

# Explanatory Note of the Coordinated NTC methodology for SWE CCR

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## 1. Introduction

This technical document sets out the main principles for the coordinated capacity calculation methodology for the day-ahead market timeframe applied in the South-Western Europe Area (SWE) and a short explanation about preliminary coordinated capacity re-calculation methodology for the intraday market. It contains a description of both the methodology and the calculation process in compliance with the Capacity Allocation and Congestion Management guideline (hereafter CACM).

The participating TSOs for this calculation are REE (ES), REN (PT) and RTE (FR), following borders are considered France – Spain and Spain – Portugal.

## 2. Coordinated NTC calculation methodology

### 2.1. Inputs

#### 2.1.1. Methodologies for operational security limits, contingencies

##### 2.1.1.1. *Critical network elements and contingencies*

A Critical Network Element (CNE) is a network element either within a bidding zone or between bidding zones monitored during the capacity calculation process. The CNEC (Critical Network Element and Contingencies) is a CNE limiting the amount of power that can be exchanged, potentially associated to a contingency (see below the definition). They are determined by each SWE TSO for its own network according to agreed rules, described below.

The CNECs are defined by:

- A CNE: a line or a transformer whose flow is significantly impacted by cross-border exchanges; a node whose voltage is significantly impacted by cross-border exchanges; a line whose voltage phase angle difference is significantly impacted by cross-border exchanges after its trip.
- An “operational situation”: base case (N regime) or contingency cases (N-1, N-2).

A contingency is defined as the trip of one single or several network elements that cannot be predicted in advance. A scheduled outage is not a contingency. The normal type of contingency comprises the loss of a single element, which can be:

- a line
- a tie-line
- a DC link
- a generation unit
- distributed generation of a relevant size like a clustered wind farm, cogeneration, etc.
- a transformer (including Phase Shifter Transformers)
- a large voltage compensation installations.

Contingencies situation could result from the combined loss of several elements.

##### 2.1.1.2. *Definition of operational security limits*

#### Maximum permanent and temporary current on a Critical Branch

The maximum permanent admissible current/power means the maximum loading that can be sustained on a transmission line, cable or transformer for an unlimited duration without risk to the equipment.

The temporary current/power limit means the maximum loading that can be sustained for a limited duration without risk to the equipment (e.g. 115% of permanent physical limit can be accepted during 20 minutes). Each individual TSO is responsible for deciding which values (permanent or temporary limit and duration of each overload) should be used.

As thermal limits and protection settings can vary in function of weather conditions, different values are calculated and set for the different seasons within a year. These values can be also adapted by the concerned TSO if a specific weather condition is forecasted to highly deviate from the seasonal values

#### Maximum/minimum voltage on a node of the network

If the voltage on a node is significantly impacted by cross-border exchanges, the voltage on this element shall be monitored in the capacity calculation.

Each TSO shall specify the voltage limits for each element of its transmission system.

#### Voltage Phase Angles Differences

Following the opening or the outage of tie-lines a manual reclosure may be refused by Parallel Switching Devices (PSDs) in case of voltage phase angle difference exceeding the pre-set threshold of the device.

The setting of the threshold depends on operational conditions in this respective area of the grid and are often chosen around 30°.

#### 2.1.2. Reliability Margin (RM)

The methodology for the capacity calculation is based on forecast models of the transmission system. The inputs are created two days before the delivery day with the best available forecast. Therefore the outcomes are subject to inaccuracies and uncertainties. The aim of the reliability margin is to cover these inaccuracies and uncertainties induced by those forecast errors.

##### 2.1.2.1. The unintended deviation (UD)

For control-related reasons, deviations occur between the scheduled values and the actual values during the exchange of energy between neighboring control areas. This implies that at any moment the exchange between two control areas can be significantly higher than the scheduled exchanged, endangering the security of supply.

Please note that this part of the reliability margin is linked to the border and not to the timeframe studied. For this reason this part will be the same for the D-2 calculation and D-1 or intra-Day.

##### 2.1.2.2. The uncertainties (UN)

The Coordinated NTC calculation methodology is based on different inputs provided by TSOs, they are based on best available forecast at the time of the capacity calculation for RES, consumption, production plans or available network elements and those could differ from the real-time situation.

This part of the reliability margin should be lower the closer the calculation is done to real-time.

##### 2.1.2.3. Current target methodology

RM can be modelled as a probability distribution function resulting from taking into account two variables:

- Unintended deviation on the (France-Spain or Portugal-Spain) interconnection and
- Uncertainties of the forecast between D-2 calculation studies and real time.

Uncertainties will be evaluated from the impact on most relevant CNE elements on the (France-Spain or Portugal-Spain) interconnection. For this approach, the list of most relevant CNE elements will be a reduced number of them whose flows are highly impacted by cross-border exchanges (typically tie-lines and the nearest internal lines). At least, a sensitivity threshold equal or higher than 10% should be considered.

In a first step, each D-2 scenario will be modified to reflect the real commercial exchange on the interconnection in the corresponding real time scenario. These changes fulfill the GSLK methodology established in section 2.1.3.

Once D-2 forecast can be compared with real time scenario, the difference between flows in D-2 and real time through each CNE element will be collected. The RM needed to compensate the flow deviation for each CNE will be determined as follow:

$$RM_{CNE} = \frac{P_{Real\ time} - P_{D-2}}{SI_{CNE}}$$

Where:

- $SI_{CNE}$ : Sensitivity Index for each CNE in base case
- $P_{real\ time}$ : monitored branch MW flow in real time scenario (base case)
- $P_{D-2}$ : monitored branch MW flow in D-2 forecast (base case)

Finally, collecting all the above mentioned RMs for each CNE and scenario during the period of the study, the equivalent Gaussian probability distribution function “UN” will be obtained.

