However, to provide the list of RAs and their impact on the capacity calculation would be an increase of transparency, which would generally concern CWE market coupling, and which therefore is out of the scope for the FB IDCC methodology. In order to avoid different levels of transparency for the different time-frames, transparency related topics should be discussed on CWE level (e.g. in CWE Consultative Group meetings).

8. TSOs developed the optimisation function in order to have a positive impact on the market as it will provide more domain in the likely market directions (around the DA market clearing point). Do you agree with this point of view (see M chapter 3.2 and EN chapter 3.2)?

Two market parties explicitely answered this question.

Market parties would favour an optimization function that prefers the most valuable market direction (which is described as the market direction that would mostly increase congestion rents under the assumption of fixed DA market prices). At the same time, one market party additionaly states that the optimization function should increases the domain in the direction that is most likely with the latest (updated) flow configuration.

Feed-back of the TSOs:

In response to the current optimisation function to optimise around the DA MCP, there was no shared opinion of market parties (MPs) observed.

On one hand MPs mention that they prefer optimisation in the most profitable direction (with increasing congestion rent) while preserving left-over day-ahead capacity but on the other hand MPs also request to optimise market capacity in the likely market directions of FB DA which results in less capacity in the opposite market direction.

As both views of MPs contradict, CWE TSOs were not able to give preference to either of the MPs suggestions. Furthermore, CWE TSOs would like to underline that due to remedial action optimisation a shift of the FlowBased domain is inevitable. This will lead to a capacity gain in some directions and a reduction of capacity in other directions. As prior studies performed have indicated that DA market spread does not necessarily align with the most congested areas in Intraday, TSOs aim to increase the domain around the DA MCP in all directions in a non-discriminatory manner for all borders.

9. Do you think it is justified to optimize the ID FB domain around the DA Market Clearing Point (MCP), knowing it can lead to FB domain reductions in the unlikely market directions (see M chapter 3.2 and EN chapter 3.2)?

Two market parties explicitely answered this question.

Market parties would favour again an optimization function that is based on an updated MCP; ID ATCs should therefore be recalculated periodically.

Feed-back of the TSOs:

TSOs acknowledge that having multiple recomputations during Intraday, based on updated MCP, is the target solution. Periodic recomputations during the day considering the last nominated capacities are foreseen in a future version of FB IDCC.

6.4.1.3 C.) Expert experimentation results and parallel run

10. Are you convinced by the experimentations performed so far and the foreseen developments (see EN chapter 4)?

One MP is not convinced by the experimentations. The use of the automatic MCP inclusion for most of the time is seen as a consequence of an insufficient set of RA or other limitation of the current approach (i.e. GSK, CNEC selection).

Another MP points out that the experimentiation is based on a very scarce evidence of five days and that further testing on the RA Optimization is needed.

For both of these MPs, it would be more relevant to consider DA market spreads to weight the variations of capacity in the different directions.

Feed-back of the TSOs:

TSOs performed the experimentation to gain first experiences and to examine the new process. In order to fine-tune the process and get more quantitative results, TSOs will perform an internal and external parallel run in 2017/2018 which results can be shared with NRAs and market parties to get a better view on the benefits and drawbacks of the new FB IDCC methodology. More details regarding the optimization function in general can be found in the answer to question number 8.

11. What are your expectations from the external parallel run process?

Two MPs see very little benefit of an external run in a countinous trading market and would rather have an offline assessment of ID FB domain for historical values and for some specific scenarios in the future.

One MP considers that the parallel run should be more thorough than what was performed for DA FBMC. Full data transparency should also accompany the parallel run from the start to speed up market participants' understanding of the whole mechanism.

Feed-back of the TSOs:

An internal and external parallel run is essential for TSOs to gain experience from technical and operational point of view as the implementation of a fully working system and sufficiently experienced operators are needed before go-live. The parallel runs will also be used to fine-tune the process and get more quantitative results.

Therefore, it is not feasible to conduct the proposed updated planning of an earlier go-live for FB IDCC.

The results of the external parallel run will be shared with NRAs and market parties. In order to get a better view on the benefits and drawbacks of the new FB IDCC methodology the recomputation of a limited number of interesting business days (e.g. days of the internal parallel run) can be considered and shared with market participants. It is to mention that finding representive days for ID (as for the DA SPAIC analysis) is difficult which makes an ID SPAIC analysis not feasible, but TSOs are open for suggestions from market parties.

TSOs will be at least as transparant as in CWE FB DA. More information on this topic can be obtained in the following question number 16.

12. Do you have enough information (results, explanations) about the performed IDCC experimentation to get a clear picture of the possible impact on cross-border capacities for the ID market (see EN chapter 4)?

Two MPs indicate that the approach and the impact assessment (in terms of types of outputs and variety of situations) should be improved.

One MP claims lack of transparency on numerical figures. The other MP argues that the metrics used by the CWE TSOs for the impact assessment are probably more pessimistic than the ID FB domain.

Feed-back of the TSOs:

Experimentations are performed on a limited period of time, and this is why internal and external parallel runs are foreseen in order to provide a wide picture of the process behaviour. External parallel run results will be shared with Market Parties. CWE TSOs would like to remind Market Parties that lower uncertainties in ID do not necessarily lead to more capacities as some lines may be more loaded in ID compared to DA. Many paramaters and assumptions have been updated between DA and ID leading to different capacities, such as generation infeed, grid topology, and updated RES infeed based on the latest assumptions available when running the FB IDCC computation.

6.4.1.4 D.) Publication of data

13. Do you have enough information regarding the Flow Based intraday capacity calculation process (see M chapter 5)?

One MP answered yes to this question.

Another MP regrets that the numerical values for each parameter used by TSOs are not provided. They also require more transparency regarding TSOs' approaches to define FRMs and GSKs.

Feed-back of the TSOs:

Transparency issues, including numerical values, parameters used by TSOs, as well as TSOs' approaches for defining FRMs and GSKs are further developed in question 16. In addition, please find additional information concering GSKs and FRMs in question 2.

6.4.1.5 E.) Additional questions

14. What are your general expectations from the new FB IDCC process?

Two MPs expect a significant increase in cross-border capacity in the most economical direction. Efficient trade-offs made by TSOs between internal redispatch and cross-border capacity reduction are also expected.

Feed-back of the TSOs:

CWE TSOs welcome this proposal to consider economical parameters in the process, however CWE TSOs consider the topic of implementing costly remedial actions in order to adapt the capacities and use of congestion rent for redispatch to be a NRA decision. TSOs would additionally like to inform that related discussions are also ongoing at ENTSO-E level.

15. What are the most important go-live criteria for the process from your point of view?

One MP sees predictability as a key criterion.

Two MPs agree that TSOs must be operationally ready and make sure that the IDCC will work smoothly and deliver in conformity to the impact assessment published.

Another MP expresses its strong disappointment regarding the level of transparency before and after the go-live of DA FBMC and is, therefore, very wary about the conditions of the ID FBCC go-live. The key criteria that this MP will require is full data transparency (chapter 5) and the inclusion of details regarding the manual adjustments made, remedial actions taken by the TSOs and their effects. They also request the publication of the intraday flow-based domain (not only the final ATC values). From their point of view, market participants need to be able to fully predict the results of the calculation process.

Feed-back of the TSOs:

Transparency topics are further developed in the following question number 16. The FB ID domain will be communicated as of the starting of the external parallel run and after go-live as well. ATC values will be publicly available, but as it is a FB methodology which is processed, the FB domain will be also provided to all interested parties. The same basis of communication as in FB DA will be used. Furthermore, during the external parallel run (at least 6 months) more data will be available for stakeholders, which can be input for their assessments to improve predictability.

About any new indicator to be followed or developed, TSOs are open to investigate additional indicators considering economic parameters. In addition to the indicators provided by TSOs, MPs are also encouraged to compute indicators during the parallel runs and share the results with CWE TSOs.

16. What is your most important criterion regarding the capacity calculation process and output? (predictability of capacity, volume of capacity…)

One MP highlights predictability and transparency as key issues to achieve an optimal use of the grid infrastructure. In their opinion, both would lead to an increase of capacity in the

most economical direction (as they allow market parties to provide TSOs with better predictions and this results in less uncertainties).

Another market party stated that the most important criterion for capacity calculation is the volume of capacity in the likely market direction. They see capacity predictability relevant but not as an ultimate goal per se, since price forecasting depends also on other information. They underline that predictability relies also on full transparency by TSO on the availability of transmission network and on the common grid models to be used as inputs.

Feed-back of the TSOs:

CWE TSOs acknowledge that a certain level of transparency is required for market parties in order to gain confidence in the FB process and make the process as a whole more understandable. However, in order to avoid different levels of transparency for the different time-frames, transparency related topics should be discussed on CWE level (e.g. in CWE Consultative Group meetings).

In FB IDCC at least as much transparency will be provided as for FB Day-Ahead (e.g. non-anonymised presolved CNECs including Fref', FRM, FAV and RAM). Future changes in the level of transparency provided for FB Day-Ahead will also be taken into account for FB Intraday.

In line with provided transparency for FB Day-Ahead, the impact of local TSO validation will be shared by publishing the Day-Ahead left-over ATC, extracted ID ATC from the Intraday FB domain and the validated Intraday ATC values provided for allocation.

During external parallel run, CWE TSOs will publish the Intraday FB domain as well.

6.4.2 Section 2: Additional questions / comments by MPs

1. MPs request TSOs to keep working on extending the process and offer several recalculations of the domain (within the intraday timeframe) as there is a market need to have updates of the FB domain during the day. They believe that the target should be to perform a recalculation of the domain every hour to get a view on what is available for each hour, provided it keep the same exchange potential as the process today (it should not deteriorate).

The TSOs agree that the target of the FB ID capacity calculation is not only to compute the capacity once in the evening of the DA but TSOs see the process as a first step to multiple recomputations. Performing additional computations during the day would require additional preparations, leading to a delay of the current implementation planning. Also, updated grid models (ID CGM) are required for re-computations but these have not been used in common processes, as the quality and stability is not clear for some TSOs. The frequency of this recalculations shall take into consideration efficiency and operational security and will be further developed.

2. It is unclear to MPs whether the TSOs have decreased their Flow Reliability Margins (FRMs) as real time gets nearer.

The aim of the FRM is to cover the uncertainties in the capacity calculation processes. In order to compute the FRM, TSOs compare the flows on the CNEC between the CGM that is used for the capacity calculation and the realized flow on this element. In the experimentation, TSOs have used proxy FRMs based on DA FRM but TSOs intend to update the FRM values before Go Live. As for DA, the values will be published per CNEC.

3. Why do you consider an external constraint? Isn't the uncertainty already covered by the FRM?

External Constraints prevent the system to reach extreme positions compared to the original market clearing point. They can also prevent grid behavior like voltage collapse that cannot be modeled with the current assumption (DC load flow).

4. The approach to define GSK remains relatively unclear: Regarding the German GSK, the fall-back solution is the GSK from a previous day; is it better than using the DA GSK? Does the French GSK include must-run units?

The fallback solution for all GSKs is to take the GSK of the previous ID and not the one from DA.

Regarding the French GSK, the method for ID is the same as for DA. All units, including must-run units which are in operation in the base case, will follow the change of the French net position on a pro-rata basis.

5. Please provide more transparency on the application of FAV and the operational adjustment in FRM.

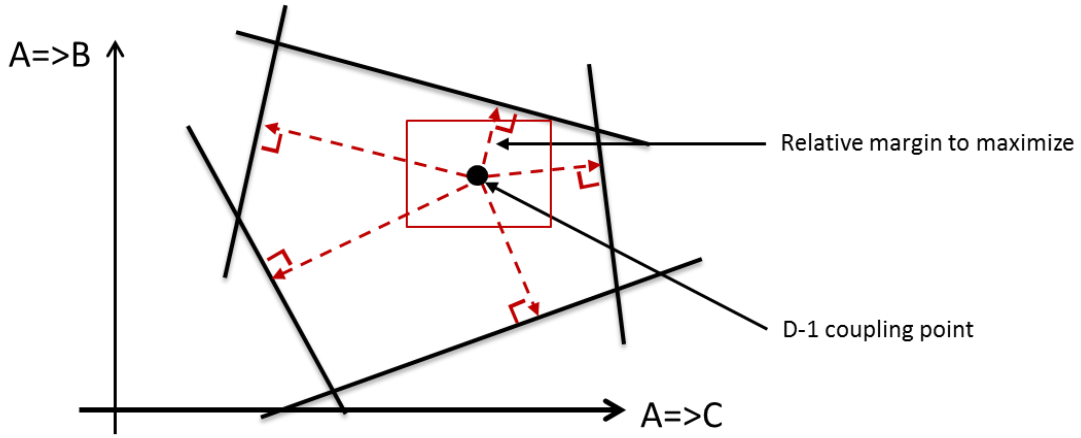
CWE TSOs do not intend to use FAV to change the output of the ID FB calculation as ATC values will be validated directly. The final need of performing operational adjustment will be evaluated after the ID FRM values have been computed and determined by the end of the year 2017.

As a rule, TSOs will be at least as transparent as in CWE FB DA, so future developments regarding the FB DA process will be considered in ID as well.

6. Why is the relative margin denominator the sum of absolute PTDF and not the difference between the max and min PTDF?

This approach was chosen in order to ensure non-discriminatory behavior of the objective function, as it prefers no particular exchange direction.

No border will be advantaged as the room around the market clearing point is maximized. An illustration of this non-discriminatory approach can be seen in the figure below.



$$Relative\ Margin\ (CNEC) = \frac{Margin(CNEC)}{\sum_{i,j \in hubs} |PTDF_{i \to j}(CNEC)|}$$

7. Questions regarding further clarification of validation phase:

- *What does the computation exactly take into account?*
- *How much time does it take?*
- *What is the exact purpose of the validation? Can it be avoided?*

It is planned to perform the validation directly on the calculated ATC values instead of validating the ID FB domain. Therefore, each TSO can check the impact of the newly calculated ATCs on the grid by their own tools and redetermine ATC values, if necessary, but only in order to ensure security of supply in exceptional cases. Hereby, the latest information on the grid can be taken into account, e.g. unforeseen outages of grid elements since the start of the ID FB process. The timing depends on the availability of input data as well as the computation times of the predecessing processes.

8. Why should TSOs be allowed to oppose/reject the new ID ATC domain since the increase of capacities will be based on individual grid inputs?

Although it is correct that the computed ID ATC is based on individual grid inputs, these inputs can change during the course of the day (e.g. due to updated grid forecasts, unforeseen outages, etc.). TSOs intend to mitigate the resulting risk, during intraday, by applying a reliability margin (i.e. FRM). Residual risk will be handled as *force-majeur* and solved by TSOs by other means.

9. It should be possible that the MCP, which serves as a starting point for ID ATC extraction, can be updated to account for potential XB redispatching actions, as a result of the ID security assessment.

Cross-border redispatch available before the FB IDCC process will be considered, as these are included in the individual grid models of the CWE TSOs. Although due to the cross-border redispatch the domain will be shifted, the MCP will not be updated to ensure the already allocated capacities are properly taken into account.

10. Taking the DA FB as a reference is contradictory with the recalculation of ID capacity (3.4.1.1): the base case should be to limit the capacities by the FB ID ATC and not the minimum of FB DA ATC and FB ID ATC.

No feed-back from the TSOs as the re-assessment process is not part of the methodology anymore.

11. Concerning the ID ATC re-assessment, one MP stated that the proposed methodology maintains the freedom for individual TSOs to refuse the ID capacity increases proposed as a result of a centralized computation. This MP reasons that this freedom should be limited under three dimensions:

- ***The approval process should apply to only one type of outcome of the centralized process, for instance the new ID Flow-Based domain. If all CWE TSOs recognize that the new FB domain is right, this means that they should cope with any corresponding increase/decrease in cross-zonal exchange capacity.***
- ***TSOs should be fully transparent on their motivation when opting out, make alternative consistent proposals, and propose improvements of the regional capacity calculation process as soon as an opt- out situation becomes frequent.***
- ***TSOs should take their decision quickly so that available capacity can be released to the market in a timely manner. To this end, the market party would suggest that no motivated response from CWE TSOs 30 minutes after proposing an increase should be considered as an acceptance.***

No feed-back from the TSOs as the re-assessment process is not part of the methodology anymore.

12. TSOs consider different FRM in cross-zonal capacity calculation and in security assessment. MPs suggest to consider identical FRMs for cross-zonal capacity calculation and for triggering internal redispatching actions.

Today, it is not common practice for TSOs to apply reliability in security analysis. The main reason is related to the fact that the security analysis aims at identifying and coordinating remedial actions that will have to be considered to ensure a normal state of operation in real time. This process and the decision which remedial actions will be applied shall be updated and optimized several times, up to close to real time, which will always allow considering the impact of changes in the system. In contrary, the capacities that will be provided to the allocation platform as outcome of the capacity calculation processes will be considered as firm, which justifies the application of Flow Reliability Margin to cover the potential impact of uncertainties. Nevertheless, in the scope of System Operation

guidelines implementation, TSOs are assessing the possibility to consider reliability margins during security analysis, but this is out of scope of the FB IDCC methodology.

13. MPs note that they do not understand why lower Imax figures were used in phase 3 of the experiment. Shouldn't corrected results be published?

CWE TSOs have used the correct Imax values during the whole experimentation phase. For cycle 4 of phase 3 the winter limits of the monitored grid elements have been used. These values are higher than the summer limits used in the first three cycles. Usually, TSO switch from summer to winter limits in November.

6.5 Annex 5: Additional information on issues raised in NRAs' position paper

6.5.1 Flow Based Domain Calculation

NRAs request TSOs to confirm that DACF files include:

- *the updated GSKs – based on the results of the DA market coupling;*
- *the updated PST tap positions and Grid topology;*
- *the updated load and RES forecasts; and*
- *the remedial actions updated after the DA MCP inclusion so that they include RA already used for the DA FB domain (i.e. in the case of LTA-inclusion)*

CWE TSOs would like to highlight that the process of DACF creation is out of scope for capacity calculation. The FB IDCC process will use the latest information available, but it cannot be confirmed that updated RAs will already be included in the DACF.

NRAs request TSOs to explicitly list all improvements achieved through the recalculation in DACF compared to D2CF

The DACF includes the last consumption forecast, topology, last RES forecast, operating schedules of generators and exchange schedules.

6.5.2 FRM calculations

NRAs request TSOs to confirm that new FRM values used in intraday are calculated on the basis of DACF-files and will correspond to a reduced uncertainty compared to D-2, as announced in the Consultative Group Meeting of March 2017.

CWE TSOs confirm that the ID FRM values are computed according to the FRM methodology described in this approval package and that ID FRM values are calculated by comparing DACF files to the snapshot files. Nevertheless, it cannot be guaranteed that there will be a reduction compared to the current operational FRM values for DA CC since different methodologies and timeframes were used for the DA and ID FRM calculations.

NRAs reques TSOs to describe the post-processing of ID FRM data. The description should include, among others:

- *If the FRM applies to a CB or to a CBCO,*
- *Which flows are used (N, N-1, average/max...),*
- *The applied risk levels*

Harmonization is strongly recommended. Where no harmonized values or rules are used, the TSOs are asked to describe the TSO-specific values or rules.

CWE TSOs clarify that the description of the post-processing of the data is included in this approval package. In case of a TSO applying an operational adjustment on the calculated FRM values, this TSO will provide additional justification to its national regulator

6.5.3 Use of Remedial Actions

NRAs request: As noted by market participants during the consultation phase, it is expected that re-dispatching measures taken to include the DA MCP in the DA flow-based domain (i.e. in the case of LTA-inclusion) are already taken into account in the DACF files, so before the calculation of the intraday FB domain. As a consequence, the use of coordinated RA in the RAO should not be steered towards including the DA MCP, but towards increasing the size of the ID FB domain.

TSOs would like to point out that capacity calculation is performed at the same time as the daily security analysis process takes place. As the security analysis is not finalized by the time the IDCC process is started, RAs cannot be guaranteed to already be included in the DACF.

6.5.4 Validation of capacities

CWE NRAs do not consider 'unforeseen market behaviour' as a Security of Supply issue which can be handled as force majeure. Force majeure is a well defined situation and

every capacity reduction made for force majeure reasons should be duly justified by the TSOs and reported to NRAs.

CWE TSOs have removed the corresponding reference to *'unforeseen market behaviour'* regarding the validation of capacities.

6.5.5 Improvement of the flow-based parameter "inputs"

NRAs request that the methodologies adopted for defining the following parameters do not exclude discrimination between internal and cross-zonal trade, leading to market distortion and inefficiency. In this respect, we recall the main of points for reconsideration:

- *The 5% PTDF CBCO selection rule*
- *The use of external constraints, if not justified by the CACM Regulation*
- *The use of positive FAVs, which should be exceptional*

CWE TSOs note that these topics are under discussion in FB DA and in the Core region, and once these discussions are finalized they will be discussed for IDCC.

