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Postbus 718, 6800 AS Arnhem, Nederland

Autoriteit Consument en Markt
T.a.v. de heer dr. F.J.H. Don
Postbus 16326
2500 BH DEN HAAG

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BEHANDELD DOOR	[redacted]
TELEFOON DIRECT	[redacted]
E-MAIL	[redacted]@tennet.eu

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BETREFT Voorstel van CWE TSO's voor de capaciteitsberekening voor intraday

Geachte heer Don,

Zoals afgesproken met de heer [redacted] van uw organisatie ontvangt u hierbij een voorstel voor de capaciteitsberekening voor de intradaymarkt dat door de gezamenlijke CWE TSO's is opgesteld:

"Methodology for capacity calculation for ID timeframe" d.d. 9 mei 2017.

Dit voorstel bevat geen vertrouwelijke gegevens.

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

Hoogachtend,
TenneT TSO B.V.

[redacted]

Senior Manager Regulation NL

Methodology for capacity calculation for ID timeframe

For NRA approval

Version	Final version
Date	09-05-2017

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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**: 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.
- **MCP**: 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.
- **Zone-to-hub PTDF**: Represent the variation of the physical flow on a critical branch induced by the variation of the net position of each hub
- **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) 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 (FR), PTDF (NL)) - min(PTDF (BE), PTDF (DE/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.

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 remedial actions during regional security analysis.

3.1.4 Remedial Actions (RA)

During FB parameter calculation, CWE TSOs take Remedial Actions (RA) 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 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 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) 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 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.

$$\text{GShK TSO}_i = \frac{\textit{Available power in control area of } TSO_i}{\sum_{k=1}^{5}(\textit{Available power in control area of } TSO_k)}$$

Where k is the index for the five 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:

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

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

Ampríon 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

APG's method to select GSK nodes is 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 case of APG pump storage and thermal units are considered. Power plants which produce band energy (river power plants) are not considered. Only river 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 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 extreme import or export scenarios. The GSK is directly adjusted in case of new power plants. Also unavailability of generators due to 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. The total production level remains the same.
The maximum production level is the contribution of the unit in a predefined extreme maximum production scenario. The minimum production level is the contribution of the unit in a predefined extreme minimum production scenario. Base-load units will have a smaller difference between their maximum and minimum production levels than start-stop units.

For the intraday timeframe, a proportional GSK based on the results of FB DA CC will 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.

3.1.6.3 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 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 Flow Reliability Margin (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 because a part of this free space - that is provided to the market to facilitate cross-border trading - must be reserved to cope with these uncertainties.

The basic idea behind the FRM determination is to quantify the uncertainty by comparing the 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.

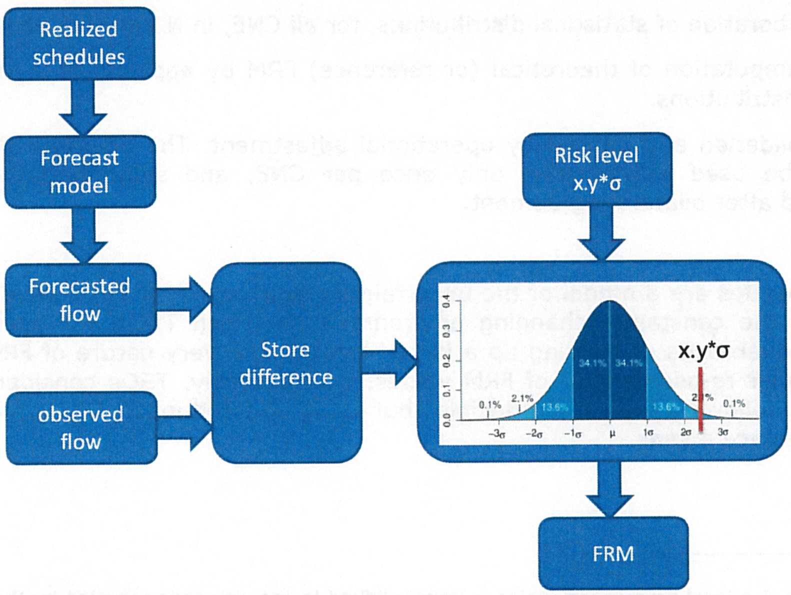

Figure 1: FRM Assessment Principle

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 definition. The rationale behind this is that TSOs remain critical towards the outcome of the pure theoretical approach in order to ensure the implementation of parameters which make sense operationally. For any reason (e.g.: data quality issue), it can occur that the "theoretical FRM" is not consistent with the TSO's experience on a specific CNE. Should this case arise, the TSO will proceed to an adjustment.

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

The theoretical 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.

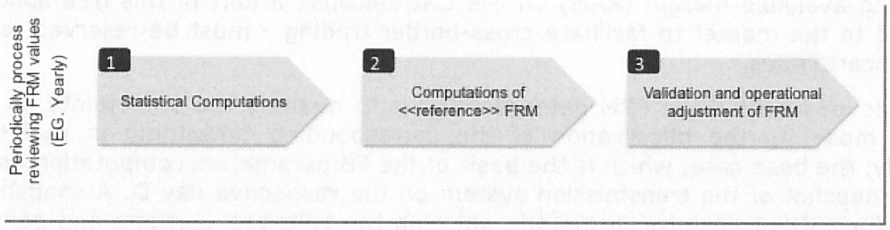

Figure 2: FRM computation process

Step 1: Elaboration of statistical distributions, for all CNE, in N and N-1 situations.