Therefore, the RM probability distribution function can be obtained by the convolution of the two probability distribution functions UD and UN corresponding to the described variables and the obtained values can be different depending on the border. Finally, the value of RM shall be defined as the 95 percentile of the distribution function.

$$\text{Reliability Margin (percentile 95\%)} = \text{Convolution (UD, UN)}$$

#### *2.1.2.4. Temporary values to be used until statistical data are available*

The following values are based on actual data that can be found in annex.

##### Portugal – Spain border

RM is calculated as the maximum of the two following values:

UD is defined with a fix value of 100 MW (covering 95% of the cases of deviation).

UN is defined at 10% of the TTC.

These thresholds are explained by the specificities of the borders

- The huge amount of RES production in Portugal and Spain makes the forecast sensible to changes which gives a high value for the UN threshold, together with high sensitivity to the localization of the production in both countries and thus a high impact of the precision of the GSK forecast.

##### France – Spain border

RM is calculated as the maximum of the two following values:

UD is defined with a fix value of 200 MW (covering 95% of the cases of deviation).

UN is defined at 7,5% of the TTC.

These thresholds are explained by the specificities of the borders

- A lower proportion of RES in France can explain a lower UN factor, even though there is a high sensitivity to the localization of the Spanish production.

#### *2.1.2.5. Assessment of percentile coverage*

As mentioned in the Proposal, the TSOs of SWE Region shall investigate whether a lower percentile could be taken into account for the reliability margin computation while guarantying security of supply. A study will be provided to the relevant regulatory authorities when available.

In order to perform this analysis, SWE TSOs will extract from the probability distribution the values of RM that would cover percentiles from 95 to 90 % and analyze the cost in term of costly remedial actions that would be necessary to cope with the deviation cases.

As a first approximation, the gain in welfare will be defined as the general benefit at Union level. The cost of the remedial actions will be approximated to the average counter-trading costs.

Every time the physical flow will be higher than the TTC, counter trading will be used to cope with the insecurity.

### 2.1.3. Generation Load Shift Key (GLSK)

#### *2.1.3.1. The proportional shift*

This shift methodology will be implemented in RTE control area.

This choice is mainly related to the fact that generation in France is composed at 75% by nuclear power that do not vary following a merit order. Indeed the French electricity market being a portfolio market, the merit order is not geographically relevant. Thus a proportional representation of the generation variation, based on RTE's best estimate of the initial generation profile, ensure the best modelling of the French market.

#### *2.1.3.2. The merit order shift*

This kind of shift methodology will be implemented in REE and REN control areas.

The main reason for this choice is due to the fact that both electrical systems have a high level of RES generation installed. Those generators as well as the conventional generation are geographically located in different areas of the countries, then for different generation profiles we get different power flows in the grid elements and consequently different stress areas in the systems with potential impact in the NTC calculations. Some examples:

- If the wind production is high the marginal production could be reduced;
- If the winter is wet the marginal price of hydro power-plants could be lower than the marginal price of thermal power-plants, and vice-versa for dry seasons.
- Depending on the primary sources' prices, the market behaviour will be different and affect the location of the production

### 2.1.4. Remedial Action (RA)

During coordinated NTC calculation SWE TSOs will take into account Remedial Actions (RAs). The general purpose of the application of RAs is to maintain the transmission system within the operational security limits during the capacity calculation process, where maximum power exchanges are reached, with the subsequent benefit of the market.

A RA can be:

- Changing the tap position of a phase shifting transformer (PST);
- Topological measure: opening or closing of one or more line(s), cable(s), transformer(s), bus bar coupler(s) or switching of one or more network element(s) from one bus bar to another;
- Change of generator in-feed or load.
- Change the flow in the HVDC links France-Spain: use of the modulation modules
- Change the flow in a line using a FACTS (flexible alternating current transmission system)
- Change the voltage on a node by activating/deactivating reactance(s) or capacitor(s)

All explicit RAs applied for NTC calculation must be coordinated in line with article 25 of Regulation (EU) 2015/1222 (CACM). Prior to each calculation process, the TSOs of a bidding zone border shall agree on the list of remedial actions that can be shared between both in the capacity calculation. These shared remedial actions can only be activated with prior consent of the neighbouring TSO since their activation have a significant impact on its control area.

A description on how the RA optimization is performed will be described in the section 3.2.1.

## 2.2. Capacity calculation approach

Due to the specificities of the SWE CCR, SWE TSOs will use coordinated NTC approach to determine the cross-border capacities for each border of the SWE CCR. An independent value will be determined for each MTU of the day.

### 2.2.1. Theoretical description of the Remedial Action Optimization (RAO)

*Disclaimer: Please be informed that the RAO methodology is under a continuous improvement process. The sections depicted below are the current status of the methodology foreseen.*

In the case of the electrical system, we face a non-convex and non-linear situation, dealing with topology changes on the network, which represent discrete actions by definition. The problem treated by the RAO tool is a combinatorial problem.

Branch and bound algorithms are commonly used for high complexity mathematical problems, containing combinatorial and discrete aspects.

#### 2.2.1.1. The inputs given to the RAO

It is up to the TSOs based on its expertise, to associate the RAs with the relevant CNECs. The RAO process allows the TSOs to do a pre-selection of associations that will both help the optimizer to find the best combinations (especially when a complex set of RAs is necessary to solve some particular constraints) and reduce the computation time. This ensures the efficiency of the calculation process in the allotted time.