CWE NRAs encourage CWE TSOs to evolve towards dynamic assessments of Imax using DLR technology, including transparent and harmonized rules for post-processing the DLR forecasts

CWE TSOs acknowledge the encouragement from NRAs, and note that the first pilot projects using DLR are ongoing.

All methodological improvements on the flow-based parameter inputs reached at FB DA level, shall be translated as soon as possible to the FB ID level, with a maximum time delay of 6 months

CWE TSOs note that it is unclear if improvements in DA can be implemented in ID within 6 months. Furthermore, CWE TSOs note that focusing resources on delivering these improvements for ID would subtract from deliverable in other projects, such as the Core region.

6.5.6 Flow-based allocation

TSOs are requested by NRAs to closely collaborate with the XBID project to realize that the full flow-based domain can be used as soon as possible for market coupling. NRAs request TSOs to deliver a report of the work done and progress made towards the implementation of FB ID MC. This report needs to be delivered within one year after the go-live of FB ID CC.

CWE TSOs acknowledge that using ATC values is suboptimal to using the Flow-Based domain, and note that CWE TSOs are already collaborating in the XBID project to realize Flow-Based market coupling for the intraday market.

6.5.7 Increased number of recalculations (hourly)

NRAs request TSOs to work towards multiple recalculations using the IDCF. Within one year after the go-live of FB ID CC NRAs request TSOs to deliver a report of the work done and progress made towards the implementation of multiple recalculations, and a corresponding project roadmap.

CWE TSOs acknowledge that multiple recomputations during intraday increases security of supply and reduces the uncertainty level which allows more capacity to be provided to the market. However, due to CACM GL deadlines, no major update (e.g. extension of the number of recomputations) of the intraday capacity calculation methodology is foreseen before the go-live of IDCC in the Core CCR. For Core IDCC, multiple recomputations of capacity are already foreseen as provided in the Core FB IDCC Proposal.

6.5.8 Optimization of the FRM through improved intraday forecasting accuracy

The improvements in the intraday common grid model will reduce uncertainties closer to real-time. This reduced uncertainty should be reflected in the significant lowering of the FRM values. NRAs request TSOs to deliver a report of the work done to reduce the FRM, together with a project roadmap for continuous improvement of forecast accuracy and uncertainty reduction. This report needs to be delivered within one year after the go-live of FB ID CC.

TSOs have presented the results of the latest ID FRM to NRAs during the dedicated workshop, CWE TSOs have taken note about the request for a report one year after the go-live of FB IDCC.

6.5.9 Earlier IDCZGOT

CWE NRAs consider an earlier IDCZGOT (21:00 D-1) as possible improvement. CWE TSOs are asked to consider how this can be implemented. NRAs request TSOs to deliver report on the actions taken to anticipate or reduce the calculation time. This report needs to be delivered within one year after the go-live of FB ID CC.

CWE TSOs note that ACER has taken a decision on the IDCZGOTand currently CWE TSOS are assessing the technical solution for existing and future intraday processes..

6.6 Annex 6: Answers to market parties' questions on CWE flow-based IDCC methodology

6.6.1 MPP letter of August 18th, 2017

6.6.1.1 General

The MPP welcomes the CWE TSOs' intention to proceed with a new capacity calculation in the intraday timeframe, based on updated inputs and considering reduced reliability margins compared to DA capacity calculation.

However, the proposal of the TSOs is insufficient. The documentation disclosed by TenneT still lacks the necessary details of the computations. Deeper comments on the level of detail that should apply to any proposal of a capacity calculation methodology can be found in the Eurelectric, EFET, Nordenergi, MPP response to the CCR proposals for the Capacity Calculation Methodologies in Nordic, Channel, Hansa, Core and SWE CCRs.

Overall, the MPP regrets the lack of transparency on the main methodological choices and the lack of ambition of the current proposal. Nevertheless, we consider this approach is acceptable as an interim solution, as it will improve the actual situation. Consistency with the day-ahead methodology is important in that respect.

The main omissions in this proposal are:

- There is no timeline for implementation, despite the related decisions by CWE NRAs.
- There is no clarity on what will be implemented as much is to the discretion of an individual TSO.

Feedback of CWE TSOs:

CWE TSOs would like to highlight that more detailed information, including the planning for implementation have been drafted in an explanatory note which has been submitted together with the methodology document. The planning was subsequently presented at the Consultative Group Meeting in September.

6.6.1.2 Inputs

"As a general rule, if there is an agreement between NRAs and TSOs to update the method for the input generation for the D-2 CWE FB process, the consequences of the implementation of these changes for the ID timeframe will be analyzed and, if possible, the FB IDCC method will be adapted in order to align it with the updated D-2 method."

The use of the method is conditional. What is the purpose of this proposal if TSOs are not bound to use it?

Feedback of CWE TSOs:

CWE TSOs foresee to analyse updates made in the D-2 method and consider these changes in ID. In general D-2 and ID consider two different time horizons, therefore it has to be proven, if changes made in D-2 are technically feasible in ID. In that case a link should be made to other projects (e.g. Core), also resources which are necessary to implement these changes have to be taken into account.

6.6.1.3 CNEC list for the FB computation

"If there is an agreement between NRAs and TSOs to update the method for the CNEC selection for the D-2 CWE FB process, the consequences of the implementation of these changes for the ID timeframe will be analyzed and, if possible, the FB IDCC method will be adapted in order to align it with the updated D-2 method."

The CNEC list for the FB computation is also conditional. What can we expect? What are the issues? In this regards, the MPP would like to stress that the FB package approval by CWE NRAs included the following statement: [excerpt from NRA feedback regarding CBCO selection rule]

As market participants, we would welcome such a demonstration [regarding optimality of 5% CNEC selection rule] and regret that no impact assessment of the CNEC selection process has been communicated so far for the DA and ID timeframes. We also note that such a demonstration should also be made with regard to external constraint selection.

Finally, the CNEC selection process should apply to each market time unit. Unlike what we experience as of today, this would lead to a situation where CNECs with all BZ-to-BZ PTDFs below 5% are never included in the capacity calculation.

Feedback of CWE TSOs:

CWE TSOs foresee to analyse updates made in the D-2 method and consider these changes in ID. In general D-2 and ID consider two different time horizons, therefore it has to be verified if changes made in D-2 are technically feasible in ID.

This topic is currently under discussion among CWE TSOs and NRAs and stakeholders are regularly informed on the status during stakeholder meeting.

6.6.1.4 Maximum current on a Critical Network Element (Imax) and Maximum allowable power flow (Fmax)

"When the Imax value depends on the outside temperature or wind conditions, its value can be reviewed by the concerned TSO if outside temperature or wind forecast is announced to be much higher or lower compared to the seasonal values."

Including weather conditions should be standard to maximise grid capacity. Especially in the intra-day timeframe, when more accurate forecasts are available. What are the reasons for not including them as a general conduct?

Feedback of CWE TSOs:

CWE TSOs would like to clarify that the limits for lines are not always determined by weather conditions, but could be limited by the sizing of feeder equipments (e.g. switcher, breaker, potential transformer).

When the limit of an element is dependent on weather conditions, and if this element is equipped with dynamic line rating, it is the practice of TSOs to consider weather condition forecasts when determining the limits for capacity calculation.

6.6.1.5 Day ahead Common Grid Model

"For intraday capacity calculation the latest available version of the day ahead Congestion Forecast process (DACF) will be used at the moment the capacity calculation process is initiated."

What exactly is the latest version that is meant here? In our view TSOs should make an update after the day-ahead market results for the intra-day calculation.

Furthermore, in the case of capacity calculations after the intraday cross-border gate opening time, should not the IDCF file be used? How would then the (moving) market clearing point be accounted in the common grid model used and FRMs considered in later capacity calculations?

Feedback of CWE TSOs:

As detailed in the FB IDCC methodology document, the latest available version of the day ahead Congestion Forecast process (DACF) includes, according to the methodology developed in line with Regulation 1222/2015 Article 16 and 17 (CACM):

- Best estimation of Net exchange program
- Best estimation exchange program on DC cables
- Best estimation for the planned grid outages, including tie-lines and the topology of the grid
- Best estimation for the forecasted load and its pattern
- If applicable best estimation for the forecasted renewable energy generation, e.g., wind and solar generation

- Best estimation for the outages of generating units
- Best estimation of the production of generating units
- All agreed remedial actions during regional security analysis.

The grid model used for ID capacity calculation is created after the DA market coupling in the evening of D-1. So the results of the DA market coupling are taken into account to create the grid model used for ID capacity calculation. The following list provides explicitly all improvements achieved through the recalculation in DACF compared to D2CF:

- Updated estimation of Net exchange program
- Updated estimation exchange program on DC cables
- Updated estimation for the planned grid outages, including tie-lines and the topology
- of the grid
- Updated estimation for the forecasted load and its pattern
- If applicable better estimation for the forecasted renewable energy generation, e.g. wind and solar generation
- Updated estimation for the outages of generating units
- Updated estimation of the production of generating units
- All agreed remedial actions during regional security analysis

In the current process, only one recomputation is coordinated with all TSOs. This recomputation is performed in the evening of the D-1. In the future, additional recomputations (i.e. after IDCZGOT) could be implemented based on the updated set of data: IGMs, but also remedial actions, in order to assess more efficiently the capacity that can be provided to the market players.

6.6.1.6 Generation Shift Key

"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 do not have sufficient flexible generation for matching maximum import or export program or if they want to moderate impact of flexible units."

What are the reasons of excluding by fuel type in the standard calculation and only in cases where additional flexible generation is needed? What are the conditions for such cases?

Why are there so many unexplainable differences in the different GSK methodologies? The Dutch, Belgian and French bidding zones use a pro rata approach, which is not market reflective. Other TSOs use a more sophisticated approach. Interesting in this respect is the difference of TenneT NL and TenneT DE.

The assessment of approaches should be transparent with respect to their impact on the level of FRMs for the most critical network elements. This would help determining the most relevant approach for each TSO.

Feedback of CWE TSOs:

CWE TSOs note that not all TSOs differentiate by fuel type in their GSK. For the TSOs who do differentiate, the differentiation between fuel types was derived based on statistical analysis of power plant schedules in order to reflect market activities of power plants. In particular, fuel types allow for a statistical relevant distinction between base load generation and market driven generation, which is a required feature for the GSK.

The technical limitation of the flow based computation requests a pure linear GSK without possibility to consider a min and max value per node. So the pure market driven oriented approach or merit order approach cannot be applied and, TSOs need to accomodate their GSK methodology accordingly, depending on the specificities of the grid and generation pattern in its control area.

CWE TSOs always aim at harmonizing their methodologies. However, the GSK is very specific for each control area and its generation. Therefore, each CWE TSO determines the GSK in a way most suitable for its control area. This explains the difference between TTG and TTN, which reflect the very different generation structure.

6.6.1.7 FRMs

In our view, deviations related to remedial actions triggered by TSOs (such as voluntary topology changes, HVDC or PST settings, or redispatching) should not be accounted within the FRM setting. Indeed, those result from decisions by TSOs whose impact can be anticipated, unlike the other dimensions mentioned in page 12 of the proposal.

TSOs should clarify how they intend to modify the scheduled flows to account for those voluntary updates between the capacity calculation and real time.

Feedback of CWE TSOs:

The FRM is determined by the timestamps where the forecasted load-flow is lower than the realized load flow. Therefore, only remedial actions that increase the real time load-flow on a CNEC are relevant for the FRM of this CNEC. Moreover, for efficiency in the process and considering the effort needed to archive, list and translate applied RAs from real time back to forecasted dataset, we only focus on the RAs which can, from a qualitative point of view, significantly impact the FRM. Considering these aspects, CWE TSOs compute PST-adjusted FRM values, which do not take into account flow deviations related to PST settings. The use of redispatching and HVDCs generally has a positive effect on FRM values and is then not considered in the adjustment of scheduled flows. As the occurrence of an outage on the grid remains very rare, the consideration of flow deviations related to curative remedial actions has a negligible impact on the FRM values and does also not require to further modify the scheduled flows. It has also to be noted that CWE TSOs provide improved grid models in which foreseen remedial actions at the time of the capacity calculation are already applied.

6.6.1.8 Validation of capacity (countertrading and redispatch)

"The use of any of the above mentioned instruments has to be monitored, and is not dedicated to enlarge the flow-based or ATC domain, as it would become too large, thus unsecure. The output of this process is the amended flow-based and/or ATC domain."

We certainly acknowledge that the inclusion by individual TSOs of additional constraints in the capacity calculation or allocation because of internal constraints should be thoroughly monitored and justified. But we disagree with the statement that enlarging the FB or ATC domain systematically makes operation less secure. Indeed, TSOs may use alternative remedial actions, such as countertrading or redispatch to restore secure system operation. In this regard, the MPP calls for a capacity calculation and allocation that leads to the most efficient trade-off between the various means TSOs can rely on to secure system operation.

Feedback of CWE TSOs:

As explained in the Consultation report, CWE TSOs welcome the proposal to consider economical parameters in the process. However CWE TSOs consider the topic of implementing costly remedial actions in order to adapt the capacities and use of congestion rent for redispatch to be an NRA decision. TSOs would additionally like to inform that related discussions are also ongoing at ENTSO-E level.

6.6.1.9 Back-up procedures

"The back-up process has to be reliable in order to ensure that capacity will always be delivered to the market players. In case the process fails, the last computed capacity will be provided to the allocation platform. For example, in case the intraday capacity calculation fails, the TSOs will provide to the allocation platforms the leftover of the day ahead capacity."

It is not clear what this really means. The fall back is the current procedure?

Feedback of CWE TSOs:

The backup procedure foresees that the leftover capacity per CWE border and direction shall be determined based on the Day-ahead flow-based domain and the day-ahead

Market clearing point using the ATC extraction algorithm from the current procedure. But no additional (bi- or multi) lateral assessment shall take place.

6.6.2 Questions by MPs following consultation process

6.6.2.1 The calculation of ID RAMs

What is taken into account in practice? An example with historical measurements on a particular CNE would be welcome.

Feedback of CWE TSOs:

The calculation of CNE is explained in the Methodology document. The calculation of RAMs does not differ from the DA FB calculation. Historical information from DA point of view is already provided by TSOs on the www.jao.eu website for MPs.

6.6.2.2 Stopping XB exchanges during the capacity calculation process

MPs consider this might reduce market efficiency (in particular when there are several recomputations) but understand this would allow considering reduced RAMs. Could TSOs provide figures about how much placing ID markets on hold during recomputation leads to reduced RAMs?

Feedback of CWE TSOs:

The FB IDCC methodology does not deal with trading on capacities and does not refer to a stop in the XB exchanges during the CC process.

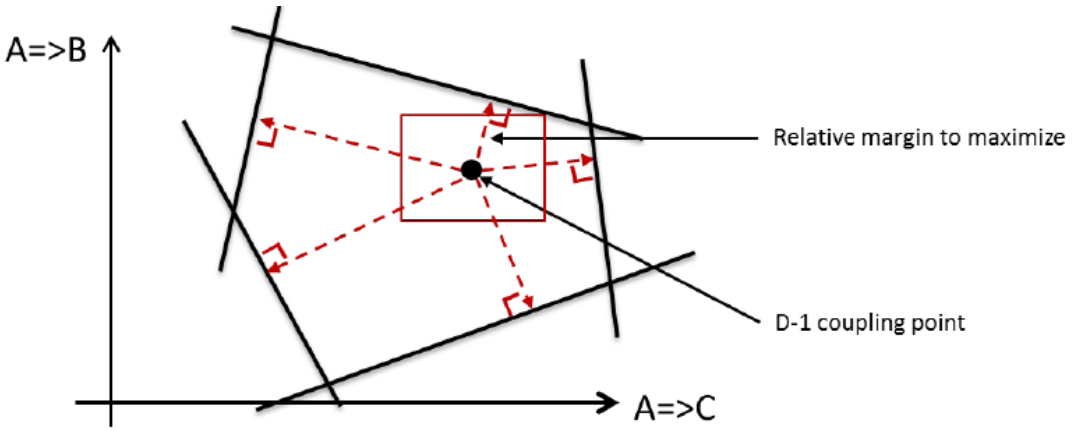
The CWE FB IDCC method will be operationalized with only one re-computation for the full day before gate opening. More re-computations for Intraday are to be expected as part of the CORE initiative.

6.6.2.3 Favoring certain directions for capacity increase through RA optimization

In terms of favoring certain directions for capacity increase through RA optimization, MPs want to highlight that their feedback do not oppose. They may differ slightly (mainly due to the extremely short delay they had to answer the consultation: 2 weeks) but tend towards the same direction, as long as there are only a few IDCCs, TSOs should give more value to enhancing the FB domain in the intraday or day-ahead market direction (depending on the timing of the recalculation) than in the reverse direction. At least the impact assessment should monitor such an indicator.

Feedback of CWE TSOs:

The present objective function is to increase the minimum relative margin by finding remedial actions that aim at improved capacities based on the day-ahead market results. The RAO tries to maximize the margins of elements to be optimized relatively to their sensitivity to exchanges, without market assumption (i.e. without a preference to any particular exchange directions). This can be explained as increasing the space around the market clearing point of the day-ahead market as illustrated in figure 3 below.



$$Relative\ Margin\ (CNEC) = \frac{Margin(CNEC)}{\sum_{i,j \in hubs} |PTDF_{i \to j}(CNEC)|}$$

Figure 3: Illustration of the non-discriminatory approach to increase the space around the market clearing point of day-ahead without one border being advantaged over another.

This means that a remedial action will be selected and implemented if it increases the margin on the limiting branch (among the CNECs to be optimized) considering the already achieved minimum margin.

From this approach it follows that the day-ahead market clearing point (more precisely its position in the FB domain) determines the directions in which the domain is optimized.

Furthermore it can be noted that the objective function of the RAO is always the same independent of the day-ahead market clearing point being included in the FB domain or not.

6.6.2.4 Impact assessment & performance indicators

MPs questioned the impact assessment, and suggested several performance indicators. Could the TSOs simulate additional results with such indicators since March?

Feedback of CWE TSOs:

CWE TSOs are performing an internal parallel run since May 30th, 2017 in order to get more quantitative results and perform a more reliable and representative impact assessment. This internal parallel run will continue during 2018 and will be followed by an external parallel run, whose results will be shared with Market Parties.

As the behavior of market participants in the intraday timeframe is not predictable, CWE TSOs are not only looking at the capacity in the DA market direction, but are also computing a market indicator that takes into account all the market directions.

CWE TSOs welcome any suggestion from Market Parties about new indicators.

6.6.2.5 Multiple IDCCs

MPs welcome the announcement by CWE TSOs that multiple IDCCs will be performed in the future. An indicative schedule would be welcome for this development.

Feedback of CWE TSOs:

CWE TSOs acknowledge that multiple recomputations during intraday increases security of supply and reduces the uncertainty level which allows more capacity to be provided to the market. However, due to CACM GL deadlines, no major update (e.g. extension of the number of recomputations) of the intraday capacity calculation methodology is foreseen before the go-live of IDCC in the Core CCR. For Core IDCC, multiple recomputations of capacity are already foreseen as provided in the Core FB IDCC Proposal.

6.6.2.6 External constraints

As of the external constraint, it is unclear to market parties to which extent voltage stability issues extent can be considered as cross-border related. Also, if external constraints prevent the market clearing point to deviate significantly from the forecast (i.e. the MCP immediately before the recomputation?), this should be duly taken into account in the FRM, which should be reduced consequently.

Feedback of CWE TSOs:

The FRM values cover uncertainties of the input parameters and not of the applied model itself, therefore External Constraints have no effect on the FRM values.

Extreme situations far away from the original market clearing point cannot be reflected in the linear approximation that is used in the DC loadflow. This approximation only remains valid in a certain area around the market clearing point. Therefore, moving far away from the original assumption, leads to large model inaccuracies and a failure of the model. This implies, that a stable grid operation is not guaranteed anymore and TSOs are obliged to prevent this.

6.6.2.7 XB redispatch

We understand that XB redispatch would shift the FB domain, and would welcome more details on the way CWE TSOs intend to organize XB redispatching. In any case, full transparency should prevail on redispatching as soon as such actions are triggered by TSOs (i.e. before real time), as they can significantly affect price formation in all bidding zones.

Feedback of CWE TSOs:

CWE TSOs agree on the need for transparency for redispatch measures, but XB redispatch is out of scope of the present process. The application of redispatch is not triggered by capacity calculation. Instead some control blocks are using internal processes for the determination of preventive redispatch or real time system operations will decide close to real time if redispatch measures are necessary.

6.6.2.8 ID Countertrading

Do TSOs foresee to use the countertrading for CWE? If not, why? Is it foreseen in the future?