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

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

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.

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[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.

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 problems. Such stability issues have to be detected via 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.

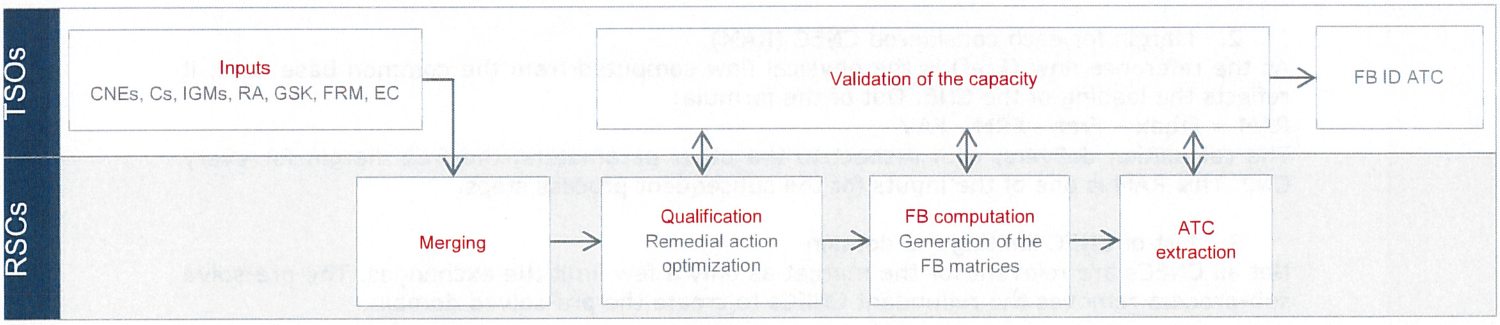

Figure 3: Operational process for FB IDCC.

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 and condition of use
- Common grid model
- Merged GSK file

3.2.4 Qualification

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 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.

The output of this part of the process is:

- A coordinated set of preventive remedial actions
- A coordinated set of curative remedial actions 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 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 to ensure grid security. Availability of these remedial actions 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 4 below.

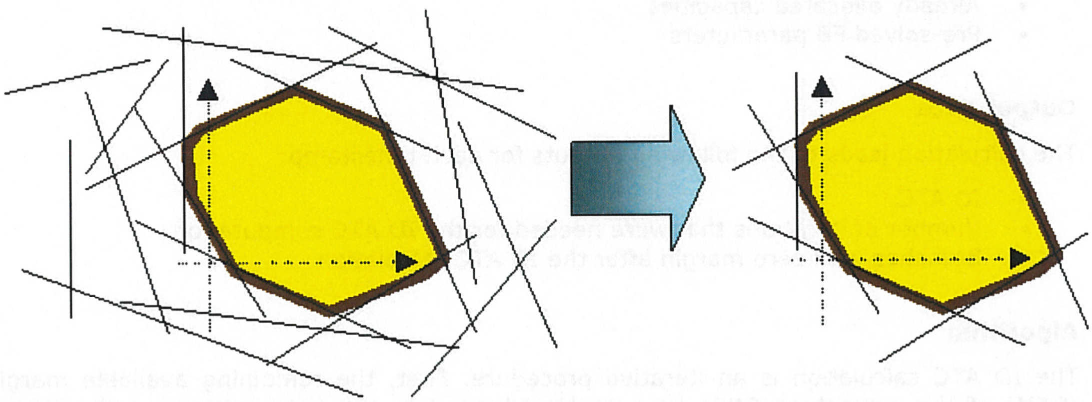

Figure 4: Pre-solve illustration

In the two-dimensional example shown in Figure 4, 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.

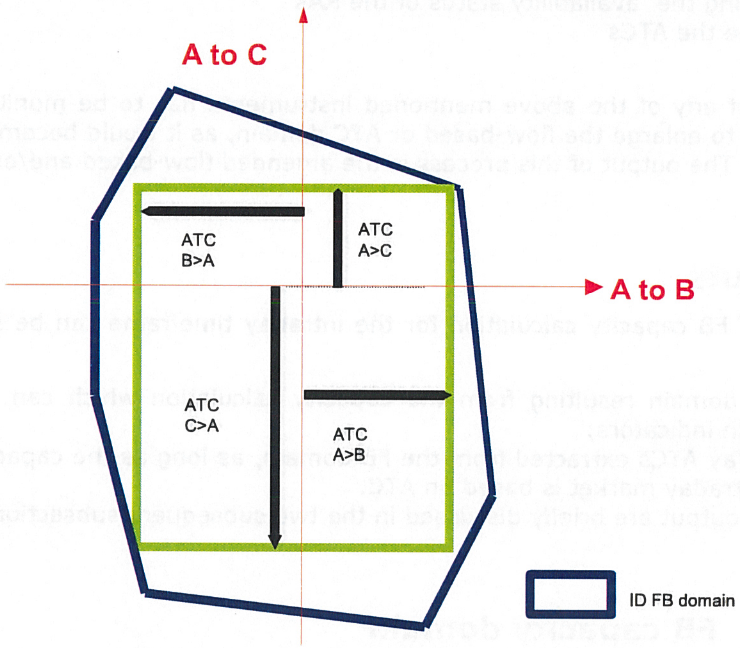

Figure 5: Illustration of ID ATC computation

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 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 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.

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.

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[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.