#### 2.2.1.2. The RA handling

The remedial actions selection process of the RAO, taking advantage of the branch and bound algorithm used, let the opportunity to define usage rules for remedial actions. These usage rules can be seen as an availability assessment of the remedial action before branching.

The algorithm will assess which remedial actions are available at this stage based on usage rules, and only after that will enter the branching algorithm to test them individually. It can be seen as a mean to filter

the remedial actions for the algorithm, or to control the usage of some remedial actions for specific constraints.

The RAO can deal with many different remedial actions such as, but not limited to:

- PST tap optimization
- HVDC set-point optimization (curative)
- Topological remedial action in a substation
- Generation redispatching (curative)
- Activation/deactivation reactance(s) or capacitor(s)

### 2.2.1.3. The computation

At a predefined TTC level, all the contingencies present in the contingency list are run together with a combination of remedial actions. After each combination, a load flow is computed.

#### The load flow computation

The load flow equations will be solved using the Newton-Raphson solution method.

Based on the CGM and the GSK from the different countries, we can determine the best estimate of flows, voltage and angle difference on all buses of the grid by solving the following load flow equations:

$$P_i = \sum_{k=1}^N |V_i| |V_k| (G_{ik} \cos \theta_{ik} + B_{ik} \sin \theta_{ik})$$

Where  $P_i$  is the net active power injected at bus  $i$ ,  $|V_i|$  and  $|V_k|$  the voltage magnitudes at bus  $i$  and  $k$ ,  $G_{ik}$  is the real part of the element in the bus admittance matrix\*  $Y_{BUS}$  corresponding to the  $i^{\text{th}}$  row and  $k^{\text{th}}$  column,  $B_{ik}$  is the imaginary part of the element in the  $Y_{BUS}$  corresponding to the  $i^{\text{th}}$  row and  $k^{\text{th}}$  column and  $\theta_{ik}$  is the difference in voltage angle between the  $i^{\text{th}}$  and  $k^{\text{th}}$  buses.

$$Q_i = \sum_{k=1}^N |V_i| |V_k| (G_{ik} \sin \theta_{ik} - B_{ik} \cos \theta_{ik})$$

Where  $Q_i$  is the net reactive power injected at bus  $i$ ,  $|V_i|$  and  $|V_k|$  the voltage magnitudes at bus  $i$  and  $k$ ,  $G_{ik}$  is the real part of the element in the bus admittance matrix\*  $Y_{BUS}$  corresponding to the  $i^{\text{th}}$  row and  $k^{\text{th}}$  column,  $B_{ik}$  is the imaginary part of the element in the  $Y_{BUS}$  corresponding to the  $i^{\text{th}}$  row and  $k^{\text{th}}$  column and  $\theta_{ik}$  is the difference in voltage angle between the  $i^{\text{th}}$  and  $k^{\text{th}}$  buses.

(\*) [https://en.wikipedia.org/wiki/Nodal\\_admittance\\_matrix](https://en.wikipedia.org/wiki/Nodal_admittance_matrix)

In order to do so, the SWE computation tool is using the Newton-Raphson method that starts an iterative process from initial arbitrary values. It then solves the following linear system of equations:

$$\begin{bmatrix} \Delta \theta \\ \Delta |V| \end{bmatrix} = -J^{-1} \begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix}$$

With

- $\Delta P$  and  $\Delta Q$  the following equations



$$\Delta P_i = -P_i + \sum_{k=1}^N |V_i||V_k|(G_{ik} \cos \theta_{ik} + B_{ik} \sin \theta_{ik})$$

$$\Delta Q_i = -Q_i + \sum_{k=1}^N |V_i||V_k|(G_{ik} \sin \theta_{ik} - B_{ik} \cos \theta_{ik})$$

- And J a Jacobian matrix defined as follow:

$$J = \begin{bmatrix} \frac{\partial \Delta P}{\partial \theta} & \frac{\partial \Delta P}{\partial |V|} \\ \frac{\partial \Delta Q}{\partial \theta} & \frac{\partial \Delta Q}{\partial |V|} \end{bmatrix}$$

The system of equations is solved to find the next guess

$$\theta_{n+1} = \theta_n + \Delta \theta$$

And

$$|V|_{n+1} = |V|_n + \Delta |V|$$

The computation stops when  $\Delta P_n$  and  $\Delta Q_n$  are small enough.

#### The Remedial Actions Optimizer (RAO)

The RAO will monitor at each step of the calculation the maximum flows, the adequate voltage levels and the maximum voltage phase angle differences defined by the TSOs on all the CNEs. The margin for a given CNE is defined as the difference between the maximum flow/voltage/angle difference allowed on the CNE and the measured flow/voltage/angle difference on the element after simulating a loadflow. In the case of under-voltage assessment, the margin is defined as the difference between the measured voltage and minimum voltage allowed on the CNE.

As an example, the flow margin on a particular CNE can be determine as:

$$Margin = F_{max} - F_n$$

With

- $F_{max}$  the maximum flow (in MW) allowed on the CNE
- $F_n$  the flow (in MW) on the CNE after the load flow

In the SWE region, the RAO is based on a branch and bound algorithm. It uses a **positive margin methodology**, meaning that it aims at finding a combination of remedial actions allowing to obtain positive margins on all the CNEs for the TTC value tested after all the contingencies. The remedial actions optimization stops when appropriate RAs are found and moves directly to the next TTC value.