Feedback of CWE TSOs:

CWE TSOs consider the topic of implementing costly remedial actions (e.g. countertrading) in the process to be an NRA decision. Should these measures be necessary in order to safeguard security of supply, CWE TSOs consider this out of scope for the present process.

Explanatory note for capacity calculation for ID timeframe

For additional information

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Contents

1 Management summary

1.1 Purpose of the document

The purpose of this explanatory note is to describe the concept of the Flow-Based Intraday Capacity Calculation (FB IDCC) and thereby to complete the Methodology for capacity calculation for intraday timeframe that is provided for approval to the CWE NRAs in the framework of Regulation 714/2009. It provides in particular a more detailed explanation of the methodology, the experimentation results and the further improvements foreseen.

In order to ensure a manageable implementation of the FB IDCC within a reasonable timeframe, TSOs focused on a set of requirements to be covered by the present concept as a first step towards a CACM enduring solution. These are the following:

- At least one FB ID computation should be performed for each time stamp (TS).
- Concerning the network model, focus is mainly on DA CGM, possibility of the applicability of ID CGM will be analysed and potentially implemented.
- For the remaining inputs, the methodology should be close to the day ahead (DA) method.
- All Remedial Actions (RA) coordinated in DA should be considered if still available, and possible additional RAs should be considered.
- In order to increase the coordination and ease the operational process, taking into account the time constraints, an optimizer will be developed to link RAs to Critical Network Element Contingency (CNEC) in a way to optimize capacities.
- At the end of the capacity calculation process, ATCs will be extracted from the flow-based domains.

This paper provides a detailed description of the inputs and processes. The major change compared to the FB DA method relates to RA optimization including usage of CNECs. Due to the time constraints in intraday, a highly automated process is needed.

Particular attention has been taken in order to provide a clear objective function and ensure that the inputs allow to apply this new methodology. The other needed inputs, processes and outputs are also described in a similar way as in the FB DA approval package.

The remainder of this document is structured as follows: chapter two contains an introduction. A description of the FB IDCC process is defined in chapter three and the ~~experimentation~~partial results of the internal parallel run with ~~the first~~ assessments and learnings are presented in chapter four. The next chapter describes the improvements on the inputs and the process for the future FB IDCC and chapter six provides technical and quality criteria for the parallel run.

2 Introduction

2.1 Background of FB IDCC

2.1.1 Recalculation of the existing Flow-Based Day-Ahead Capacity Values

Due to the structural change in the electricity sector, mainly due to the increase of intermittent renewable energy sources, liquid and efficient intraday markets become more and more important. Cross border capacities are of major importance for the liquidity by increasing trade and balancing opportunities for the market players between market areas. While guarantying security of supply, TSOs have the obligation to deliver to the market as much available capacity as possible.

With the implementation of the FB Market Coupling, CWE TSOs developed a flow-based capacity calculation for the day ahead timeframe. Using the latest available information on grid, demand and supply TSOs compute the available capacity before the day ahead allocation (12 am D-1). As this information is supposed to change over time, a recalculation of the available capacity after the day ahead timeframe might lead to additional capacity for the intraday allocation, supporting cross border trade and balancing opportunities for market parties. However, it has to be noted that a recalculation taking into account the latest available information on grid, demand and supply could also result in less available capacity for the intraday timeframe. In any case, the already allocated capacity will be ensured.

According to the CACM Guideline the target model used in the capacity calculation methodologies shall be a flow-based approach and should ensure that cross-zonal capacity is recalculated within the intraday market timeframe based on the latest available information. Moreover, the frequency of this recalculation shall take into consideration efficiency and operational security. On the way towards a CACM compliant capacity calculation methodology CWE TSOs will apply a step-wise approach on the basis of the current intraday ATC solution and under consideration of the target model to be developed and implemented in the Core region.

2.1.2 Current solution is an ID ATC calculation after FBMC process

The current capacity calculation methodology for the intraday timeframe is based on an ATC approach (intraday ATC calculation). This solution is an outcome of a step-wise evolution from a bilateral increase/decrease process to a coordinated increase/decrease process.

The intraday ATC calculation process was inspired by the process that was implemented before FB Go Live on the DE-NL and BE-NL borders and the CWE ATC day ahead process, which also combined different local processes with coordination on CWE level in consecutive steps. Starting point for the intraday ATC calculation methodology are the initial intraday ATC values, which result from the FB day ahead process. The initial intraday ATC is computed out of the day ahead FB domain around the day ahead market clearing point and is the result of a unique and common centralized computation. The first step is followed by a local assessment by CWE TSOs evaluating a possible increase or decrease on their own borders. The third step is a merging step by a common system. A Central Matching Tool (CMT) consolidates the increase requests and the decrease notifications. Based on this consolidated input, all CWE TSOs perform a local analysis that enables them to accept, partially accept or reject the requested capacity increases in a justified manner. Finally, the acceptance or rejection messages are handled in a common way by the CMT.

2.2 Context of FB IDCC

2.2.1 Request from CWE NRAs to design a Flow-Based IDCC process

According to Regulation EC 714/2009, TSOs shall establish a congestion management method for the different timeframes taking into account the electrical and physical realities of the network.

After receiving the "Position Paper of CWE NRAs on Flow-Based Market Coupling" of March 2015, CWE TSOs implemented a bilateral increase/decrease process starting from initial intraday ATC values, which was extended to a coordinated increase/decrease process by November 2015. This process allows for more capacity at the intraday timeframe, taking stock of recent information on grid, consumption, generation parameters and renewables.
In February 2016 CWE NRAs communicated their position regarding the implementation of the coordinated intraday ATC calculation to CWE TSOs. CWE NRAs stressed that the proposed method is not in line with the request made in the Position Paper, since the proposed method is seen as a reassessment but not as a recalculation of the intraday ATC values by CWE NRAs.

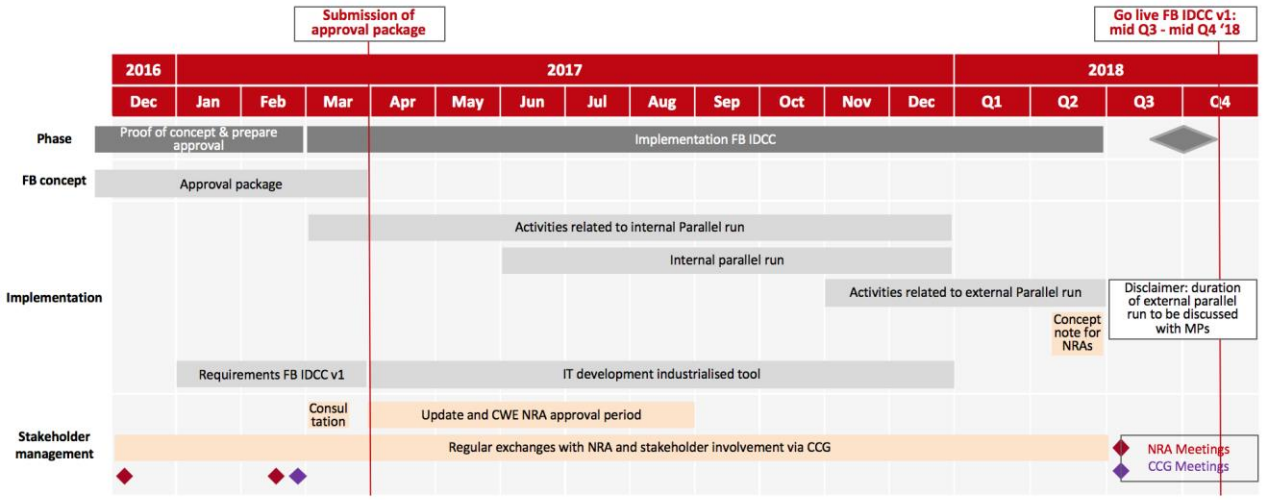
CWE NRAs and TSOs discussed the development of a flow-based capacity calculation for the intraday timeframe during 2016. In May 2016 a workshop was held in order to discuss the FB IDCC concept foreseen to be implemented in CWE, the challenges compared to FB day ahead and the implementation approach. Also the aim of the workshop was to provide detailed explanations and receive direct feedback from the regulators.

After the decision taken by ACER on CCRs on November 17th 2016, CWE NRAs have communicated to CWE TSOs on January 4th 2017 a letter officially requesting CWE TSOs to continue with the development and implementation of a Flow-Based Intraday Capacity Calculation Methodology in CWE, as an extension of the original and already approved CWE FB DA MC. This letter also reminds that the Flow-Based Intraday Methodology has to be compliant with the general and content-related objectives of the CACM Regulation.

2.2.2 Planning for implementation

~~The~~CWE TSOs ~~aim at implementing a solution in the short term in order to~~are working towards the implementation of FB IDCC, which will replace the current coordinated bilateral increase/decrease process ~~(see Figure 1 for the~~. The FB IDCC implementation planning~~).~~

~~The next steps of the project will be an internal parallel run followed by an external parallel run beginning~~, up-to-date as of ~~2018. The launch~~the submission of ~~the process is foreseen in the second semester of 2018~~this document, can be found in Figure 1.



CWE TSOs would like to highlight that this is a challenging planning reflecting the earliest go-live date seen as feasible as of this submission, but that high uncertainties remain, including:

- progress in the central and local implementation of industrialized IT tools;
- the need for significant testing and validation of these tools, as this is the first CC process running in CGMES format and using an automated RAO;
- the potential need for further optimization of system performance, considering the shorter duration of the FB IDCC process when compared to the FB DA process.
- the approval by NRAs of the FB IDCC methodology and potential requests for additional ammendments.

TSOs plan the go-live of FB IDCC on BD 20190619, but note that, considering the elements above, the go-live could be delayed until the end of September 2019.

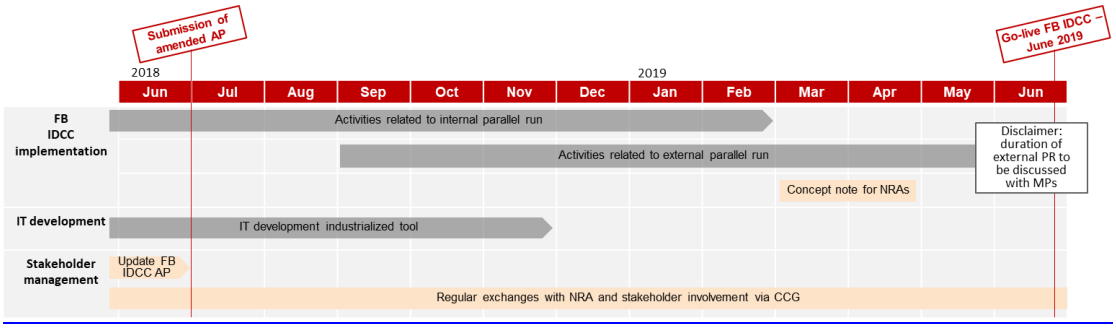


Figure 1: Planning for implementation FB IDCC.

~~In parallel of the TSO activity, stakeholders will be consulted on the method beginning of 2017.~~ During meetings with NRAs and the CCG ~~meeting~~, the project will inform ~~the~~ stakeholders of ~~the~~additional updates and next steps.

3 General principles of Flow-Based Intraday Capacity Calculation

3.1 Inputs

Each time intraday capacity will be computed, the TSOs will have first to provide all the required input data: Individual Grid Models (IGMs) aiming at representing the best forecast of his control area for the computed timestamps, especially for what concern the latest consumption forecast, topology, latest RES forecast, operating schedules of generators and exchange schedules, the list of Critical Network Elements (CNEs), Contingencies (Cs), Flow Reliability Margins (FRMs), available Remedial Actions (RAs), the Generation Shift Key (GSK) and the External Constraints (ECs). These inputs will be provided for each remaining hour of the day.

3.1.1 ECs

The following sections will depict in detail the method used by each TSO[1] to design and implement external constrains. These methods were already approved together with the DA FB methodology.

3.1.1.1 German External Constraint

~~Amprion, TransnetBW and TenneT Germany determine the external constraints for the German CWE net position in order to limit the German export and import in interdependence with the day ahead market clearing point. As such, the deviation from expected flows can be restricted to avoid flows in real-time that are too far from the expected flows going through Germany and therefore, cannot be verified as safe during the flow-based process. As a consequence, the external constraint is set to a value in a certain range around the day ahead market clearing point. The magnitude of this range is based on offline studies.~~
~~Under extreme grid conditions it can further be necessary to reduce the external constraint in order to ensure security of supply.~~
Amprion, TransnetBW and TenneT Germany do not apply External Constraints for the German Market area.

3.1.1.2 Dutch External Constraint

TenneT NL determines the maximum import and export constraints for the Netherlands based on off-line studies, which include voltage collapse analysis, stability analysis and an analysis on the increased uncertainty introduced by the GSK, 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.

3.1.1.3 Belgian External Constraint

To ensure operational security, Elia uses an import limit constraint as an additional FB constraint which is related to the voltage control and dynamic stability of the network. The value is set to be the global constraint minus the allocated capacities after Market Coupling (in relevant import or export direction) on non-CWE borders and the capacity calculated on non CWE borders. This limitation is estimated with offline studies which are performed on a regular basis.

3.1.1.4 French External Constraint

RTE will not use any External Constraint in most cases.
In some specific cases (cold front for example) though, RTE could use an import/export limit constraint related to the voltage control and dynamic stability of the network. If required, these limitations will be calculated with a dynamic study performed on the

[1]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.

afternoon of D-1. The use of External Constraints will be systematically reported to the NRA.

3.1.1.5 Austrian External Constraint

APG will not use an External Constraint in most cases.

In some situations APG would use an import/export limit constraint to address specific load flow situations (e.g. change of the likely market direction). The EC would be based on offline studies which are performed on a regular basis and after first operational experience is gained with the bidding zone border split DE/AT. The use of External Constraints will be systematically reported to the NRA.

3.2 FB ID CC Process

On an abstract level, the Flow-based Intraday Capacity Calculation process can be described by the following flow chart in Figure 2.

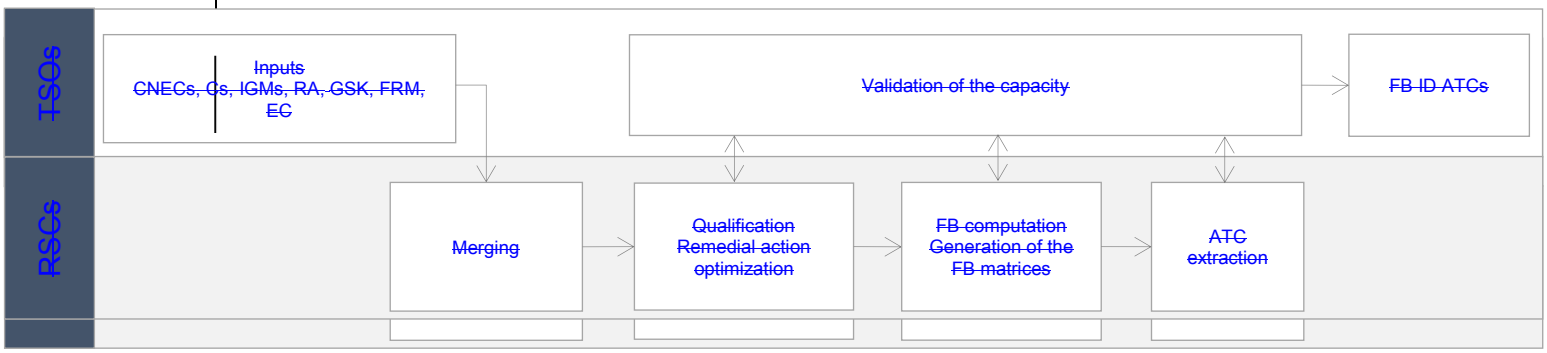


Figure 2: FB IDCC process.

Once the inputs have been provided, the Regional Security Coordinators (RSCs) in charge of the merging and computation will merge the IGMs. The aim of the merging process is to define a common set of data based on the data provided by the TSOs. This will result in Common Grid Models (CGMs). During the merging process quality checks are performed.
For the construction of the CGMs the IGMs of CWE TSOs but also of every continental European TSO will be used. At the time of the merge this CGM is the best forecast of the infeeds and flows in Continental Europe.

Once the CGMs are generated the qualification phase starts. The aim of the qualification phase is first to include the already allocated capacity and second to increase the capacity around the already allocated capacity.

In order to achieve this goal, a branch-and-bound optimizer is used in order to associate remedial actions to constraints creating an additional margin that can be offered to the market participants. The objective of the optimization is to maximize the relative margin of the CNEC that has the lowest relative margin using available RAs, which means to optimize those ~~margins~~RAMs that can be effectively optimized and yield the highest impact on capacities. The relative margin is the ~~absolute margin~~ RAM divided by the absolute sum of the ~~four~~commercial bilateral CWE zone to zone PTDF. If a CNEC has a negative RAM, its relative margin will be equal to the RAM.

The aim is to introduce a gain in terms of capacity and not absolute Ampere. Presently the PTDFs are computed before and after the choice of the preventive remedial actions. The risk policy of each TSO has to be respected during the association and the impact of the RA on CNECs has also to be assessed in order not to create an insecure grid situation. The outputs of this part of the process is, for each remaining hour of the day:

- A coordinated set of preventive remedial actions,
- A coordinated set of curative remedial actions for contingencies.

Based on these outputs, the FB computation will be performed with the aim to deliver the flow-based parameters just like in the DA FB computation.
The outputs of the FB computation process are for each remaining hour of the day:

- a PDTF per hub and CNEC
- a margin per CNEC
- a list of limiting CNEC (pre-solved domain)
- and, optionally, Power Shift Distribution Factors (including virtual hubs) per special grid element (Eg. HVDC links)

In case the day ahead market clearing point is not included in the FB domain (at least one CNEC has negative margin after the Remedial Action Optimization and flow-based computation), the day ahead market clearing point will be automatically included in the domain (Annex ~~7.1~~6.1~~6.1~~).

The resulting FB domain will then be used to extract the available transfer capacities (ATCs) for each remaining hour of the day, for each border and direction. Remedial Action Optimization, FB computation and ATC extraction will be performed in a central place by RSCs.

As in any capacity calculation process, the results of Remedial Action Optimization, FB computation and ATC extraction will be subject to validation by TSOs. The aim of this validation is to verify if the computed flow-based domains and extracted ATCs are still secured after computation. The proposed methodology foresees different ways to perform a validation after Remedial Action Optimization and FB computation like using FAV, changing EC, modifying CNECs and/or change of RAs. However, it has to be noticed that for the time being no TSO intends to use one of these possibilities. Currently, only a validation of the ATCs after ATC extraction is foreseen.
After the validation, the ATCs will be made available to the market players on the allocation platforms for the 24 hours.

4 Flow-Based IDCC internal parallel run Results
Flow-Based IDCC Experimentation Results

~~4.1 Approach of the experimentation~~

TSOs in collaboration with RSCs ~~performed~~are performing an ~~experimentation~~internal parallel run in several phases in order to develop~~ the~~, test and verify a new capacity calculation process~~.~~ for the intraday timeframe. The ~~core of the experimentation has been the development of a~~ new capacity calculation process is based on a Flowbased approach using ATC extraction to determine the final capacities to be provided to the market.

The main focus of the internal parallel run is on implementing a new operational process on RSC and TSO side, and improving the Remedial Action Optimizer ~~(RAO)~~ in accordance with TSO's business ~~requirements.~~

~~For each of the phases an experimentation goal was defined and lessons learned from previous phase(s) were directly used~~requirement, while developing the final IT environment in ~~next phase(s)~~parallel.

During the parallel run, the results are monitored and analyzed in order to constantly improve the quality and development of the Intraday Flowbased process.

~~Experimentation process~~

~~The experimentation process is different~~ Results for the timespan from ~~the general FB process in order~~**29/05/2017** to **31/03/2018** are analyzed.

4.1 Approach~~avoid unnecessary actions~~

The process of the internal parallel run is designed to be as ~~much~~close as possible~~.~~ to the later operational process. Nevertheless, due to the challenges for the introduction of a new operational process like IT development and operator availability, different process timings and increased expert involvement is required.

~~Three~~Five main steps ~~in~~of the ~~experimentation~~internal parallel run process can be identified:

- Initial data preparation, mapping & checks
- ~~Baseline computation (without RA)~~
- Remedial Action Optimization
- Flowbased computation
- ATC extraction
- Validation of capacities

1. Initial data preparation, mapping & checks

The main objective is to prepare the input for ~~baseline computation and~~ the daily RA optimization and Flowbased computation. The following input is required:

- Initial DA CGM (containing corrections on tie-lines inconsistencies, balance mismatch, correction of loadflow parameters etc.)
- Reference program
- Critical Network Elements, Contingencies and Remedial Actions (CNE, C, RA)
- Generation Shift Key (GSK)
- External Constraints (EC)
- Initial and increased ID ATC domain (for comparison)

~~1. Baseline computation~~

~~The main objective of the baseline computation is to perform a FB computation excluding Remedial Action Optimization in order to assess the added value of the RA optimization on the provided ID capacity.~~

2. Remedial Action Optimization

In this step ID capacities are optimized by ~~applying a certain~~a set of shared remedial actions (see section 3.1.4. of Methodology). TSOs define the remedial actions that are available for the Remedial Action Optimization and the set of ~~monitored~~considered CNECs.

~~4.2 Experimentation Results~~

~~4.2.1 Phase 1: first step to define an intraday process[2]~~

~~In phase 1, experimentation was performed on four runs of one time stamp (TS) each. In this phase, the objective function was to maximize the minimum absolute margin of all CNECs that constitute the FB domain. The aim was to test the first version of the process including the use of a Remedial Action Optimization algorithm and analyse first timestamps.~~

~~The main results of this phase are:~~

- ~~Improved understanding of Remedial Action Optimization and impact of prepared inputs;~~
- ~~Improvements on Remedial Action Optimization objective function were identified.~~

3. ~~Phase 2: experience over one day~~Flowbased computation

~~In phase 2, Remedial Action Optimization experimentation was performed on five runs of one full business day (24 TS) each. In this phase Remedial Action Optimization was perfomed only for a few TSs per day and afterwards the resulting RAs were extrapolated on the neighbouring hours. The Remedial Action Optimization was performed with the previous objective function and also with the new one to maximize the minimum relative margin.~~
~~The objective was to fine tune and finalize the methodology and to prepare phase 3 activities in terms of tools and organisation on TSO and RSC level.~~
The main objective of step is to perform a Flowbased computation considering all Remedial Action determined by the Remedial Action Optimization.

4. ATC extraction

ATCs are extracted from the Flowbased Domains of step 3 for each hour.

5. Validation of capacities

Before the ATCs are considered as final, each TSO has the opportunity to validate the calculated capacities.

~~[2] During experimentation phase 1 APG was not fully integrated in all technical CWE processes yet. Therefore it was not possible to consider APG CNECs already in this phase. However APG was fully involved in the subsequent phases 2 and 3.~~

4.2 Intraday Flowbased Key Performance Indicators

In order to assess and monitor the performance and the impact of the new intraday capacity calculation process, CWE TSOs developed four main indicators, the Intraday Flowbased Key Performance Indicators (KPI), that are more detailed below:

- Computed Business Days

MCP

~~The main results of the second phase are:~~

- ~~Improved objective function gives better results from capacity perspective as the algorithm focusses more on the elements that are sensitive to the cross border exchanges instead of only the elements with absolute low margin;~~
- ~~Extrapolation of Remedial Action Optimization results does not give satisfying results and the extracted ATCs are low.~~

~~4.2.2 Phase 3: gaining confidence to launch a parallel run~~

~~In phase 3, Remedial Action Optimization experimentation was performed on four runs of five full business days (24 TS each). The optimization is performed for every hour only with the updated (new) objective function.~~

~~The objective was to perform recurrent FB ID computations in order to develop a quantitative assessment of the proposed concept / methodology that can be approved by CWE NRAs.~~

~~During this phase 3 experimentation, additional indicators have been developed to monitor~~

- ~~The DA Market Clearing Point (MCP) Inclusion: The~~ indicator ~~will look after Remedial Action Optimization to~~
- ATC indicator
- Minimum ATCs

Results from **29/05/2017** to **31/03/2018** are analyzed.

4.2.1 Computed Business Days

The percentage of all successfully computed timestamps or business days during the parallel run indicates the reliability of the current process from an IT and operational point of view.

The overall results for the internal parallel run and the 30 days moving average can be seen below.

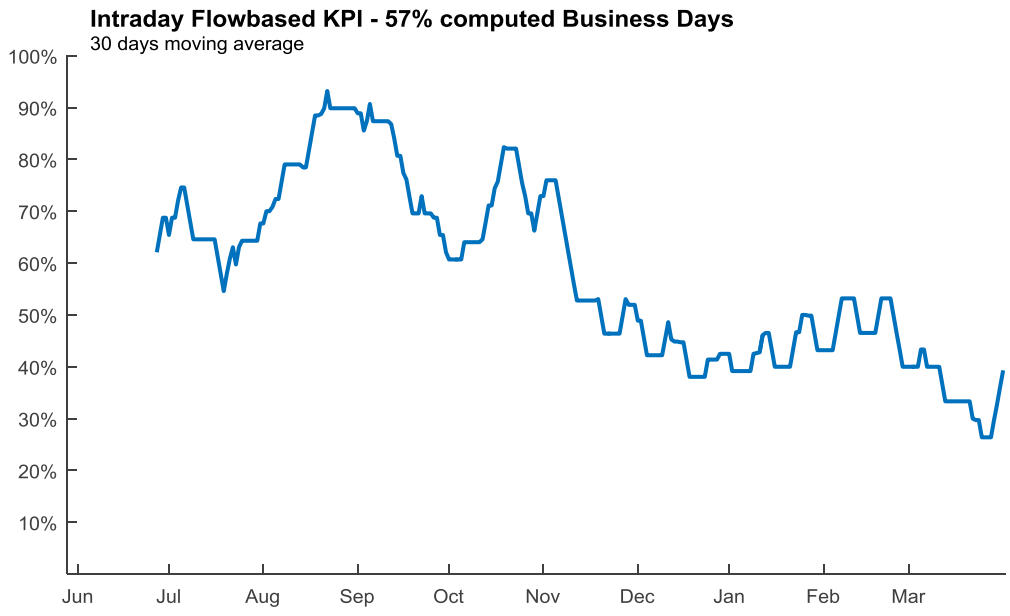


Figure 1: Computed Business Days (29/05/2017 to 31/03/2018)

Overall, 57% of all business days are successfully computed. Main reasons for non-computed days are issues with the IT prototypes being used for the parallel run and challenges of a new daily operational process.

Starting in November 2017 re-occurring IT issues prevent more computed business days. However, the problems could be fixed in April 2018 and a higher rate of computed business days is expected for the remaining parallel run.

4.2.2 MCP indicator – percentage of the DA Market Clearing Point (MCP) Inclusion without FRM

This indicator looks at the minimum absolute margin on the CNECs that will be monitored during the FB computation~~.~~ after Remedial Action Optimization. If this value is ~~below 0~~above or equal to 0 MW, the MCP is considered as ~~non~~ included and ~~is marked as red~~all congestions could be removed before the Flowbased calculation starts. In order to have an indicator reflecting the flows in the gridmodels, the security margins (ID FRM) are not considered for this indicator.

The following figure shows the behavior of the MCP indicator (30 days moving average) from 29/05/2017 to 31/03/2018.

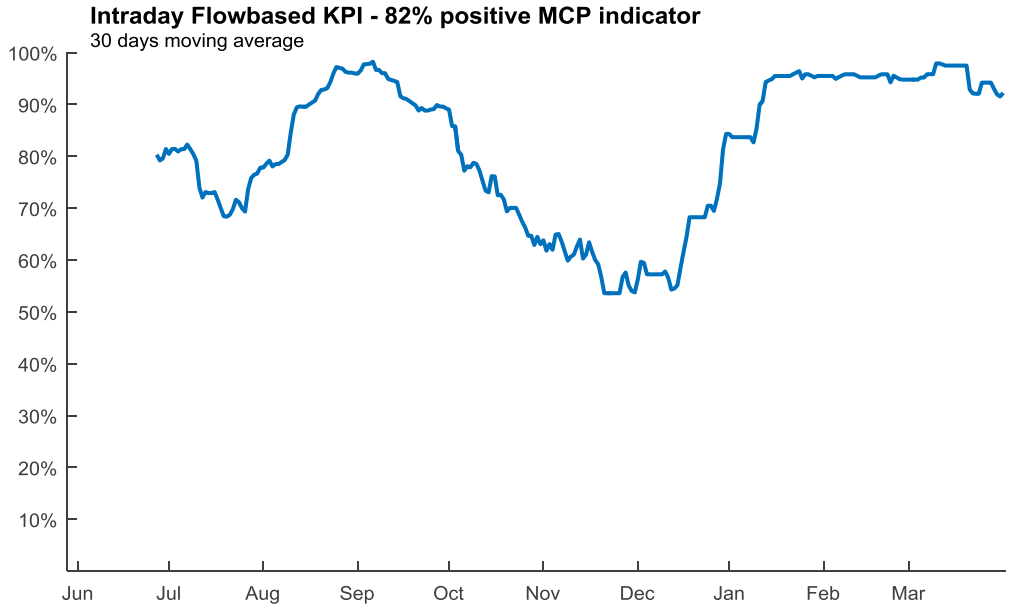


Figure 2: MCP indicator (29/05/2017 to 31/03/2018)

The DA MCP inclusion indicator without FRM averages at 82% for the internal parallel run. It surpasses values of 95% or higher in August and September, before it decreases below 55% during autumn due to a stressed grid situation and planned outages. At the end of 2017 several improvements in the grid and in the process were implemented that positively affected this indicator.

In December, the positive MCP indicator values raises and remains at approximately 95% for the 30 days moving average in January, February and March.

4.2.3 ATC ~~indicators: the~~indicator

The resulting ATCs per border and direction extracted from the ID FB domain are compared to the ~~initial~~ ATCs ~~extracted~~ from the ~~DA FB domain~~current Intraday ATC after FBMC increase/decrease process and a reference ATC obtained from a statistical analysis on the intraday ~~behaviour~~behavior of the market ~~participants'~~ participants and cross border nominations.

For each hour, ~~these~~the differences for all borders are summed. If the sum is ~~below 0, then~~equal to or higher than zero, the value is ~~marked~~counted as ~~red.~~ positive.

The ~~main~~ results are shown below:

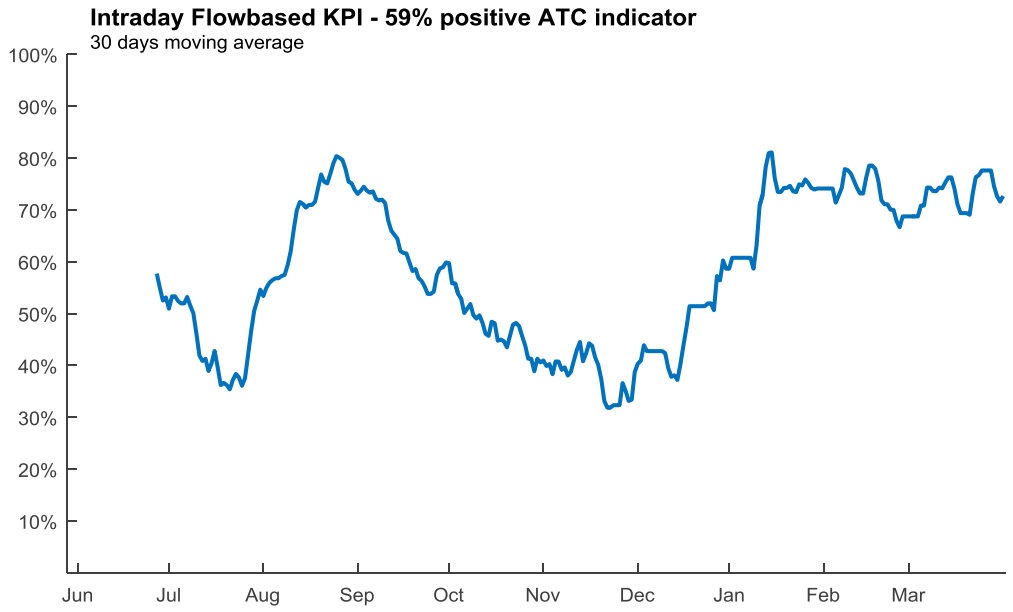


Figure 3: ATC indicator (29/05/2017 to 31/03/2018)

On average, 59% of the ~~last phase are:~~timestamps show positive values which means that more frequently capacities similar or better fitting the historical market use, when compared to the ID ATC after FBMC increase/decrease process, can be offered to the market.

- ~~3 runs out of 4 (run 1 to 3) have very limited FB domain, except during weekends. This is illustrated in table 1 below, which provides the value of the above indicators for each hour of the business days simulated in run 1. Reasons are:~~
  - ~~MCP non inclusion~~
  - ~~High congestions in the used grid models~~
  - ~~Lack of available/efficient RA in some congested areas~~
  - ~~Usage of lower Imax (in run 4 higher Imax values have been used for some lines)~~

	10/10/2016		11/10/2016		12/10/2016		13/10/2016		15/10/2016	
	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion
Hours	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin
H01	-2006	-179	-1220	-149	1953	107	-107	-89	2159	65
H02	-1339	-250	-1013	-252	171	-194	1	-84	1517	51
H03	-1337	-264	-1606	-324	196	-234	-1173	-195	2013	109
H04	-1337	-283	-1532	-346	432	-251	-1174	-250	1545	42
H05	-1165	-310	-1532	-383	553	-287	-1146	-292	-444	23
H06	-1174	-343	-862	-347	375	-312	-1485	-248	-179	15
H07	-1773	-456	-1174	-420	-1174	-454	-1175	-432	1365	58
H08	-1936	-379	-1975	-356	-2006	-329	-1695	-314	-670	-12
H09	-1773	-333	-1898	-293	-1531	-238	-1979	-198	-1461	-66
H10	-1936	-386	-2006	-318	-1936	-210	-2006	-162	-1461	-45
H11	-1936	-428	-2074	-350	-1778	-211	-1532	-197	-2451	-37
H12	-599	-419	-1937	-373	-1739	-174	-1532	-171	-2564	-43
H13	-762	-429	-1984	-369	-1704	-179	-1779	-120	-2191	-4
H14	-1936	-489	-1834	-455	-1475	-244	-1953	-107	-2123	-1
H15	-1773	-513	-1806	-463	-1532	-324	-2006	-101	-338	26
H16	-1773	-537	-1918	-474	-1174	-298	-2006	-133	-1841	-16
H17	-1797	-612	-1810	-423	-1843	-281	-2006	-179	-1627	-78
H18	-1843	-364	-1889	-400	-1843	-320	-1532	-249	-1347	-89
H19	-3243	-244	-1677	-363	-1620	-273	-1753	-222	-1832	-20
H20	-2297	-345	-2034	-305	-1948	-410	-1558	-278	-352	39
H21	-2006	-473	-1678	-373	-1987	-336	-1696	-173	-1092	10
H22	-1843	-355	-2017	-321	-1532	-539	-1799	-106	-1936	-31
H23	-1442	-320	-1459	-208	-1751	-491	-2006	-86	-1765	-40
H24	-1576	-439	-1383	-285	-1971	-326	1032	52	-1696	-12

~~**Table 1: Experimentation**~~Similar to the MCP indicator, constant high positive values can be seen starting in January, while low values occur during the stressed grid situations in autumn.

In the figure below, the ATC indicator is shown for each border.

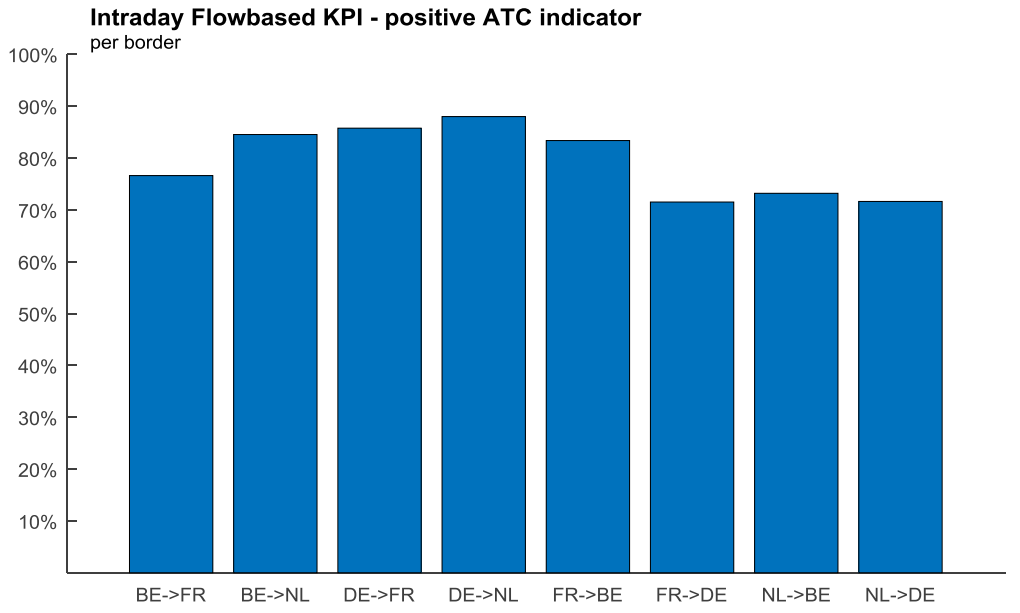


Figure 4: ATC indicator per border (29/05/2017 to 31/03/2018)

The ID ATC indicator reaches at least 70% for each individual border for the parallel run. The most positive impact can be observed for the German export capability with values over 85%.

4.2.4 Minimum ATC

This indicator compares the minimum ATC for the Intraday Flowbased process and the actual values of the ID ATC after FBMC increase/decrease process. The minimum ATC is the lowest ATC value of all commercial borders for each timestamp. In case the difference between the Intraday Flowbased process and the current process is zero or higher, the timestamp is counted as positive.

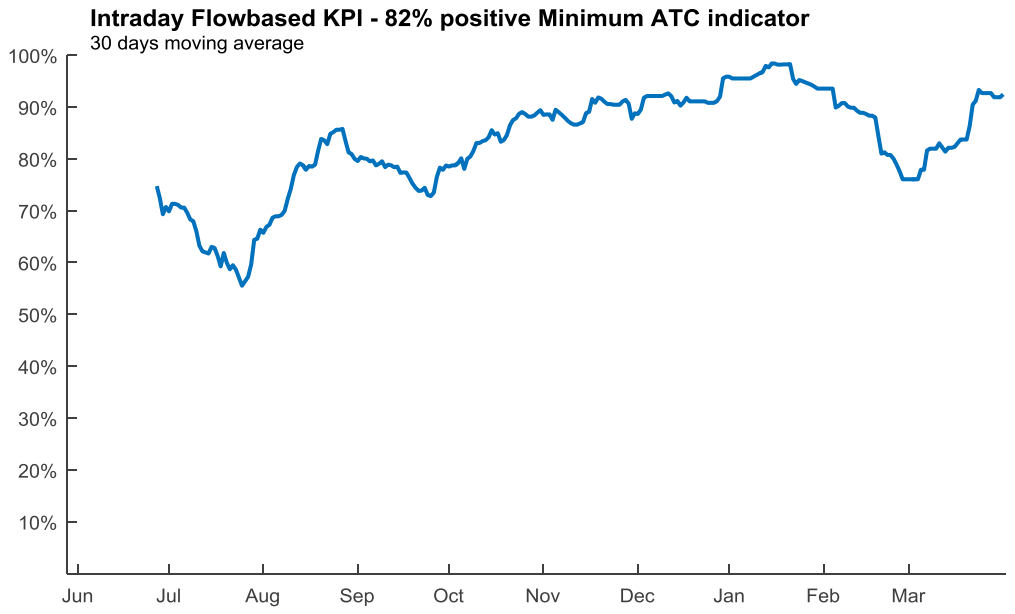


Figure 5: Minimum ATC indicator (29/05/2017 to 31/03/2018)

On average, a value of 82% is observed for the minimum ATCs. In particular, during the more stressed grid situation in autumn and winter, constant high values can be seen, although the MCP inclusion and ATC indicator show decreased values for this period. This is caused by low initial ATC values of the current process during that period. The new calculated ATC are able to match or surpass them most of the time.

The following figure gives a more detailed look of the actual values of the minimum ATCs. The differences between the current process and the IDCC process can be seen.