#### 2.2.2. CNEC & RA selection

A four-step approach will be used to determine the CNEC selection which will be used for the Coordinated NTC calculation. The CNEC selection process is a local process and its application is the responsibility of the TSOs.

As the first step an initial pool of CNEs and Contingencies will be created: this pool is the result of the input from each TSO. As the second step, the CNEs to be monitored will be selected. The third step is defined in order to identify the Contingencies that have a cross-border relevance. Finally, the TSOs will keep the possibility to maintain additional CNEs that can be sensible to cross border exchanges within a particular

combination of Outage(s), Contingencie(s), Remedial Action(s). These additional CNEs will have to comply with the selection criteria after an ex-post analysis.

The process requires the determination of two separate thresholds: one to assess CNEs relevance and the second to assess the Contingencies relevance.

#### 2.2.2.1. Creation of an initial pool of CNEs and Contingencies

Each TSO will define a list of CNEs and Contingencies which need to be monitored during the Coordinated NTC calculation process. The selection will be based on each TSO's needs and operational experience. The result of the decentralized process will be an initial pool of CNEs and Contingencies to be used for RAO.

The pool is defined during an offline process and will remain fixed during the computation. The list of CNEs and Contingencies will be assessed and updated periodically (e.g. with the commissioning of new grid elements, generation units) and at least once a year.

#### 2.2.2.2. Selection of regional CNEs for the RA optimization

From the CNECs list defined by the TSOs, a sensitivity study for a set of scenarios will be carried out to determine the CNEs which have a cross border relevance in base case and after a contingency. The sensitivity of the element will be determined by the variation of the flow, voltage or voltage phase angle difference in the CNE when the cross border exchanges increase by 100 MW, for several initial cross border exchange values.

The sensitivity formula to establish the different CNEs will be the following:

$$SI_{monitored\ element} (\%) = \frac{P_{final} - P_{initial}}{\Delta E_{border}} \times 100$$

We will call 5% the sensitivity factor to be applied. All CNEs with a sensitivity equal or higher than this threshold will be monitored during the capacity calculation. The tie-lines should always be monitored.

Where:

- $SI$ : Sensitivity Index for each monitored element
- $\Delta E$ : Increase of Exchange program through the border in MW (100 MW by default)
- $P_{initial}$ : monitored branch MW flow in initial state
- $P_{final}$ : monitored branch MW flow after a variation of  $\Delta Exchange$  through the border

With one year of data after starts the parallel run and three month to perform the study, the SWE TSOs should provide to the SWE NRAs a study, based in a technical economical analyses, with the impact of implementing a higher sensitivity threshold.

### 2.2.2.3. Selection of Contingencies for the RA optimization

The third step of the process will associate the CNEs with relevant Contingencies and will determine the selection of CNECs considered for RA optimization.

The Contingencies of a TSO will be automatically associated to all selected CNEs of the SWE Region. The TSO will then perform a sensitivity study to determine the Contingencies that have a cross border relevance.

If the delta of sensitivity, between the base case and the case with the contingency of one CNE, is higher than a threshold 5% then the contingency shall be considered as relevant for the RAO.

### 2.2.2.4. CNECs sensible in particular situations

If out of the studied scenarios, real time constraints occurs due to cross-border exchanges, the TSOs have the possibility to add any new CNECs in the list of the CNEs and contingencies that they consider relevant. These additional CNECs shall meet the requirement of sensitivity as defined here above, through an ex post analysis.

As an example, where a particular combination of contingency with a particular RA could create a specific constraint, these new limiting elements can be added to the list.

### 2.2.2.5. RA selection

Each TSO of SWE Region shall define individually the remedial actions of its responsibility area to be used in the capacity calculation within SWE Region with MTU resolution.

The remedial actions to be defined by each TSO of SWE Region shall be either preventive (pre-fault) or curative (post-fault). The TSOs of SWE Region may use the following remedial actions:

- a. Changing the tap position of a phase shifter transformer.
- b. 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.
- c. HVDC modulation.
- d. Modification of generation.
- e. Activation/deactivation of FACTS, reactance(s), capacitor(s).

### 2.2.2.6. Costly RA selection

Each TSO of the SWE Region may decide, based on regulation, to make available costly remedial actions. Where a costly remedial action is used in the capacity calculation process, it shall be performed in accordance with the provisions of the methodology for coordinated redispatching and countertrading with cross-border relevance as defined in Article 35 of CACM Regulation. It shall also be applied only when economically relevant at Union level.

To guaranty this, SWE TSOs should perform the following process:

- a) One of the SWE TSOs identifies a curative costly RA that could help to increase the capacity
- b) The SWE TSOs run the CBA as described bellow
- c) If the Benefit is higher than the cost, then we add this RA to the RA list available for the RAO
- d) Once a year (or based on expertise if there is a significant change in the grid), we run the CBA and take out the RA if it's not cost efficient anymore

The CBA would consist of comparing the potential cost of a curative costly remedial action over a year with the average loss in global welfare estimated over 4 representing timesteps.

The methodology will be re-assessed in a more general way when implementing the intra-day capacity calculation process.

### 3. Coordinated NTC calculation process

#### 3.1. Creation of a common grid model (CGM)

##### 3.1.1. Forecast of net positions

Forecasting of the net positions two days preceding the delivery day in SWE CCR is based on a common process established in ENTSO-E: the Common Grid Model Alignment (CGMA). This centrally operated process ensures the grid balance of the models used for the daily capacity calculation across Europe. The process is described in the Common Grid Model Alignment Methodology (CGMAM), which was approved by all TSOs in ENTSO-E.