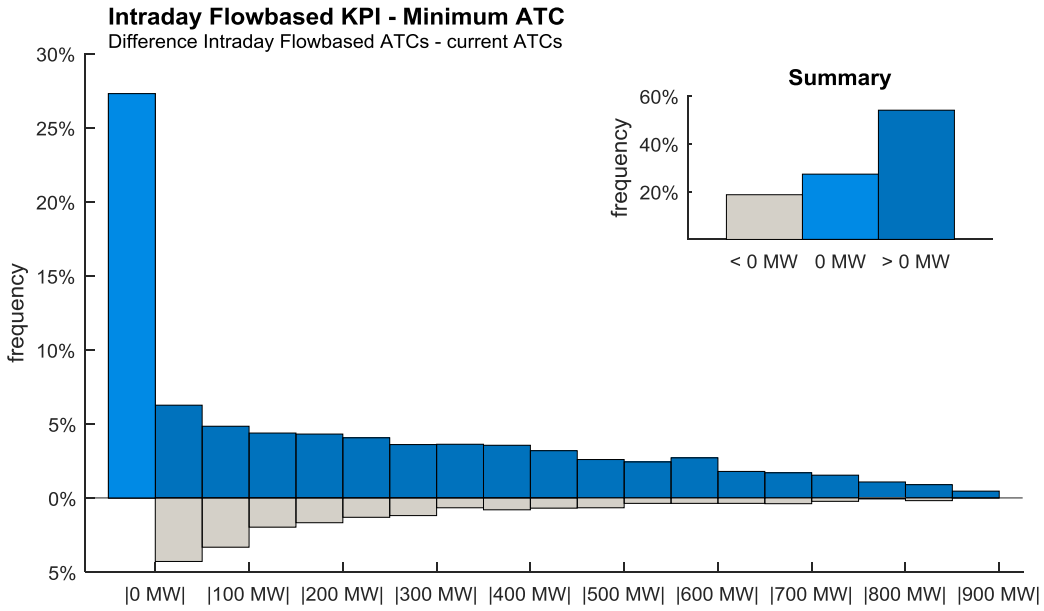


Figure 6: Minimum ATC indicator – values in MW (29/05/2017 to 31/03/2018)

The FB IDCC process shows higher minimum capacities when compared to the current ID ATC after FBMC incr/decr. process in 54% of all timestamps, and lower minimum capacities in around 19% of all timestamps.

A noticeable positive effect on the minimum ATC occur for the range from 0 MW to 900 MW for positive values (dark blue bars). The frequency for higher delta of positive minimum ATCs slightly decreases with higher delta values.

For negative values (grey bars), frequent decreases mainly occur for the range between 0 MW and 100 MW.

One of the main drivers for the positive results ~~for phase 3 run 1.~~

- ~~Only run 4 provides interesting results in terms of FB domain to be compared with initial ATC domain for normal business days. But even during this run, it can be noticed, as illustrated in the table 2 below, that non-inclusion of the MCP generally leads to negative results in terms of FB domain and related ID ATCs.~~

	1/11/2016		2/11/2016		3/11/2016		4/11/2016		6/11/2016	
	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion
Hours	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin
H01	1475	333	1003	66	1221	33	1843	191	1931	302
H02	1015	215	1047	63	895	56	1544	172	2845	445
H03	1463	283	-74	21	686	43	1821	141	2601	198
H04	1513	131	-2266	-41	787	44	1984	122	2263	497
H05	1408	122	-2293	-40	175	23	1900	65	1269	
H06	1095	243	-570	10	763	15	2005	149	1340	547
H07	756	75	190	45	-1489	-355	2156	112	204	455
H08	1123	114	-1761	-135	-120	-65	-1514	-64	174	358
H09	1137	283	-1531	-70	-343	-10	138	0	97	119
H10	1265	281	-1576	-42	-350	-136	934	52	1128	302
H11	1154	276	-1513	-4	-209	-153	908	108	179	203
H12	1193	271	464	45	-1421	-200	1297	81	207	203
H13	1193	225	427	42	-587	-189	700	112	174	112
H14	1283	136	981	45	-330	-168	1223	114	173	165
H15	1393	130	1456	119	-1827	-215	866	98	174	289
H16	1605	136	1680	92	-862	-185	1226	70	130	376
H17	1000	116	1665	60	-1173	-132	1828	113	127	425
H18	1120	83	212	-31	-1486	-135	2013	278	1563	308
H19	637	69	-633	15	-1843	-38	1545	92	1983	253
H20	1107	93	-494	0	-2002	-180	1798	137	1766	187
H21	1588	43	1048	30	-1689	-146	1667	343	1571	158
H22	1232	64	778	92	-121	17	2000	128	1128	251
H23	1195	82	1362	58	1095	10	2013	171	1128	72
H24	1705	145	1435	65	-1174	-48	1611	565	1128	77

~~**Table 2: Experimentation results for phase 3 run 4.**~~

~~4.3 Assessment results and learnings~~

~~Despite the suboptimal results of experimentation phase 1-3, there has been a significant improvement of the method and the RAO tool (as described in the sections above). The proper functioning of the proposed concept based on an optimizer has been verified as well.~~

~~As illustrated in the table 1 and 2 above and the table 3 and 4 in chapter 8.2 the quantitative assessment performed in phase 3 shows limited results in terms~~ of ~~available ID capacity. Only in the last run of phase 3, results comparable with the initial ATC domain have been obtained. Qualitative assessment of these results shows however that MCP inclusion after~~ this indicator is the Remedial Action Optimization ~~generally leads to positive results in term of resulting ATCs compared to the initial ones. Based on this correlation, better fine-tuning of the inputs data and Remedial Action Optimization parameters as well as provision of additional RA for the Remedial Action Optimization with the objective to significantly reduce the use of automatic MCP inclusion have been identified as important improvements that would be implemented in further experimentation and parallel runs.~~ that defines the ideal set of Remedial Action to improve the capacities around the Market Clearing Point.

4.3 ~~More~~Conclusion

Results in terms of capacities show positive elements.

Furthermore, there are additional benefits to the process that justify an implementation of FB IDCC:

- A better coordinated process;
- A more secure grid, as accuracy of forecasts is improved when compared to FB DA CC;
- More transparency regarding results.

However, more capacities for all directions compared to FB DA and the ATC increase/decrease process cannot be guaranteed with the new process~~. Optimization~~ as the simultaneous optimization of FB domains ~~can benefit the likely~~in all market directions ~~at the cost of capacity in the opposite directions~~is not possible.

~~New calculated FB IDCC domains reflect better the expected real-time situation which improves security of supply.~~

~~Further improvements of the FB IDCC methodology, and especially the Remedial Action Optimization, have been identified as well. After the analysis of parallel run results quick wins will be implemented if possible.~~

~~The~~The main challenges are to improve reliability of the process and the frequency of MCP inclusion. CWE TSOs commit to include the DA MCP in the FB ID CC domain up to the FRM value – except in case of force-majeure. ~~In order to do so CWE TSOs foresee to include costly remedial actions to avoid automatic DA MCP inclusion. CWE TSOs will work on developing, testing and implementing this and seek for intermediate steps to reach this commonly agreed target with limited DA MCP inclusion~~Automatic DA MCP inclusion for values higher than FRM should only occur in very exceptional cases.

~~Automatic DA MCP inclusion for values higher than FRM should only occur in very exceptional cases (aim to reach a pre-defined threshold).~~

5 Developments for future FB IDCC

The current FB IDCC method has been developed in the CWE area. The new capacity calculation region is now the Core CCR and subsequently a FB IDCC method will be developed in that ~~CCRs~~CCR as set forth in CACM. The following improvements of the CWE FB IDCC methodology will therefore need to be coordinated at Core level. Hereafter is a list of possible future improvements to be implemented in that context:

5.1 Additional recomputations in ID

In the current process, only one recomputation is coordinated with all TSOs. This recomputation is performed in the evening of the D-1. In the future, additional recomputations (i.e. after IDCZGOT) could be implemented based on the updated set of data: IGMs, but also remedial actions, in order to assess more efficiently the capacity that can be provided to the market players.

~~5.2 Improvements of the tools~~

~~In the current version, the tools used are based on existing tools. In the future, new methods will be developed to focus the remedial action optimizer even more on the elements that will provide additional capacity by not optimizing the margin on all elements but only on the elements that limit the flow-based domain and thereafter the capacity that provided to the market players.~~

~~5.3~~5.2 Developments foreseen in order to cope with the evolution of the system in the region

In the case of new HVDC interconnectors within the CWE area that will be operated in parallel with the AC system, the following is presenting possible adaptations to the capacity calculation process which would allow considering the influence of this grid element:

The impact of an exchange over the HVDC is considered for all relevant Critical Network Elements Contingencies (CNECs).

The outage of the HVDC interconnector is considered as a contingency for all relevant CNEs in order to simulate a zero flow over the interconnector, since this is becoming the n-1 state.

In order to achieve the integration of the HVDC interconnector into the FB process, two "virtual hubs" at the converter stations of the HVDC are added. These hubs represent the impact of an exchange over the HVDC interconnector on the relevant CNE/Contingency combinations. By placing a GSK value of 1 at the location of each converter station the impact of a commercial exchange can be translated into an equivalent PTDF value which will be called PSDF for Power Shift Distribution Factor. This action adds two columns to the existing PTDF matrix.

6 Criteria for an operational process

TSOs will assess the process against several criteria. The following list is not exhaustive and will evolve during the parallel run, in order to provide the best measure of the reliability and outputs of the process.

6.1 Criteria for the process operation

The first criteria is to have a reliable process that can produce results every day. The number of process fails will be monitored.

6.2 Criteria for the released capacity

The second criteria will monitor the output of the process:

- The already allocated capacity should be included in the domain with explicit remedial actions.
- The capacity computed with the new process will be compared to the results of the coordinated bilateral increase/decrease process.

The percentage of automatic DA MCP inclusion for values higher than the FRM values will be monitored separately

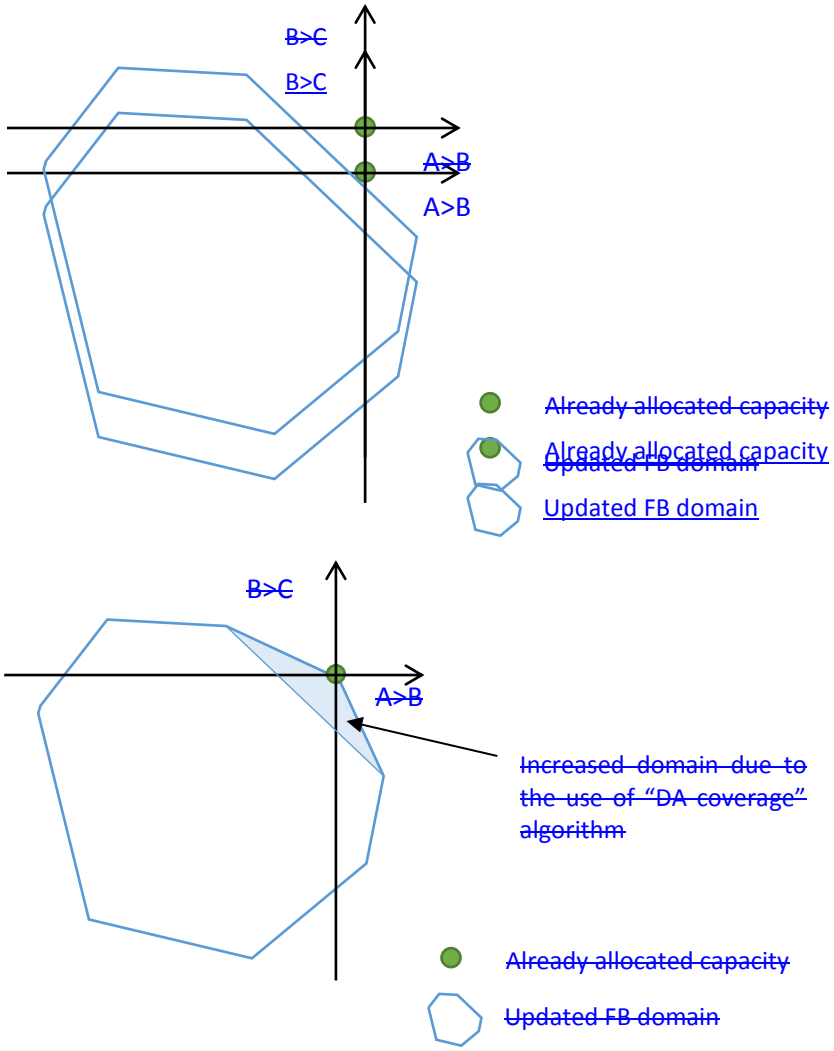
6.3 Criteria for the market

The updated capacity should provide more flexibility to the market players:

- The updated capacity will be compared to the current behaviour of the market players in the market direction and in the opposite market direction.
- The additional capacity that can be provided in the market direction will be monitored.

~~7~~6 Annexes

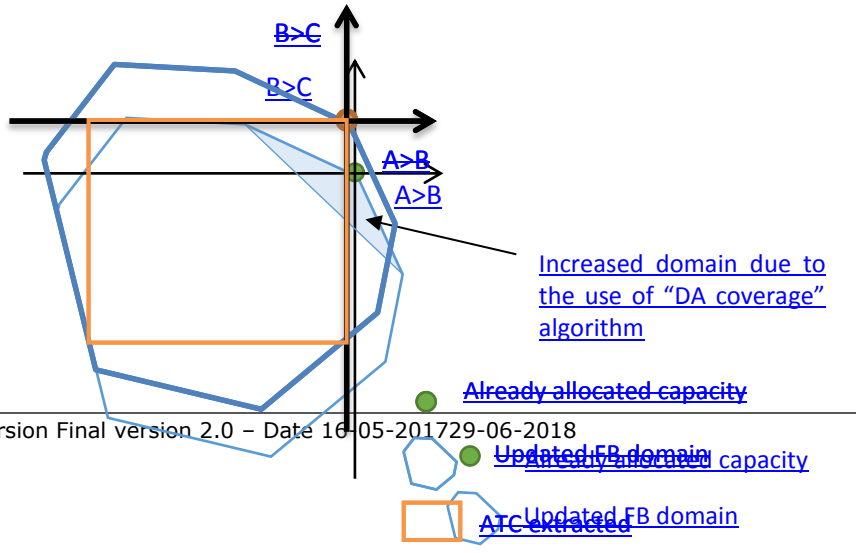
~~7.1~~6.1 Annex 1: Example for automatic market clearing inclusion



Step 1: Shift the FB domain according to the market clearing point

Step 2: Add the origin (zero NPs) as a vertex when it is not part of the FB domain

Step 3: Run the ATC extraction module to assess the ID ATCs



~~7.2 Annex 2: Experimentation results for phase 3 run 2 and 3~~

	17/10/2016		18/10/2016		19/10/2016		20/10/2016		23/10/2016	
	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion
Hours	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin
H01	862	42	-669	-157	-1693	-33	1713	127	2012	466
H02	-1459	-9	-669	-64	443	37	1306	66	2013	238
H03	-1773	-61	-1870	-107	-2006	-20	1426	94	2013	241
H04	66	70	-1927	-90	-2006	-112	1746	96	2013	296
H05	-1115	38	-2027	-146	-1870	-164	1848	95	1084	281
H06	-2223	-286	-1588	-184	-1924	-107	809	42	2013	267
H07	-1773	-595	-1174	-308	-1337	-282	-680	-348	2013	268
H08	-1877	-685	-2236	-241	-1843	-301	-841	-532	2013	247
H09	-1969	-714	-1399	-313	-2007	-343	-1268	-434	2013	294
H10	-1053	-614	-1873	-278	-1935	-330	-311	-441	2013	570
H11	-1334	-606	-1831	-302	-2009	-396	-439	-284	2013	432
H12	-1283	-539	-1486	-346	-1850	-379	-977	-227	2013	589
H13	-1174	-529	-1662	-377	-1843	-323	-1057	-220	2013	501
H14	-1337	-664	-1648	-373	-1843	-251	-598	-201	2074	415
H15	-1174	-580	-1534	-448	-1843	-181	-681	-178	1640	459
H16	-1629	-693	-1612	-452	-1843	-195	-1703	-170	617	432
H17	-1174	-648	-1792	-462	-2065	-268	-1485	-243	578	432
H18	-1291	-600	-2069	-460	-1956	-393	-1772	-245	1522	300
H19	-640	-342	-1909	-283	-1888	-340	-2328	-220	1548	728
H20	-1014	-279	-1285	-273	-1121	-336	-868	-251	2261	449
H21	-389	-408	-1915	-327	-1950	-480	-287	-296	2381	339
H22	-1843	-395	-1958	-388	-1843	-436	-1143	-212	1597	131
H23	-1624	-625	-1263	-198	-1674	-203	-570	-58	2138	486
H24	-450	-398	-1843	-338	293	33	1235	70	2532	212

~~Table 3: Experimentation results for phase 3 run 2.~~

	24/10/2016		26/10/2016		27/10/2016		28/10/2016		29/10/2016	
	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion	ATC indicator	MCP inclusion
Hours	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin	Total Sum	Minimum Margin
H01	2013	211	259	25	978	-18	1015	45	1514	174
H02	2013	216	233	27	2013	279	-1316	-75	1287	180
H03	2013	418	1365	36	2013	279	-2006	-132	1416	221
H04	2013	202	1319	28	2013	97	-2006	-139	1494	188
H05	2013	157	743	12	2013	97	-2006	-111	1319	320
H06	1992	159	-780	-2	1717	222	-2008	-122	1440	207
H07	-27	-69	71	-76	1174	69	-1531	-52	1161	194
H08	311	-141	357	-77	-961	-103	-1472	-215	1065	199
H09	-8	-134	-6	-16	427	15	-2010	-211	1234	280
H10	-158	-123	-262	-71	802	23	-1928	-118	1651	195
H11	177	-43	-240	-132	938	29	-2130	-119	2707	214
H12	662	-39	-595	-154	-746	-3	-1973	-153	2488	170
H13	308	-71	-697	-228	-968	-22	-2070	-31	2410	112
H14	-330	-80	-1567	-249	-964	-28	824	51	2196	82
H15	-825	-121	-650	-295	-954	-17	1062	48	1794	30
H16	-1073	-178	-1773	-345	-1004	-49	1322	65	973	106
H17	-369	-240	-1563	-411	-2192	-87	1291	65	1281	232
H18	-1140	-251	-1641	-385	-1223	-207	630	23	1985	207
H19	-599	-219	-1174	-410	-2011	-299	1221	24	1192	179
H20	-762	-204	-220	-381	-2204	-321	174	6	2186	69
H21	-98	-240	-1	-390	-2131	-38	804	25	769	76
H22	-635	-147	-1309	-219	-1531	-19	-1340	-256	1219	186
H23	312	-137	-862	-195	-1537	-21	-887	-4	1227	427
H24	1665	41	583	37	-1651	-17	-204	-20	1078	62

~~Table 4: Experimentation results for phase 3 run 3.~~

~~Annex 3~~

~~7.3~~6.2 Annex 2: Current behavior of the remedial action tool

In the following part, the remedial actions optimizer that ~~was~~is used in the ~~experimentation phase 3~~internal parallel run is presented.

The ~~Remedial Action Optimizer (~~RAO~~)~~ tool determines a set of ~~Remedial Actions (~~RAs~~)~~ that improve the flow-based domain according to a defined objective function. In the CWE FB IDCC framework, this function aims to increase the minimum relative margins in MW, around the ~~Day-Ahead Market Clearing Point (~~DA MCP~~).~~.

RAO needs several inputs: merged CNEC with the Remedial Actions to be used by the RAO tool, merged GSK, and merged CGM. The output of the RAO service is a coordinated set of RAs.

~~Remedial Actions~~RAs can be split into two different categories: Preventive Remedial Actions (PRA) and Curative Remedial Actions (CRA) (cf. 3.1.4). The aim of the RAO tool is to find the optimal set of PRAs and CRAs in order to enlarge the Flow-Based domain.

~~7.3.1~~6.2.1 Determining the PRAs and CRAs

The RAO algorithm explores solutions through a sequential approach made of two sub-problems:

1. Preventive problem for all CNECs
2. Curative problems for every Contingency (C)

In the proposed method, all CNECs are ~~monitored~~considered during RAO in order to take into account the influence of remedial actions.

It can be set as a constraint of the optimisation that the margins of certain CNECs shall not be optimised but only respect a certain value:

- If the initial margin of such element is positive, it should not become negative.
- If the initial margin is negative, it should not become even smaller than initially, or if smaller, not more than a defined threshold.

On both preventive and curative steps, the available remedial actions are tested: the most efficient RA according to the objective function (see Section 1.1.2) is selected , which are then implemented. RAs are selected, tested and implemented one by one. The iterations are managed through ~~-~~a search tree. Once the preventive optimization is finished, the set of preventive actions is fixed and implemented as starting point for all curative optimizations. For CRAs, approach is different, and is made C per C.

→ Algorithm keeps applying RA until one of the following conditions is fulfilled:

In preventive :

- All available preventive remedial actions have been evaluated
- At a certain step of optimization, no preventive remedial actions improve the objective function more than a defined threshold

In curative:

- The maximum number of curative actions have been reached
- All available curative remedial actions have been evaluated
- At a certain step of optimization, no curative actions improve the objective function more than a defined threshold

The two figures below illustrate the sequential approach and the search tree approach for RA selection (some names of CNECs are provided as an example):

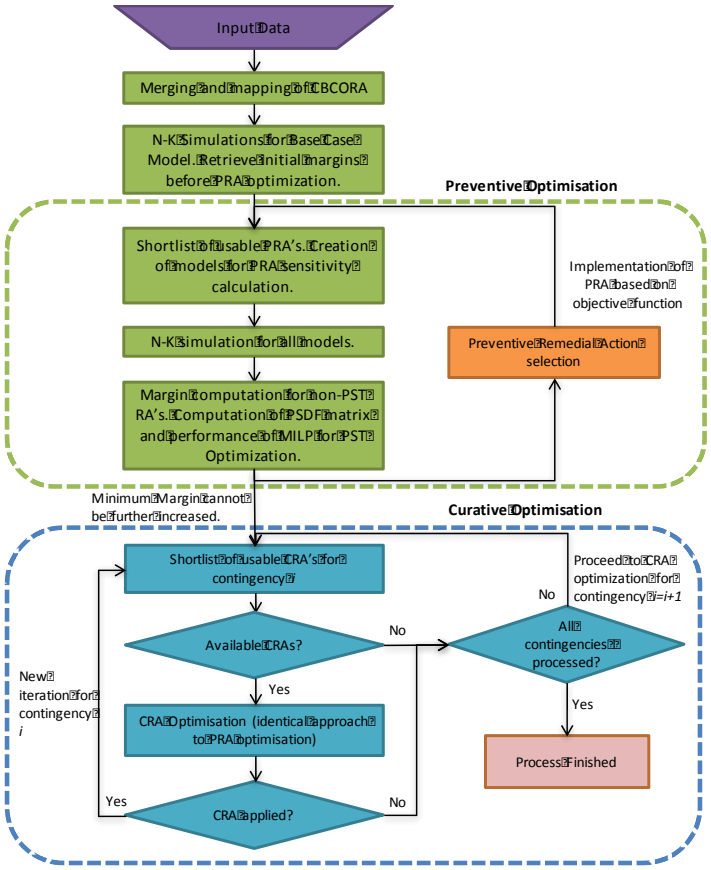


Figure 1: Presentation of PRA and CRA process selection.

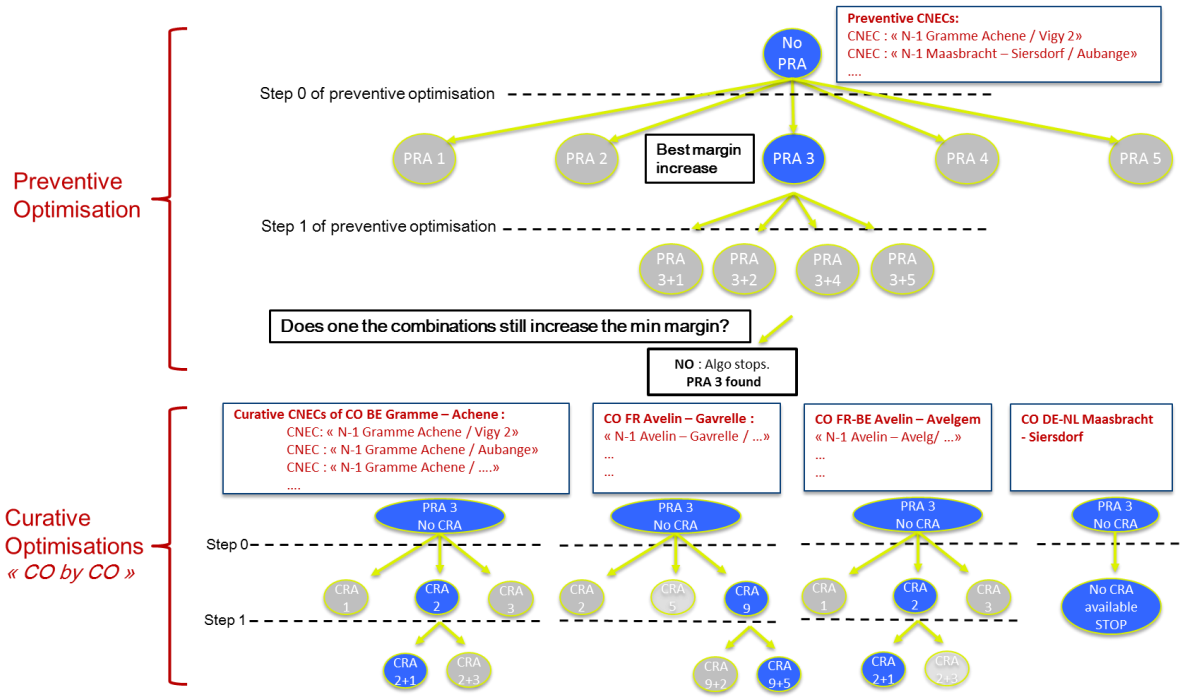
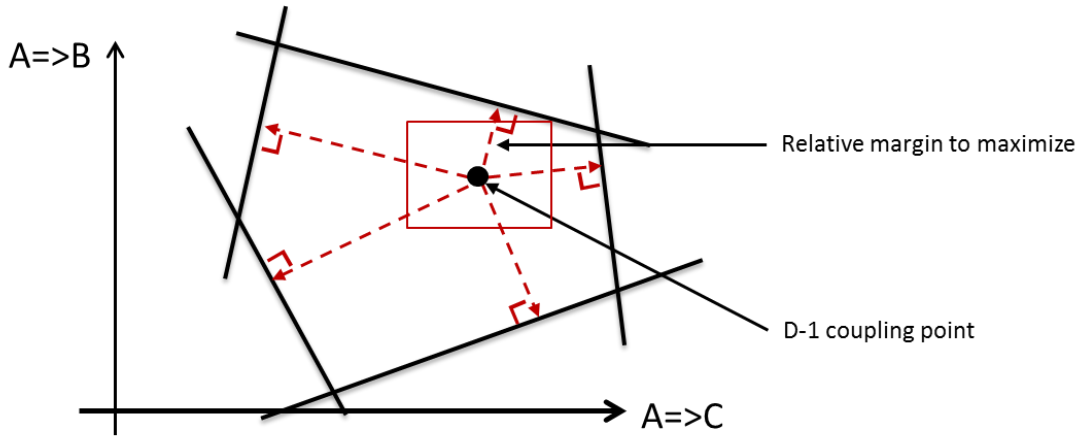


Figure 2: Presentation of the search tree approach for PRA and CRA process selection.

~~7.3.2~~6.2.2 Objective Function

The present objective function is to **increase the minimum relative margin by finding remedial actions that aim at improved capacities based on the day-ahead market results**. The RAO tries to maximize the ~~margins~~RAM of ~~monitored~~ elements to be optimized **relatively to their sensitivity to exchanges**, without market assumption (i.e. without a preference to any particular exchange directions). This can be explained as increasing the space around the market clearing point of the day-ahead market as illustrated in figure 3 below.



$$Relative\ Margin\ (CNEC) = \frac{Margin(CNEC)}{\sum_{i,j \in hubs} |PTDF_{i \to j}(CNEC)|}$$

Figure 3: Illustration of the non-discriminatory approach to increase the space around the market clearing point of day-ahead without one border being advantaged over another.

This means that a remedial action will be selected and implemented if it increases the margin on the limiting branch (among the ~~monitored~~ CNECs to be optimized) considering the already achieved minimum margin.

Margins are assessed through DC loadflows in order to enable faster optimization and to get results, which are compliant with the current flow based capacity calculation processes. The borders for PTDF computation in the objective function are ~~DE-NL, FR-BE, BE-NL, DE-FR~~the commercial bilateral borders of CWE.

The output of the RAO is a coordinated set of PRAs and CRAs linked to each C.

Found remedial actions are then applied for the final flowbased computation at each hour:

- The set of preventive actions is applied on each and every CNEC.
- For each contingency, the corresponding set of curative actions is applied on all CNECs linked with this contingency.

~~7.4~~6.3 Annex ~~4~~3: List of remedial actions

In the following part, the remedial actions that were used in the experimentation phase 3 are presented.

~~7.4.1~~6.3.1 Amprion

The list of RAs that are currently used for FB IDCC activities by Amprion is the following:

PST

PST Gronau 380kV

6.3.2 APG

Topological Remedial Action

Bus bar coupler in St. Peter 220kV

PST

PST Ernsthofen 220kV (*)

PST Tauern 220kV (*)

PST Ternitz 220kV (*)

(*) APG PSTs are going to be used in a range of max. + - 6 steps.

~~7.4.2~~6.3.3 Elia

The list of RAs that are currently used for FB IDCC activities by Elia is the following:

PST 380 Zandvliet 1
PST 380 Zandvliet 2
PST 380 Van Eyck 1
PST 380 Van Eyck 2

Opening of Bus-bar coupler in Avelgem 380
Opening of Bus-bar coupler in Horta 380
Opening of Bus-bar coupler in Courcelles 380
Open Line 220.513 Aubange-Moulaine
Open Line 220.514 Aubange-Mont-Saint-Martin

~~7.4.3~~6.3.4 RTE

The list of RAs that are currently used for FB IDCC activities by RTE is the following:

Modification of the topology

Avelin 400kV
Beautor 225kV
Bezaumont 400kV
Chevalet 400kV
Gavrelle 400Kv
Lonny 400kV
Mambelin 400kV
Mastaing 400kV
Moulaine 225kV
Muhlbach 400kV

Revigny 400kV
Sierentz 400kV
Vigy 400kV
Vogelgrun 225kV

Opening of line

Trois Domaines-Vandière 225kV
Muhlbach-Scheer 400kV

Modification of the dispatch

Hydro power plant in Revin

~~7.4.4~~6.3.5 TNG

The list of RAs that are currently used for FB IDCC activities by TNG is the following:

PST

Bürs 380/225kV

Topological Remedial Action

Dellmensingen 380kV

~~7.4.5~~6.3.6 TTG

The list of RAs that are currently used for FB IDCC activities by TTG is the following:

PST

Diele 380kV

Topological Remedial Action

Opening of bus-bar coupler in Grafenrheinfeld 380kV

Opening of bus-bar coupler in Doerpen West 380kV

~~7.4.6~~6.3.7 TTN

The list of RAs that are currently used for FB IDCC activities by TTN is the following:

PST

PST Meeden W 380kV

PST Meeden Z 380kV

Topological Remedial Action

Opening of bus-bar coupler in Lelystad 380kV

Opening of bus-bar coupler in Ens 380kV

Opening of bus-bar coupler in Doetinchem 380kV

Opening of bus-bar coupler in Hengelo 380kV

Opening of bus-bar coupler in Geertruidenberg 380kV

Opening of bus-bar coupler in Diemen 380kV

Opening of bus-bar coupler in Eindhoven 380kV

Opening of bus-bar coupler in Zwolle 380kV

Opening of bus-bar coupler in Borssele 380kV

Opening of bus-bar coupler(s) in Maasbracht 380kV

Opening of bus-bar coupler in Krimpen 380kV

Opening of bus-bar coupler in Dodewaard 380kV

The

availability of remedial actions for the RAO from the list above will be determined on daily basis and are related to the gridconditions.

~~7.5~~6.4 Annex ~~5~~4: CWE Flow-based Intraday Capacity Calculation Consultation Report

Results of the consultation in March 2017

CWE Flow-Based Intraday Capacity Calculation Survey results: Executive Summary of answers received from the Market Parties

The online survey was available for Market Parties from 1st March 2017 to 15th March 2017. In total, 4 Stakeholders (Market Participants and Associations) submitted their answers.

The public consultation process is anonymous, therefore the identity of respondents will not be disclosed with the publication of this consultation's outcome. Please note that it was however disclosed to the CWE National Regulatory Authorities together with the complete responses.

Main market views and recurring comments have been summed up in this report. The CWE TSOs wish to clarify that the contents of this document are intended to summarize the results obtained in the public consultation. This also means that the report should not be interpreted as the CWE TSOs' position on the concerned topics. The CWE partners will do their best to reply to all comments and concerns. However before engaging in more in-depth discussions within the project and with market parties, CWE TSOs cannot commit to comply with all reported concerns and requests.

In addition to specific observations (see below), market parties provided TSOs with general comments. Some market parties raised concerns over the fact that TSOs do not include countertrading as a possible remedial action. In addition, the consideration of different FRM values for cross-zonal capacity calculation and security assessmenst is perceived as discriminatory behavior. All responses by market parties expressed concerns over TSOs' ability to re-assess ID ATCs, and generally, over TSOs' possibilities to manually influence available capacities.

Even though this consultation focuses on the capacity calculation process, some market parties further criticize that capacity allocation is based on ATC values, which are extracted from the flow based intraday domain. Market parties express that they see a need for a fully flow based capacity allocation system, which from their point of view is a prerequisite for the full exploitation of possible welfare gains.

~~7.5.1~~6.4.1 Section 1: Survey Questions

~~7.5.1.1~~6.4.1.1 A.) Introduction

1. After studying the consultation document, do you have a clear view on the challenges and benefits of the implementation of Flow Based intraday capacity calculation?

Three market parties explicitely answered this question.

Two market parties express their satisfaction with the overview that is provided in the consultation document. However, TSOs are asked to provide exact numerical values for the parameters they plan to apply in the FB IDCC calculation process. In addition, two market parties express their fear that welfare gains of FB IDCC might be underestimated because of an inaccurate impact assessment.

One market party states that the one calculation approach is acceptable as a first step for the implementation of FB IDCC, but urges for multiple recomputations during the day in the future.

One market party states that the evidence provided by the experimentation results is insufficient. Furthermore, this market party is worried that an increase of available capacities compared to the current approach cannot be guaranteed. In addition, the market party fears that TSOs do not properly take into account the improvements in the quality of information in D-1 compared to D-2.

Feed-back of the TSOs:

The economic assessment of the capacity in intraday is more difficult than in DA, indeed no agreed indicator as the social welfare exists. In the current version of the Explanatory Note, TSOs proposed two economic indicators. TSOs will investigate the feasibility of additional indicators as proposed by the market parties.

In parallel, TSOs will perform an internal and external parallel run and the outcomes will allow for MPs and regulators to get a better view on the benefits and drawbacks of the FB IDCC methodology.

The TSOs propose as a first step a recomputation based on updated information in the evening of the DA, after DA allocation but before gate opening. In future versions of the FB ID capacity calculation, TSOs will develop multiple recomputations in the ID timeframe to take into account the latest information of the market.

Transparency topics (parameters and use of costly remedial actions) are further developed in the following question number 16.

~~7.5.1.2~~6.4.1.2 B.) Coordinated Flow Based intraday capacity calculation process

One market party provided a combined comment on answers 2 to 9, which states that there seem to be too many opportunities for TSOs to intervene in the algorithm and to manually reduce capacities. From the point of view of this market party, this makes it impossible for market parties and regulators to determine how available capacities have been calculated, resulting in inefficient bidding strategies and, consequently, in welfare losses.

2. Are the inputs for the capacity calculation clearly described and understandable (see M chapter 3.1 and EN chapter 3.1)[3]?

Two market parties explicitely answered this question.

Market parties advocate that TSOs compare historical forcasted flows with realized flows in order to set values for FRM. In addition, market parties wish to receive more information on TSOs' risk policy, especially with regard to the assessment of FRMs and external constraints.

Furthermore, market parties urge TSOs to demonstrate that their approach to determine GSKs is representative. Also, it is asked to review the CNEC selection criteria.

Feed-back of the TSOs:

Regarding the lack of information for the risk policy per TSO, the new ID FRM values will be published by the end of 2017 after the ID FRM assessment has been performed.

CWE TSOs are convinced that the DA GSK approach used is representative. The method to generate the GSK in ID is the same as in DA. Furthermore, TSOs are updating the GSK with the new ID assumption. Moreover, the current use of ID capacity is smaller than the DA capacity, therefore the inevitable error made by the needed linearization of the GSK will be lower.

In ID, most CWE TSOs are using the same method to determine their EC as in DA.

The CNEC selection criteria are presently being investigated in the Core region.

3. Is the capacity calculation process clearly described and understandable (see M chapter 3.2 and EN 3.2)?

Two market parties explicitely answered this question.

Market parties consider the description of the capacity calculation as insufficient and incomprehensible. More transparency is requested on the underlying parameters for capacity calculation. Additionally, the RAO algorithm is considered as not clearly described. Market parties state that costly remedial actions should only be taken into account if economically relevant.

Feed-back of the TSOs:

[3] M = Methodology, EN = Explanatory note.

The CWE FB ID capacity calculation process relies on the same principle as the DA capacity calculation process. The main change in the process is the introduction of the optimizer to choose the remedial actions in order to cover the already allocated capacity and increase the space around the day-ahead market clearing point for every hour. In DA, this activity is performed manually by the operators.

Transparency topics (parameters and use of costly remedial actions) are further discussed in the following question number 16.

4. Are the outputs of the capacity calculation process clearly described and understandable (see M chapter 3.3 and EN chapter 3.2)?

Two market parties explicitely answered this question.

Market parties feel sufficiently informed regarding the outputs of the capacity calculation process.

Feed-back of the TSOs:

The TSOs will remain available to the market parties through the CWE Consultative Group to continue the discussion on the outputs of the process.

5. Which sections of the capacity calculation process should be more clearly described (see M chapter 3 and EN chapter 3)?

Two market parties explicitely answered this question.

Market parties ask for more information on the capacity validation process.

Feed-back of the TSOs:

For validation, it is planned to directly validate extracted ATC values instead of validating the ID FB domain. Therefore, each TSO can check the impact of the newly calculated ATCs on the grid and redetermine ATC values, if necessary, but only in order to ensure security of supply in exceptional cases.

6. Is the re-assessment of ID ATCs for allocation process clearly described and understandable (see M chapter 3.4 and EN chapter 3.3)?

Two market parties explicitely answered this question.

Market parties recommend that the MCP can be updated to account for potential cross border redispatching actions. In addition, one market party is concerned that TSOs have the option to oppose the new ID ATC domain.

Feed-back of the TSOs:

No feed-back from the TSOs as the re-assessment process is not part of the methodology anymore.

7. Do you feel sufficiently informed about the method of Remedial Action Optimisation and their influences for cross-border capacity (see M chapter 3.1 and 3.2)?

Two market parties explicitely answered this question.

Market parties ask for more detailed information on the method of remedial action optimization, especially with regard to alternative objective functions and the list of remedial actions under consideration.

Additionally, one market party asks for more information about the impact of remedial action optimisation on capacity increase, and generally for more transparency regarding this process.

Feed-back of the TSOs:

CWE TSOs acknowledge that a certain level of transparency is required for market parties in order to gain confidence in the FB process and make the process as a whole more understandable.

However, to provide the list of RAs and their impact on the capacity calculation would be an increase of transparency, which would generally concern CWE market coupling, and which therefore is out of the scope for the FB IDCC methodology. In order to avoid different levels of transparency for the different time-frames, transparency related topics should be discussed on CWE level (e.g. in CWE Consultative Group meetings).

8. TSOs developed the optimisation function in order to have a positive impact on the market as it will provide more domain in the likely market directions (around the DA market clearing point). Do you agree with this point of view (see M chapter 3.2 and EN chapter 3.2)?

Two market parties explicitely answered this question.

Market parties would favour an optimization function that prefers the most valuable market direction (which is described as the market direction that would mostly increase congestion rents under the assumption of fixed DA market prices). At the same time, one market party additionaly states that the optimization function should increases the domain in the direction that is most likely with the latest (updated) flow configuration.

Feed-back of the TSOs:

In response to the current optimisation function to optimise around the DA MCP, there was no shared opinion of market parties (MPs) observed.

On one hand MPs mention that they prefer optimisation in the most profitable direction (with increasing congestion rent) while preserving left-over day-ahead capacity but on the other hand MPs also request to optimise market capacity in the likely market directions of FB DA which results in less capacity in the opposite market direction.

As both views of MPs contradict, CWE TSOs were not able to give preference to either of the MPs suggestions. Furthermore, CWE TSOs would like to underline that due to remedial action optimisation a shift of the FlowBased domain is inevitable. This will lead to a capacity gain in some directions and a reduction of capacity in other directions. As prior studies performed have indicated that DA market spread does not necessarily align with the most congested areas in Intraday, TSOs aim to increase the domain around the DA MCP in all directions in a non-discriminatory manner for all borders.

9. Do you think it is justified to optimize the ID FB domain around the DA Market Clearing Point (MCP), knowing it can lead to FB domain reductions in the unlikely market directions (see M chapter 3.2 and EN chapter 3.2)?

Two market parties explicitely answered this question.

Market parties would favour again an optimization function that is based on an updated MCP; ID ATCs should therefore be recalculated periodically.

Feed-back of the TSOs:

TSOs acknowledge that having multiple recomputations during Intraday, based on updated MCP, is the target solution. Periodic recomputations during the day considering the last nominated capacities are foreseen in a future version of FB IDCC.

~~7.5.1.3~~6.4.1.3 C.) Expert experimentation results and parallel run

10. Are you convinced by the experimentations performed so far and the foreseen developments (see EN chapter 4)?

One MP is not convinced by the experimentations. The use of the automatic MCP inclusion for most of the time is seen as a consequence of an insufficient set of RA or other limitation of the current approach (i.e. GSK, CNEC selection).