Main concept of the CGMAM is presented in Figure 1 below:

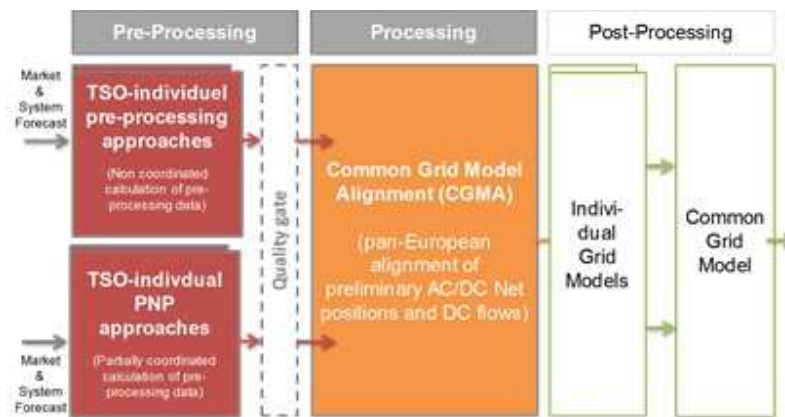


Figure 1: Main concept of the CGMAM

The CGMAM input data are created in the pre-processing phase, which shall be based on the best available forecast of the market behaviour and Renewable Energy Source (RES) generation.

Pre-Processing Data (PPD) of CGMA are based on either an individually or regionally coordinated forecast. Basically the coordinated approach shall yield a better indicator about the final Net Position (NP) than an individual forecast. Therefore, TSOs in SWE CCR agreed to prepare the PPD in a coordinated way.

The main concept of the coordinated approach intends to use statistical data as well as linear relationships between forecasted NP and input variables. The data shall represent the market characteristic and the grid conditions in the given time horizon. The coefficients of the linear model will be tuned by archive data.

As result of the coordinated forecast the following values are foreseen:

- NP per bidding zone

### 3.1.2. Individual Grid Model (IGM)

All TSOs develop scenarios for each market time unit and establish the IGM. This means that SWE TSOs create hourly D-2 IGMs for each day. The scenarios contain structural data, topology, and forecast of:

- Renewable Energy Source (RES) generation and conventional generation;
- Load;
- Flows on direct current lines (when applicable).

The detailed structure of the model, as well as the content is described in the Common Grid Model Methodology (CGMM), which is common for entire ENTSO-E area. In some aspects, SWE TSOs decided to make the agreement more precise concerning IGMs.

D-2 IGMs are based on the best available forecast of conventional generation and Renewable Energy Source (RES) generation. As regards the net positions, the IGMs are compliant with the Common Grid Model Alignment (CGMA) process, which is common for entire ENTSO-E area. More specifically, the IGMs are created based on coordinated preliminary net positions (PNP), which reflect the aforementioned best available forecast.

As an input of the CGMA for a starting point, SWE borders will use a NP on each SWE bidding zone border equal to zero in order to ease the implementation of this new calculation process.

### 3.1.3. IGM replacement for CGM creation

If a TSO cannot ensure that its D2CF IGM for a given market time unit is available by the deadline, or if the D2CF IGM is rejected due to poor or invalid data quality and cannot be replaced with data of sufficient quality by the deadline, the merging agent will apply all methodological & process steps for IGM replacement as defined in the CGMM (Common Grid Model Methodology).

### 3.1.4. Common Grid models

The individual TSOs' IGMs are merged to obtain a CGM according to the CGMM. The process of CGM creation is performed by the merging agent and comprises the following services:

- Check the consistency of the IGMs (quality monitoring);
- Merge D-2 IGMs and create a CGM per market time unit;
- Make the resulting CGM available to all TSOs.

The merging process is standardized across Europe as described in European Merging Function (EMF) requirements.

As a part of this process the merging agent checks the quality of the data and requests, if necessary, the triggering of backup (substitution) procedures (see below).

SWE CGM represents the SWE transmission system.

### 3.2. Regional calculation of cross-zonal capacity

#### 3.2.1. The capacity calculation process

The capacity calculation process designed by the SWE CCR can be represented by the schema below.