Another MP points out that the experimentiation is based on a very scarce evidence of five days and that further testing on the RA Optimization is needed.

For both of these MPs, it would be more relevant to consider DA market spreads to weight the variations of capacity in the different directions.

Feed-back of the TSOs:

TSOs performed the experimentation to gain first experiences and to examine the new process. In order to fine-tune the process and get more quantitative results, TSOs will perform an internal and external parallel run in 2017/2018 which results can be shared with NRAs and market parties to get a better view on the benefits and drawbacks of the new FB IDCC methodology. More details regarding the optimization function in general can be found in the answer to question number 8.

11. What are your expectations from the external parallel run process?

Two MPs see very little benefit of an external run in a countinous trading market and would rather have an offline assessment of ID FB domain for historical values and for some specific scenarios in the future.

One MP considers that the parallel run should be more thorough than what was performed for DA FBMC. Full data transparency should also accompany the parallel run from the start to speed up market participants' understanding of the whole mechanism.

Feed-back of the TSOs:

An internal and external parallel run is essential for TSOs to gain experience from technical and operational point of view as the implementation of a fully working system and sufficiently experienced operators are needed before go-live. The parallel runs will also be used to fine-tune the process and get more quantitative results.

Therefore, it is not feasible to conduct the proposed updated planning of an earlier go-live for FB IDCC.

The results of the external parallel run will be shared with NRAs and market parties. In order to get a better view on the benefits and drawbacks of the new FB IDCC methodology the recomputation of a limited number of interesting business days (e.g. days of the internal parallel run) can be considered and shared with market participants. It is to mention that finding representive days for ID (as for the DA SPAIC analysis) is difficult which makes an ID SPAIC analysis not feasible, but TSOs are open for suggestions from market parties.

TSOs will be at least as transparant as in CWE FB DA. More information on this topic can be obtained in the following question number 16.

12. Do you have enough information (results, explanations) about the performed IDCC experimentation to get a clear picture of the possible impact on cross-border capacities for the ID market (see EN chapter 4)?

Two MPs indicate that the approach and the impact assessment (in terms of types of outputs and variety of situations) should be improved.

One MP claims lack of transparency on numerical figures. The other MP argues that the metrics used by the CWE TSOs for the impact assessment are probably more pessimistic than the ID FB domain.

Feed-back of the TSOs:

Experimentations are performed on a limited period of time, and this is why internal and external parallel runs are foreseen in order to provide a wide picture of the process behaviour. External parallel run results will be shared with Market Parties. CWE TSOs would like to remind Market Parties that lower uncertainties in ID do not necessarily lead to more capacities as some lines may be more loaded in ID compared to DA. Many paramaters and assumptions have been updated between DA and ID leading to different capacities, such as generation infeed, grid topology, and updated RES infeed based on the latest assumptions available when running the FB IDCC computation.

~~7.5.1.4~~6.4.1.4 D.) Publication of data

13. Do you have enough information regarding the Flow Based intraday capacity calculation process (see M chapter 5)?

One MP answered yes to this question.

Another MP regrets that the numerical values for each parameter used by TSOs are not provided. They also require more transparency regarding TSOs' approaches to define FRMs and GSKs.

Feed-back of the TSOs:

Transparency issues, including numerical values, parameters used by TSOs, as well as TSOs' approaches for defining FRMs and GSKs are further developed in question 16. In addition, please find additional information concering GSKs and FRMs in question 2.

~~7.5.1.5~~6.4.1.5 E.) Additional questions

14. What are your general expectations from the new FB IDCC process?

Two MPs expect a significant increase in cross-border capacity in the most economical direction. Efficient trade-offs made by TSOs between internal redispatch and cross-border capacity reduction are also expected.

Feed-back of the TSOs:

CWE TSOs welcome this proposal to consider economical parameters in the process, however CWE TSOs consider the topic of implementing costly remedial actions in order to adapt the capacities and use of congestion rent for redispatch to be a NRA decision. TSOs would additionally like to inform that related discussions are also ongoing at ENTSO-E level.

15. What are the most important go-live criteria for the process from your point of view?

One MP sees predictability as a key criterion.

Two MPs agree that TSOs must be operationally ready and make sure that the IDCC will work smoothly and deliver in conformity to the impact assessment published.

Another MP expresses its strong disappointment regarding the level of transparency before and after the go-live of DA FBMC and is, therefore, very wary about the conditions of the ID FBCC go-live. The key criteria that this MP will require is full data transparency (chapter 5) and the inclusion of details regarding the manual adjustments made, remedial actions taken by the TSOs and their effects. They also request the publication of the intraday flow-based domain (not only the final ATC values). From their point of view, market participants need to be able to fully predict the results of the calculation process.

Feed-back of the TSOs:

Transparency topics are further developed in the following question number 16. The FB ID domain will be communicated as of the starting of the external parallel run and after go-live as well. ATC values will be publicly available, but as it is a FB methodology which is processed, the FB domain will be also provided to all interested parties. The same basis of communication as in FB DA will be used. Furthermore, during the external parallel run (at least 6 months) more data will be available for stakeholders, which can be input for their assessments to improve predictability.

About any new indicator to be followed or developed, TSOs are open to investigate additional indicators considering economic parameters. In addition to the indicators provided by TSOs, MPs are also encouraged to compute indicators during the parallel runs and share the results with CWE TSOs.

16. What is your most important criterion regarding the capacity calculation process and output? (predictability of capacity, volume of capacity…)

One MP highlights predictability and transparency as key issues to achieve an optimal use of the grid infrastructure. In their opinion, both would lead to an increase of capacity in the

most economical direction (as they allow market parties to provide TSOs with better predictions and this results in less uncertainties).

Another market party stated that the most important criterion for capacity calculation is the volume of capacity in the likely market direction. They see capacity predictability relevant but not as an ultimate goal per se, since price forecasting depends also on other information. They underline that predictability relies also on full transparency by TSO on the availability of transmission network and on the common grid models to be used as inputs.

Feed-back of the TSOs:

CWE TSOs acknowledge that a certain level of transparency is required for market parties in order to gain confidence in the FB process and make the process as a whole more understandable. However, in order to avoid different levels of transparency for the different time-frames, transparency related topics should be discussed on CWE level (e.g. in CWE Consultative Group meetings).

In FB IDCC at least as much transparency will be provided as for FB Day-Ahead (e.g. non-anonymised presolved CNECs including Fref', FRM, FAV and RAM). Future changes in the level of transparency provided for FB Day-Ahead will also be taken into account for FB Intraday.

In line with provided transparency for FB Day-Ahead, the impact of local TSO validation will be shared by publishing the Day-Ahead left-over ATC, extracted ID ATC from the Intraday FB domain and the validated Intraday ATC values provided for allocation.

During external parallel run, CWE TSOs will publish the Intraday FB domain as well.

~~7.5.2~~6.4.2 Section 2: Additional questions / comments by MPs

1. MPs request TSOs to keep working on extending the process and offer several recalculations of the domain (within the intraday timeframe) as there is a market need to have updates of the FB domain during the day. They believe that the target should be to perform a recalculation of the domain every hour to get a view on what is available for each hour, provided it keep the same exchange potential as the process today (it should not deteriorate).

The TSOs agree that the target of the FB ID capacity calculation is not only to compute the capacity once in the evening of the DA but TSOs see the process as a first step to multiple recomputations. Performing additional computations during the day would require additional preparations, leading to a delay of the current implementation planning. Also, updated grid models (ID CGM) are required for re-computations but these have not been used in common processes, as the quality and stability is not clear for some TSOs. The frequency of this recalculations shall take into consideration efficiency and operational security and will be further developed.

2. It is unclear to MPs whether the TSOs have decreased their Flow Reliability Margins (FRMs) as real time gets nearer.

The aim of the FRM is to cover the uncertainties in the capacity calculation processes. In order to compute the FRM, TSOs compare the flows on the CNEC between the CGM that is used for the capacity calculation and the realized flow on this element. In the experimentation, TSOs have used proxy FRMs based on DA FRM but TSOs intend to update the FRM values before Go Live. As for DA, the values will be published per CNEC.

3. Why do you consider an external constraint? Isn't the uncertainty already covered by the FRM?

External Constraints prevent the system to reach extreme positions compared to the original market clearing point. They can also prevent grid behavior like voltage collapse that cannot be modeled with the current assumption (DC load flow).

4. The approach to define GSK remains relatively unclear: Regarding the German GSK, the fall-back solution is the GSK from a previous day; is it better than using the DA GSK? Does the French GSK include must-run units?

The fallback solution for all GSKs is to take the GSK of the previous ID and not the one from DA.

Regarding the French GSK, the method for ID is the same as for DA. All units, including must-run units which are in operation in the base case, will follow the change of the French net position on a pro-rata basis.

5. Please provide more transparency on the application of FAV and the operational adjustment in FRM.

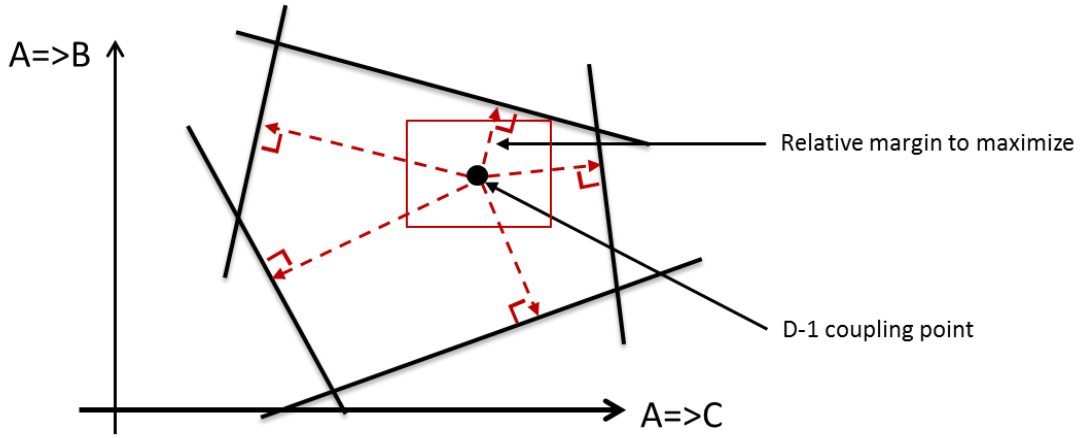
CWE TSOs do not intend to use FAV to change the output of the ID FB calculation as ATC values will be validated directly. The final need of performing operational adjustment will be evaluated after the ID FRM values have been computed and determined by the end of the year 2017.

As a rule, TSOs will be at least as transparent as in CWE FB DA, so future developments regarding the FB DA process will be considered in ID as well.

6. Why is the relative margin denominator the sum of absolute PTDF and not the difference between the max and min PTDF?

This approach was chosen in order to ensure non-discriminatory behavior of the objective function, as it prefers no particular exchange direction.

No border will be advantaged as the room around the market clearing point is maximized. An illustration of this non-discriminatory approach can be seen in the figure below.



$$Relative\ Margin\ (CNEC) = \frac{Margin(CNEC)}{\sum_{i,j\in hubs}|PTDF_{i\rightarrow j}(CNEC)|}$$

7. Questions regarding further clarification of validation phase:

- *What does the computation exactly take into account?*
- *How much time does it take?*
- *What is the exact purpose of the validation? Can it be avoided?*

It is planned to perform the validation directly on the calculated ATC values instead of validating the ID FB domain. Therefore, each TSO can check the impact of the newly calculated ATCs on the grid by their own tools and redetermine ATC values, if necessary, but only in order to ensure security of supply in exceptional cases. Hereby, the latest information on the grid can be taken into account, e.g. unforeseen outages of grid elements since the start of the ID FB process. The timing depends on the availability of input data as well as the computation times of the predecessing processes.

8. Why should TSOs be allowed to oppose/reject the new ID ATC domain since the increase of capacities will be based on individual grid inputs?

Although it is correct that the computed ID ATC is based on individual grid inputs, these inputs can change during the course of the day (e.g. due to updated grid forecasts, unforeseen outages, etc.). TSOs intend to mitigate the resulting risk, during intraday, by applying a reliability margin (i.e. FRM). Residual risk will be handled as *force-majeur* and solved by TSOs by other means.

9. It should be possible that the MCP, which serves as a starting point for ID ATC extraction, can be updated to account for potential XB redispatching actions, as a result of the ID security assessment.

Cross-border redispatch available before the FB IDCC process will be considered, as these are included in the individual grid models of the CWE TSOs. Although due to the cross-border redispatch the domain will be shifted, the MCP will not be updated to ensure the already allocated capacities are properly taken into account.

10. Taking the DA FB as a reference is contradictory with the recalculation of ID capacity (3.4.1.1): the base case should be to limit the capacities by the FB ID ATC and not the minimum of FB DA ATC and FB ID ATC.

No feed-back from the TSOs as the re-assessment process is not part of the methodology anymore.

11. Concerning the ID ATC re-assessment, one MP stated that the proposed methodology maintains the freedom for individual TSOs to refuse the ID capacity increases proposed as a result of a centralized computation. This MP reasons that this freedom should be limited under three dimensions:

- ***The approval process should apply to only one type of outcome of the centralized process, for instance the new ID Flow-Based domain. If all CWE TSOs recognize that the new FB domain is right, this means that they should cope with any corresponding increase/decrease in cross-zonal exchange capacity.***
- ***TSOs should be fully transparent on their motivation when opting out, make alternative consistent proposals, and propose improvements of the regional capacity calculation process as soon as an opt- out situation becomes frequent.***
- ***TSOs should take their decision quickly so that available capacity can be released to the market in a timely manner. To this end, the market party would suggest that no motivated response from CWE TSOs 30 minutes after proposing an increase should be considered as an acceptance.***

No feed-back from the TSOs as the re-assessment process is not part of the methodology anymore.

12. TSOs consider different FRM in cross-zonal capacity calculation and in security assessment. MPs suggest to consider identical FRMs for cross-zonal capacity calculation and for triggering internal redispatching actions.

Today, it is not common practice for TSOs to apply reliability in security analysis. The main reason is related to the fact that the security analysis aims at identifying and coordinating remedial actions that will have to be considered to ensure a normal state of operation in real time. This process and the decision which remedial actions will be applied shall be updated and optimized several times, up to close to real time, which will always allow considering the impact of changes in the system. In contrary, the capacities that will be provided to the allocation platform as outcome of the capacity calculation processes will be considered as firm, which justifies the application of Flow Reliability Margin to cover the potential impact of uncertainties. Nevertheless, in the scope of System Operation

guidelines implementation, TSOs are assessing the possibility to consider reliability margins during security analysis, but this is out of scope of the FB IDCC methodology.

13. MPs note that they do not understand why lower Imax figures were used in phase 3 of the experiment. Shouldn't corrected results be published?

CWE TSOs have used the correct Imax values during the whole experimentation phase. For cycle 4 of phase 3 the winter limits of the monitored grid elements have been used. These values are higher than the summer limits used in the first three cycles. Usually, TSO switch from summer to winter limits in November.

6.5 Annex 5: Additional information on issues raised in NRAs' position paper

6.5.1 Flow Based Domain Calculation

NRAs request TSOs to confirm that DACF files include:

- *the updated GSKs – based on the results of the DA market coupling;*
- *the updated PST tap positions and Grid topology;*
- *the updated load and RES forecasts; and*
- *the remedial actions updated after the DA MCP inclusion so that they include RA already used for the DA FB domain (i.e. in the case of LTA-inclusion)*

CWE TSOs would like to highlight that the process of DACF creation is out of scope for capacity calculation. The FB IDCC process will use the latest information available, but it cannot be confirmed that updated RAs will already be included in the DACF.

NRAs request TSOs to explicitly list all improvements achieved through the recalculation in DACF compared to D2CF

The DACF includes the last consumption forecast, topology, last RES forecast, operating schedules of generators and exchange schedules.

6.5.2 FRM calculations

NRAs request TSOs to confirm that new FRM values used in intraday are calculated on the basis of DACF-files and will correspond to a reduced uncertainty compared to D-2, as announced in the Consultative Group Meeting of March 2017.

CWE TSOs confirm that the ID FRM values are computed according to the FRM methodology described in this approval package and that ID FRM values are calculated by comparing DACF files to the snapshot files. Nevertheless, it cannot be guaranteed that there will be a reduction compared to the current operational FRM values for DA CC since different methodologies and timeframes were used for the DA and ID FRM calculations.

NRAs reques TSOs to describe the post-processing of ID FRM data. The description should include, among others:

- *If the FRM applies to a CB or to a CBCO,*
- *Which flows are used (N, N-1, average/max...),*
- *The applied risk levels*

Harmonization is strongly recommended. Where no harmonized values or rules are used, the TSOs are asked to describe the TSO-specific values or rules.

CWE TSOs clarify that the description of the post-processing of the data is included in this approval package. In case of a TSO applying an operational adjustment on the calculated FRM values, this TSO will provide additional justification to its national regulator

6.5.3 Use of Remedial Actions

NRAs request: As noted by market participants during the consultation phase, it is expected that re-dispatching measures taken to include the DA MCP in the DA flow-based domain (i.e. in the case of LTA-inclusion) are already taken into account in the DACF files, so before the calculation of the intraday FB domain. As a consequence, the use of coordinated RA in the RAO should not be steered towards including the DA MCP, but towards increasing the size of the ID FB domain.

TSOs would like to point out that capacity calculation is performed at the same time as the daily security analysis process takes place. As the security analysis is not finalized by the time the IDCC process is started, RAs cannot be guaranteed to already be included in the DACF.

6.5.4 Validation of capacities

CWE NRAs do not consider 'unforeseen market behaviour' as a Security of Supply issue which can be handled as force majeure. Force majeure is a well defined situation and

every capacity reduction made for force majeure reasons should be duly justified by the TSOs and reported to NRAs.

CWE TSOs have removed the corresponding reference to *'unforeseen market behaviour'* regarding the validation of capacities.

6.5.5 Improvement of the flow-based parameter "inputs"

NRAs request that the methodologies adopted for defining the following parameters do not exclude discrimination between internal and cross-zonal trade, leading to market distortion and inefficiency. In this respect, we recall the main of points for reconsideration:

- *The 5% PTDF CBCO selection rule*
- *The use of external constraints, if not justified by the CACM Regulation*
- *The use of positive FAVs, which should be exceptional*

CWE TSOs note that these topics are under discussion in FB DA and in the Core region, and once these discussions are finalized they will be discussed for IDCC.

CWE NRAs encourage CWE TSOs to evolve towards dynamic assessments of Imax using DLR technology, including transparent and harmonized rules for post-processing the DLR forecasts

CWE TSOs acknowledge the encouragement from NRAs, and note that the first pilot projects using DLR are ongoing.

All methodological improvements on the flow-based parameter inputs reached at FB DA level, shall be translated as soon as possible to the FB ID level, with a maximum time delay of 6 months

CWE TSOs note that it is unclear if improvements in DA can be implemented in ID within 6 months. Furthermore, CWE TSOs note that focusing resources on delivering these improvements for ID would subtract from deliverable in other projects, such as the Core region.

6.5.6 Flow-based allocation

TSOs are requested by NRAs to closely collaborate with the XBID project to realize that the full flow-based domain can be used as soon as possible for market coupling. NRAs request TSOs to deliver a report of the work done and progress made towards the implementation of FB ID MC. This report needs to be delivered within one year after the go-live of FB ID CC.

CWE TSOs acknowledge that using ATC values is suboptimal to using the Flow-Based domain, and note that CWE TSOs are already collaborating in the XBID project to realize Flow-Based market coupling for the intraday market.

6.5.7 Increased number of recalculations (hourly)

NRAs request TSOs to work towards multiple recalculations using the IDCF. Within one year after the go-live of FB ID CC NRAs request TSOs to deliver a report of the work done and progress made towards the implementation of multiple recalculations, and a corresponding project roadmap.

CWE TSOs acknowledge that multiple recomputations during intraday increases security of supply and reduces the uncertainty level which allows more capacity to be provided to the market. However, due to CACM GL deadlines, no major update (e.g. extension of the number of recomputations) of the intraday capacity calculation methodology is foreseen before the go-live of IDCC in the Core CCR. For Core IDCC, multiple recomputations of capacity are already foreseen as provided in the Core FB IDCC Proposal.

6.5.8 Optimization of the FRM through improved intraday forecasting accuracy

The improvements in the intraday common grid model will reduce uncertainties closer to real-time. This reduced uncertainty should be reflected in the significant lowering of the FRM values. NRAs request TSOs to deliver a report of the work done to reduce the FRM, together with a project roadmap for continuous improvement of forecast accuracy and uncertainty reduction. This report needs to be delivered within one year after the go-live of FB ID CC.

TSOs have presented the results of the latest ID FRM to NRAs during the dedicated workshop, CWE TSOs have taken note about the request for a report one year after the go-live of FB IDCC.