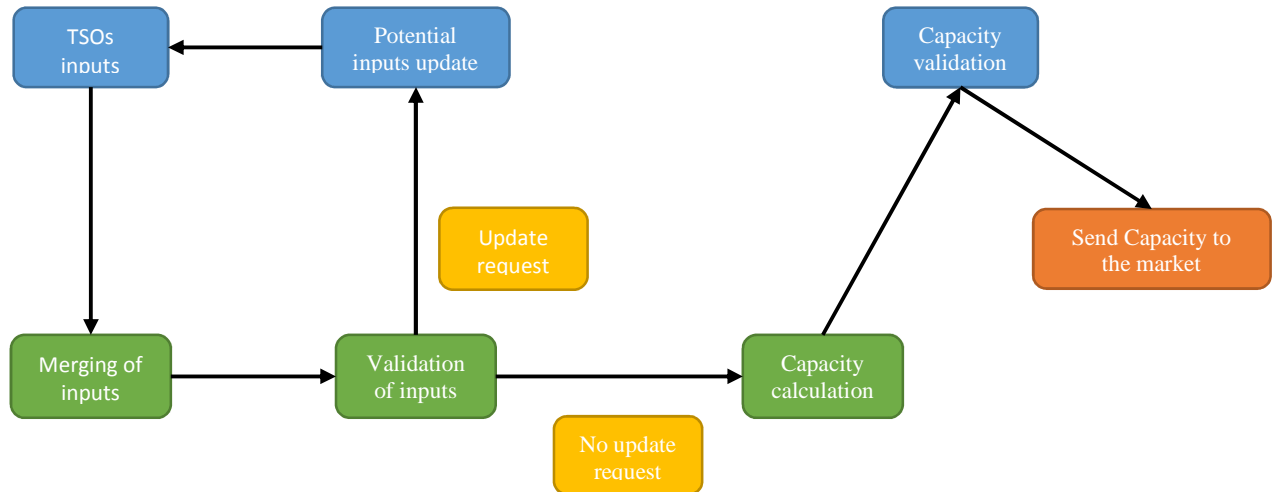


Figure 2: Capacity Calculation process

The blue boxes represent tasks that TSOs are responsible of.

The green boxes represent the tasks that the coordinated capacity calculator is responsible of.

The orange box is still to be defined. Today in the SWE CCR the TSOs are in charge of this task. In the CACM methodology it is written that the coordinated capacity calculator is responsible of this task. To limit the complexity of the calculation process' implementation, SWE TSOs will continue as a starting point to perform this action on behalf of the coordinated capacity calculator.

The timings for the process are not yet defined for the intraday timeframe, but you can find below indicative timings for the computation aiming at the day-ahead market allocation (please note that they could change depending on the parallel run results):

- All inputs should be sent by TSOs before 8 pm in D-2
- The computation should be done before 7 am in D-1
- The validation should be done before 8 am in D-1

#### 3.2.2. The TTC calculation

The coordinated capacity calculator will determine the Total Transfer Capacity (TTC) available on both France-Spain border and Portugal Spain border.

It is the maximum physical exchange possible on the border based on the best forecast available at TSO level.

#### 3.2.3. A calculation by dichotomy

The Capacity calculation step can be described as a calculation by dichotomy.

The coordinated capacity calculator will define a starting capacity level and check if this level of exchange allows the transmission system to be operated within its operational security limits using the generation and load available in the GSLK, the RAO and the different extra-validations required.

If the level is secure and are more generation and/or load available into GSLK, it will then test a higher value of TTC. Otherwise the coordinated capacity calculator will then test a TTC value in between the secure and unsecure TTC values until it reaches the last secure TTC. The dichotomy is set with a 50 MW step in order to optimize the capacity offered to the market while reducing the computation time.

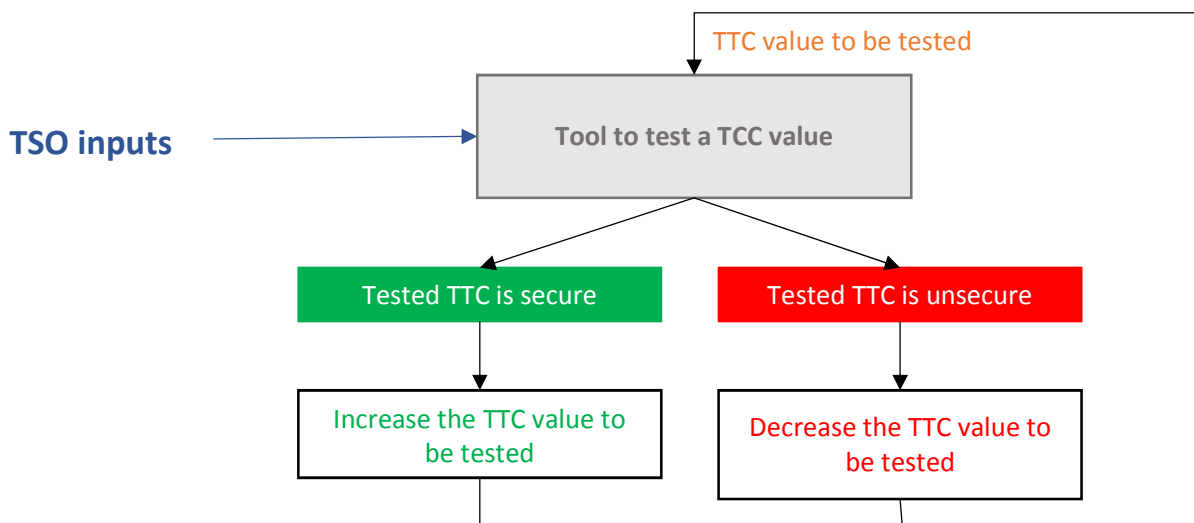


Figure 3: The dichotomy process

#### 3.2.4. The voltage validation

Power flows and voltage levels will be evaluated within the same sequence of the capacity calculation process. The RAO will monitor at each step of the calculation the maximum flows and the adequate voltage levels defined by the TSOs on all the CNEs. At the time of writing of this explanatory note some features of the SWE capacity calculation tool are under development, as it is the case of voltage levels assessment inside the RAO algorithm. While this feature is not implemented, the following temporary solution will be applied:

After the flows assessment of the RAO has been completed, it will be validated that after a set of contingencies the voltage level on some CNEs (nodes) is within a safety range based on the TSOs operational rules.

- If yes, the computation is over.
- If no, a list of specific remedial actions defined by the TSOs such as topological actions, activation of reactance(s), capacitor(s) and FACTS, can be applied.
- If these remedial topological actions relieve the constraint, RAO could be performed again if relevant as these remedial actions are preventive remedial actions.
- If remedial actions other than topological ones relieve the constraint, the computation is over.