6.5.9 Earlier IDCZGOT

CWE NRAs consider an earlier IDCZGOT (21:00 D-1) as possible improvement. CWE TSOs are asked to consider how this can be implemented. NRAs request TSOs to deliver report on the actions taken to anticipate or reduce the calculation time. This report needs to be delivered within one year after the go-live of FB ID CC.

CWE TSOs note that ACER has taken a decision on the IDCZGOTand currently CWE TSOS are assessing the technical solution for existing and future intraday processes..

6.6 Annex 6: Answers to market parties' questions on CWE flow-based IDCC methodology

6.6.1 MPP letter of August 18th, 2017

6.6.1.1 General

The MPP welcomes the CWE TSOs' intention to proceed with a new capacity calculation in the intraday timeframe, based on updated inputs and considering reduced reliability margins compared to DA capacity calculation.

However, the proposal of the TSOs is insufficient. The documentation disclosed by TenneT still lacks the necessary details of the computations. Deeper comments on the level of detail that should apply to any proposal of a capacity calculation methodology can be found in the Eurelectric, EFET, Nordenergi, MPP response to the CCR proposals for the Capacity Calculation Methodologies in Nordic, Channel, Hansa, Core and SWE CCRs.

Overall, the MPP regrets the lack of transparency on the main methodological choices and the lack of ambition of the current proposal. Nevertheless, we consider this approach is acceptable as an interim solution, as it will improve the actual situation. Consistency with the day-ahead methodology is important in that respect.

The main omissions in this proposal are:

- There is no timeline for implementation, despite the related decisions by CWE NRAs.
- There is no clarity on what will be implemented as much is to the discretion of an individual TSO.

Feedback of CWE TSOs:

CWE TSOs would like to highlight that more detailed information, including the planning for implementation have been drafted in an explanatory note which has been submitted together with the methodology document. The planning was subsequently presented at the Consultative Group Meeting in September.

6.6.1.2 Inputs

"As a general rule, if there is an agreement between NRAs and TSOs to update the method for the input generation for the D-2 CWE FB process, the consequences of the implementation of these changes for the ID timeframe will be analyzed and, if possible, the FB IDCC method will be adapted in order to align it with the updated D-2 method."

The use of the method is conditional. What is the purpose of this proposal if TSOs are not bound to use it?

Feedback of CWE TSOs:

CWE TSOs foresee to analyse updates made in the D-2 method and consider these changes in ID. In general D-2 and ID consider two different time horizons, therefore it has to be proven, if changes made in D-2 are technically feasible in ID. In that case a link should be made to other projects (e.g. Core), also resources which are necessary to implement these changes have to be taken into account.

6.6.1.3 CNEC list for the FB computation

"If there is an agreement between NRAs and TSOs to update the method for the CNEC selection for the D-2 CWE FB process, the consequences of the implementation of these changes for the ID timeframe will be analyzed and, if possible, the FB IDCC method will be adapted in order to align it with the updated D-2 method."

The CNEC list for the FB computation is also conditional. What can we expect? What are the issues? In this regards, the MPP would like to stress that the FB package approval by CWE NRAs included the following statement: [excerpt from NRA feedback regarding CBCO selection rule]

As market participants, we would welcome such a demonstration [regarding optimality of 5% CNEC selection rule] and regret that no impact assessment of the CNEC selection process has been communicated so far for the DA and ID timeframes. We also note that such a demonstration should also be made with regard to external constraint selection.

Finally, the CNEC selection process should apply to each market time unit. Unlike what we experience as of today, this would lead to a situation where CNECs with all BZ-to-BZ PTDFs below 5% are never included in the capacity calculation.

Feedback of CWE TSOs:

CWE TSOs foresee to analyse updates made in the D-2 method and consider these changes in ID. In general D-2 and ID consider two different time horizons, therefore it has to be verified if changes made in D-2 are technically feasible in ID.

This topic is currently under discussion among CWE TSOs and NRAs and stakeholders are regularly informed on the status during stakeholder meeting.

6.6.1.4 Maximum current on a Critical Network Element (Imax) and Maximum allowable power flow (Fmax)

"When the Imax value depends on the outside temperature or wind conditions, its value can be reviewed by the concerned TSO if outside temperature or wind forecast is announced to be much higher or lower compared to the seasonal values."

Including weather conditions should be standard to maximise grid capacity. Especially in the intra-day timeframe, when more accurate forecasts are available. What are the reasons for not including them as a general conduct?

Feedback of CWE TSOs:

CWE TSOs would like to clarify that the limits for lines are not always determined by weather conditions, but could be limited by the sizing of feeder equipments (e.g. switcher, breaker, potential transformer).

When the limit of an element is dependent on weather conditions, and if this element is equipped with dynamic line rating, it is the practice of TSOs to consider weather condition forecasts when determining the limits for capacity calculation.

6.6.1.5 Day ahead Common Grid Model

"For intraday capacity calculation the latest available version of the day ahead Congestion Forecast process (DACF) will be used at the moment the capacity calculation process is initiated."

What exactly is the latest version that is meant here? In our view TSOs should make an update after the day-ahead market results for the intra-day calculation.

Furthermore, in the case of capacity calculations after the intraday cross-border gate opening time, should not the IDCF file be used? How would then the (moving) market clearing point be accounted in the common grid model used and FRMs considered in later capacity calculations?

Feedback of CWE TSOs:

As detailed in the FB IDCC methodology document, the latest available version of the day ahead Congestion Forecast process (DACF) includes, according to the methodology developed in line with Regulation 1222/2015 Article 16 and 17 (CACM):

- Best estimation of Net exchange program
- Best estimation exchange program on DC cables
- Best estimation for the planned grid outages, including tie-lines and the topology of the grid
- Best estimation for the forecasted load and its pattern
- If applicable best estimation for the forecasted renewable energy generation, e.g., wind and solar generation

- Best estimation for the outages of generating units
- Best estimation of the production of generating units
- All agreed remedial actions during regional security analysis.

The grid model used for ID capacity calculation is created after the DA market coupling in the evening of D-1. So the results of the DA market coupling are taken into account to create the grid model used for ID capacity calculation. The following list provides explicitly all improvements achieved through the recalculation in DACF compared to D2CF:

- Updated estimation of Net exchange program
- Updated estimation exchange program on DC cables
- Updated estimation for the planned grid outages, including tie-lines and the topology
- of the grid
- Updated estimation for the forecasted load and its pattern
- If applicable better estimation for the forecasted renewable energy generation, e.g. wind and solar generation
- Updated estimation for the outages of generating units
- Updated estimation of the production of generating units
- All agreed remedial actions during regional security analysis

In the current process, only one recomputation is coordinated with all TSOs. This recomputation is performed in the evening of the D-1. In the future, additional recomputations (i.e. after IDCZGOT) could be implemented based on the updated set of data: IGMs, but also remedial actions, in order to assess more efficiently the capacity that can be provided to the market players.

6.6.1.6 Generation Shift Key

"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 do not have sufficient flexible generation for matching maximum import or export program or if they want to moderate impact of flexible units."

What are the reasons of excluding by fuel type in the standard calculation and only in cases where additional flexible generation is needed? What are the conditions for such cases?

Why are there so many unexplainable differences in the different GSK methodologies? The Dutch, Belgian and French bidding zones use a pro rata approach, which is not market reflective. Other TSOs use a more sophisticated approach. Interesting in this respect is the difference of TenneT NL and TenneT DE.

The assessment of approaches should be transparent with respect to their impact on the level of FRMs for the most critical network elements. This would help determining the most relevant approach for each TSO.

Feedback of CWE TSOs:

CWE TSOs note that not all TSOs differentiate by fuel type in their GSK. For the TSOs who do differentiate, the differentiation between fuel types was derived based on statistical analysis of power plant schedules in order to reflect market activities of power plants. In particular, fuel types allow for a statistical relevant distinction between base load generation and market driven generation, which is a required feature for the GSK.

The technical limitation of the flow based computation requests a pure linear GSK without possibility to consider a min and max value per node. So the pure market driven oriented approach or merit order approach cannot be applied and, TSOs need to accomodate their GSK methodology accordingly, depending on the specificities of the grid and generation pattern in its control area.

CWE TSOs always aim at harmonizing their methodologies. However, the GSK is very specific for each control area and its generation. Therefore, each CWE TSO determines the GSK in a way most suitable for its control area. This explains the difference between TTG and TTN, which reflect the very different generation structure.

6.6.1.7 FRMs

In our view, deviations related to remedial actions triggered by TSOs (such as voluntary topology changes, HVDC or PST settings, or redispatching) should not be accounted within the FRM setting. Indeed, those result from decisions by TSOs whose impact can be anticipated, unlike the other dimensions mentioned in page 12 of the proposal.

TSOs should clarify how they intend to modify the scheduled flows to account for those voluntary updates between the capacity calculation and real time.

Feedback of CWE TSOs:

The FRM is determined by the timestamps where the forecasted load-flow is lower than the realized load flow. Therefore, only remedial actions that increase the real time load-flow on a CNEC are relevant for the FRM of this CNEC. Moreover, for efficiency in the process and considering the effort needed to archive, list and translate applied RAs from real time back to forecasted dataset, we only focus on the RAs which can, from a qualitative point of view, significantly impact the FRM. Considering these aspects, CWE TSOs compute PST-adjusted FRM values, which do not take into account flow deviations related to PST settings. The use of redispatching and HVDCs generally has a positive effect on FRM values and is then not considered in the adjustment of scheduled flows. As the occurrence of an outage on the grid remains very rare, the consideration of flow deviations related to curative remedial actions has a negligible impact on the FRM values and does also not require to further modify the scheduled flows. It has also to be noted that CWE TSOs provide improved grid models in which foreseen remedial actions at the time of the capacity calculation are already applied.

6.6.1.8 Validation of capacity (countertrading and redispatch)

"The use of any of the above mentioned instruments has to be monitored, and is not dedicated to enlarge the flow-based or ATC domain, as it would become too large, thus unsecure. The output of this process is the amended flow-based and/or ATC domain."

We certainly acknowledge that the inclusion by individual TSOs of additional constraints in the capacity calculation or allocation because of internal constraints should be thoroughly monitored and justified. But we disagree with the statement that enlarging the FB or ATC domain systematically makes operation less secure. Indeed, TSOs may use alternative remedial actions, such as countertrading or redispatch to restore secure system operation. In this regard, the MPP calls for a capacity calculation and allocation that leads to the most efficient trade-off between the various means TSOs can rely on to secure system operation.

Feedback of CWE TSOs:

As explained in the Consultation report, CWE TSOs welcome the proposal to consider economical parameters in the process. However CWE TSOs consider the topic of implementing costly remedial actions in order to adapt the capacities and use of congestion rent for redispatch to be an NRA decision. TSOs would additionally like to inform that related discussions are also ongoing at ENTSO-E level.

6.6.1.9 Back-up procedures

"The back-up process has to be reliable in order to ensure that capacity will always be delivered to the market players. In case the process fails, the last computed capacity will be provided to the allocation platform. For example, in case the intraday capacity calculation fails, the TSOs will provide to the allocation platforms the leftover of the day ahead capacity."

It is not clear what this really means. The fall back is the current procedure?

Feedback of CWE TSOs:

The backup procedure foresees that the leftover capacity per CWE border and direction shall be determined based on the Day-ahead flow-based domain and the day-ahead

Market clearing point using the ATC extraction algorithm from the current procedure. But no additional (bi- or multi) lateral assessment shall take place.

6.6.2 Questions by MPs following consultation process

6.6.2.1 The calculation of ID RAMs

What is taken into account in practice? An example with historical measurements on a particular CNE would be welcome.

Feedback of CWE TSOs:

The calculation of CNE is explained in the Methodology document. The calculation of RAMs does not differ from the DA FB calculation. Historical information from DA point of view is already provided by TSOs on the www.jao.eu website for MPs.

6.6.2.2 Stopping XB exchanges during the capacity calculation process

MPs consider this might reduce market efficiency (in particular when there are several recomputations) but understand this would allow considering reduced RAMs. Could TSOs provide figures about how much placing ID markets on hold during recomputation leads to reduced RAMs?

Feedback of CWE TSOs:

The FB IDCC methodology does not deal with trading on capacities and does not refer to a stop in the XB exchanges during the CC process.

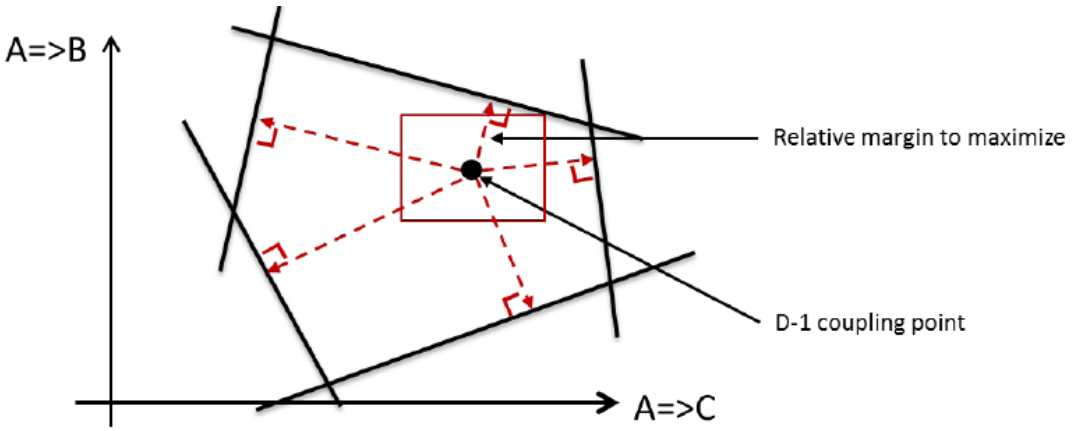
The CWE FB IDCC method will be operationalized with only one re-computation for the full day before gate opening. More re-computations for Intraday are to be expected as part of the CORE initiative.

6.6.2.3 Favoring certain directions for capacity increase through RA optimization

In terms of favoring certain directions for capacity increase through RA optimization, MPs want to highlight that their feedback do not oppose. They may differ slightly (mainly due to the extremely short delay they had to answer the consultation: 2 weeks) but tend towards the same direction, as long as there are only a few IDCCs, TSOs should give more value to enhancing the FB domain in the intraday or day-ahead market direction (depending on the timing of the recalculation) than in the reverse direction. At least the impact assessment should monitor such an indicator.

Feedback of CWE TSOs:

The present objective function is to increase the minimum relative margin by finding remedial actions that aim at improved capacities based on the day-ahead market results. The RAO tries to maximize the margins of elements to be optimized relatively to their sensitivity to exchanges, without market assumption (i.e. without a preference to any particular exchange directions). This can be explained as increasing the space around the market clearing point of the day-ahead market as illustrated in figure 3 below.



$$Relative\ Margin\ (CNEC) = \frac{Margin(CNEC)}{\sum_{i,j \in hubs} |PTDF_{i \to j}(CNEC)|}$$

Figure 3: Illustration of the non-discriminatory approach to increase the space around the market clearing point of day-ahead without one border being advantaged over another.

This means that a remedial action will be selected and implemented if it increases the margin on the limiting branch (among the CNECs to be optimized) considering the already achieved minimum margin.

From this approach it follows that the day-ahead market clearing point (more precisely its position in the FB domain) determines the directions in which the domain is optimized.

Furthermore it can be noted that the objective function of the RAO is always the same independent of the day-ahead market clearing point being included in the FB domain or not.

6.6.2.4 Impact assessment & performance indicators

MPs questioned the impact assessment, and suggested several performance indicators. Could the TSOs simulate additional results with such indicators since March?

Feedback of CWE TSOs:

CWE TSOs are performing an internal parallel run since May 30th, 2017 in order to get more quantitative results and perform a more reliable and representative impact assessment. This internal parallel run will continue during 2018 and will be followed by an external parallel run, whose results will be shared with Market Parties.

As the behavior of market participants in the intraday timeframe is not predictable, CWE TSOs are not only looking at the capacity in the DA market direction, but are also computing a market indicator that takes into account all the market directions.

CWE TSOs welcome any suggestion from Market Parties about new indicators.

6.6.2.5 Multiple IDCCs

MPs welcome the announcement by CWE TSOs that multiple IDCCs will be performed in the future. An indicative schedule would be welcome for this development.

Feedback of CWE TSOs:

CWE TSOs acknowledge that multiple recomputations during intraday increases security of supply and reduces the uncertainty level which allows more capacity to be provided to the market. However, due to CACM GL deadlines, no major update (e.g. extension of the number of recomputations) of the intraday capacity calculation methodology is foreseen before the go-live of IDCC in the Core CCR. For Core IDCC, multiple recomputations of capacity are already foreseen as provided in the Core FB IDCC Proposal.

6.6.2.6 External constraints

As of the external constraint, it is unclear to market parties to which extent voltage stability issues extent can be considered as cross-border related. Also, if external constraints prevent the market clearing point to deviate significantly from the forecast (i.e. the MCP immediately before the recomputation?), this should be duly taken into account in the FRM, which should be reduced consequently.

Feedback of CWE TSOs:

The FRM values cover uncertainties of the input parameters and not of the applied model itself, therefore External Constraints have no effect on the FRM values.

Extreme situations far away from the original market clearing point cannot be reflected in the linear approximation that is used in the DC loadflow. This approximation only remains valid in a certain area around the market clearing point. Therefore, moving far away from the original assumption, leads to large model inaccuracies and a failure of the model. This implies, that a stable grid operation is not guaranteed anymore and TSOs are obliged to prevent this.

6.6.2.7 XB redispatch

We understand that XB redispatch would shift the FB domain, and would welcome more details on the way CWE TSOs intend to organize XB redispatching. In any case, full transparency should prevail on redispatching as soon as such actions are triggered by TSOs (i.e. before real time), as they can significantly affect price formation in all bidding zones.

Feedback of CWE TSOs:

CWE TSOs agree on the need for transparency for redispatch measures, but XB redispatch is out of scope of the present process. The application of redispatch is not triggered by capacity calculation. Instead some control blocks are using internal processes for the determination of preventive redispatch or real time system operations will decide close to real time if redispatch measures are necessary.

6.6.2.8 ID Countertrading

Do TSOs foresee to use the countertrading for CWE? If not, why? Is it foreseen in the future?

Feedback of CWE TSOs:

CWE TSOs consider the topic of implementing costly remedial actions (e.g. countertrading) in the process to be an NRA decision. Should these measures be necessary in order to safeguard security of supply, CWE TSOs consider this out of scope for the present process.

CWE flow-based Intraday Capacity Calculation methodology

29th of June 2018

Subject: Regulatory approval for the flow-based Intraday Capacity Calculation methodology

Dear CWE NRAs,

CWE TSOs are pleased to provide the attached final approval document for the flow-based intraday capacity calculation (FB IDCC) methodology. The document is an amended version of the FB IDCC methodology submitted to CWE NRAs on May 9th 2017, to consider the feedback received from NRAs as reflected in their CWE NRAs Position Paper on FB IDCC of 15th September 2017, as well as the split of the German-Austrian bidding zone border.

For ease of reference, a compared version of the updated text with the text of the initial approval document is attached in annex to this letter.

Approval document

The NRA approval document covers the coordinated FB IDCC methodology. This document is considered as a follow-up of the CWE flow-based market coupling (FB MC) approval package for the day-ahead timeframe dated August 1st 2014 and in particular of the "Position Paper of CWE NRAs on Flow-Based Market Coupling" of March 2015, as well as the approval package on the methodology for capacity calculation for the ID timeframe submitted to NRAs on November 9th 2015.

In addition to the CWE FB IDCC methodology (legal document), an Explanatory Note has been drafted in order to provide additional information. This document will not have to be approved as such. It contains the following information:

- FB IDCC implementation planning;
- Description of internal parallel run results from May 29th 2017 to March 31st 2018, and examples explaining the methodology;
- Criteria to be monitored to assess and evaluate the methodology in the operational process;
- Results of the public consultation and answers to additional questions provided by Market Parties;
- CWE TSOs' feedback on the Position Paper on FB IDCC, as presented to NRAs during the dedicated workshop on FB IDCC on February 20th 2018;
- Description of possible future improvements.

As detailed in the updated implementation planning included in the Explanatory Note, CWE TSOs intend to be technically ready for go-live on June 19th 2019. CWE TSOs note that this is a challenging planning reflecting the earliest go-live date seen as feasible as of this submission, but that high uncertainties remain that might impact the implementation planning. Prior to go-live, the results of the internal parallel run will be shared with the CWE NRAs.

CWE TSOs would like to thank NRAs for their input and discussions in NRA Expert Meetings, market forums and dedicated workshops, which supported to create a common understanding and to design this solution for future CWE flow-based IDCC.

Best Regards,

CWE Transmission System Operators