If it is not possible to ensure that the transmission system is maintained within the operational security limits with this level of exchange, the same process while decreasing the TTC value by 50 MW is performed.

This process will be repeated until the TTC value ensures the operation of the transmission system within the operational security limits.

### 3.2.5. The Voltage Phase Angles Differences validation

Power flows and voltage phase angle difference will be evaluated within the same sequence of the capacity calculation process. At the time of writing of this explanatory note some features of the SWE capacity calculation tool are under development, as it is the case of voltage phase angle difference assessment inside the RAO algorithm. While this feature is not implemented, the following temporary solution will be applied:

After the calculation has been completed by the coordinated capacity calculator, this latter shall carry out a final validation: it has to validate that after some particular contingencies the grid network could still be in a state where it could be operated within the operational security limits. In order to achieve that the TSO should be able to close a line after its trip without damaging the grid, which requires the voltage phase between the two extremities of the line should be lower than a certain value.

The coordinated capacity calculator will validate that after some particular Contingencies, the transport angle is lower than this value.

- If yes, the computation is over.
- If no, it can then apply a list of specific curative remedial actions defined by the TSOs such as redispatching or topological actions.
- If these remedial actions relieve the constraint, then the computation is over and the last calculated TTC is sent to the TSOs for validation.
- If the coordinated capacity calculator cannot ensure the transmission system is maintained within the operational security limits with this level of exchange, it then performs again the same process while decreasing the TTC value by 50 MW. It then repeats this process until the TTC value ensures the operation of the transmission system within the operational security limits.

### 3.2.6. The final validation

Once the coordinated capacity calculator has calculated the TTC, it provides the concerned TSOs with these values. Each TSO then has the opportunity to validate the TTC value calculated centrally or can reduce the value in case the centralized calculation could not see a particular constraint.

Such constraints cannot be monitored by the RAO process or other centralized processes. Those constraints could be dynamic behavior of the grid, unplanned outage that occurs after the deadline to update the inputs, significant forecast change and incomplete input.

The TSO requesting a capacity reduction is required to provide a reason for this reduction, its location and the amount of MW to be reduced in accordance with article 26.5 of CACM regulation.

Where the two TSOs of a bidding zone border request a capacity reduction on their common border, the coordinated capacity calculator will select the minimum value provided by the TSOs. The reason associated to this value will be the one taken into account in all report required by relevant legislation.

## 3.3. Backup & Fallback processes

### 3.3.1. Backups and replacement process

For all inputs related to the capacity calculation, standard backup communication process have been defined among SWE TSOs and the coordinated capacity calculator. Where inputs are not available for one



of the parties at the expected time, back up procedures are applied until a critical deadline is reached, in order to get the associated inputs and carry on with the original process.

Where a critical deadline is reached and the inputs could not be provided to the concerned party on time, then fallbacks are applied, meaning that SWE TSOs and the coordinated capacity calculator could use other inputs to perform their tasks.

As an example, inputs from the day before, since network situations are usually stable from one day to another and could be re-used in order to complete the Capacity Calculation process.

### 3.3.2. Fallback NTC values

If the SWE TSOs and the coordinated capacity calculator could not complete a Coordinated Capacity Calculation within the allotted time for calculation, the last coordinated cross border capacity calculated within the long term timeframe is then used as an input for validation.

The coordinated capacity calculator uses this Capacity as an input of the Validation process described in 3.2.6. The TSOs have then the opportunity to adjust these values following the rules of this process.

## 4. Transparency

### 4.1. Transparency channels

#### 4.1.1. ENTSOe transparency platform

SWE TSOs shall fulfill the obligations from the Transparency regulation 543/2013.

#### 4.1.2. Individual TSO websites

Each TSO shall publish daily the agreed NTC values for day-ahead market on their respective websites no later than 11h D-1.

#### 4.1.3. Reports toward SWE NRAs

The limiting element can be:

- The limiting CNEC means the first overloaded element after RAO.
- The GLSK of a bidding zone
- The voltage on a specific node
- The voltage phase angle differences on a specific contingency

The limiting element and associated figures will be provided to SWE NRAs upon request.

According to CACM GL (article 26 (5)), the coordinated capacity calculator shall, every three months, report all reductions made during the validation of cross-zonal capacity to all regulatory authorities of the capacity calculation region. This report shall include the location and amount of any reduction in cross-zonal capacity and shall give reasons for the reductions.

The quarterly report shall include at least statistics of:

- Capacities per MTU offered to market.
- Reductions made during the validation of cross-zonal capacity and cause of the reduction.
- Limiting elements (CNEC, GLSK, voltage, voltage phase angle) in MTUs with and without reduction.

SWE TSOs will participate in the elaboration of the ENTSO-E biennial report on capacity calculation and allocation, which will be provided each two years and updated under request of the relevant authorities, according to Article 31 of CACM GL. For SWE region, this report will contain the capacity calculation approach used, statistical indicators on reliability margins, statistical indicators of cross-zonal capacity, quality indicators for the information used for the capacity calculation and, if appropriate, proposed measures to improve capacity calculation.

The Agency shall decide whether to publish all or part of this report.

## 5. Intraday CCM

*Disclaimer: No intraday capacity calculation project has been launched yet in the SWE CCR. These information are based on the first assumptions of the Day-2 capacity calculation project experts.*

### 5.1. The Capacity Calculation methodology for the Intraday Market

As much as possible the same Coordinated NTC Capacity Calculation methodology will be applied for the intraday capacity calculation implementation.

For a transitory period, the same Reliability Margin values as for the D-2 calculation will be applied. These values will be updated no later than 15 months after the launch of the intraday capacity calculation parallel run after performing a statistical analysis to define the relevant RM related to the intraday capacity calculation.

### 5.2. The number of calculations

So far, there is no feedback available from capacity calculation within the day-ahead market timeframe in SWE region. SWE TSOs do not have sufficient inputs to justify the added value of more than 2 recalculations of capacity within the SWE region and propose a pragmatic approach by implementing only two recalculations for the intraday market, before 22:00 in Day-Ahead, based on all the latest available inputs and during the intra-day based on intra-day inputs. This frequency could be reviewed later on, after performing a cost benefit analysis at least 2 years after the launch of the first calculation in order to have enough data to perform the proper CBA.

## 6. Timescale for the CCM implementation

Article 9(9) of the CACM Regulation requires that:

*"The proposal for terms and conditions or methodologies shall include a proposed timescale for their implementation and a description of their expected impact on the objectives of this Regulation."*

The deadline for implementing a harmonized CCM within a Capacity Calculation Region is defined in article 21(4):

*"All TSOs in each capacity calculation region shall, as far as possible, use harmonized capacity calculation inputs. By 31 December 2020, all regions shall use a harmonized capacity calculation methodology which shall in particular provide for a harmonized capacity calculation methodology for the flow-based and for the coordinated net transmission capacity approach."*

The following section provides the description of the planned implementation timeline for the SWE capacity calculation methodology.

### 6.1. Prerequisites

When the new Capacity Calculation (CC) goes live, the calculation will be performed by the coordinated capacity calculator based on input provided by the TSOs, and finally validated by the TSOs. Two crucial elements in this process are the Common Grid Model (CGM) and the Industrialized Capacity Calculation Tool, neither of them being developed by the SWE CCM project. The CGM is being developed by a coordinated project of all EU TSOs, and the industrialized capacity calculation tool is being developed by the coordinated capacity calculator. Both shall be implemented before the "go-live" of the CCM.

### 6.2. Additional steps for transparency

Following NRAs and stakeholders feedbacks, we decided to propose several additional intermediate steps. Especially we will consult again for each timeframe of the capacity calculation around 6 month before launching the calculation in operations. We will also organize at least stakeholders meeting for the launch of the external parallel runs and during the (at least) two extra consultation period.

### 6.3. Timeline for implementation of the CCM

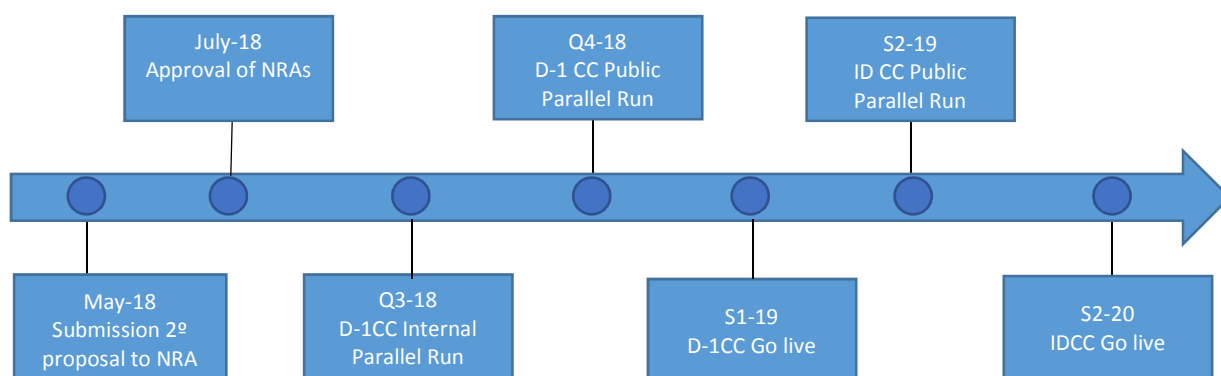


Figure 4: Timeline

#### Main dates:

- September 2017: Submission of the first proposal of the methodology for approbation
- March 2018: Request for Amendments by the SWE NRAs
- May 2018: Submission of the second proposal of the methodology for approbation
- July 2018: Approval of the methodology by the SWE NRAs
- Q3 2018: Start of Internal parallel run
- Q4 2018: Start of Public Parallel Run
- S1 2018: Start of the Capacity Calculation for the day-ahead market timeframe External parallel run
- S1 2019: Go-Live criteria of the Capacity Calculation for the day-ahead market timeframe are met
- S2 2019: Start of Capacity Calculation for the intraday market timeframe parallel run
- S2 2020: Go-Live criteria of the Capacity Calculation for the intraday market timeframe are met

ANNEX 1: RELIABILITY MARGIN TEMPORARY VALUES TO BE USED UNTIL STATISTICAL DATA ARE AVAILABLE

France-Spain border

Reminder

In the CCM for the SWE CCR, SWE TSOs ask for the following transitory TRM values:

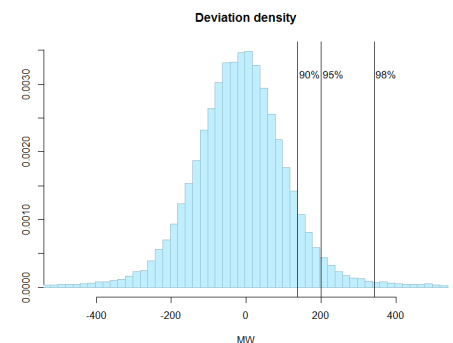
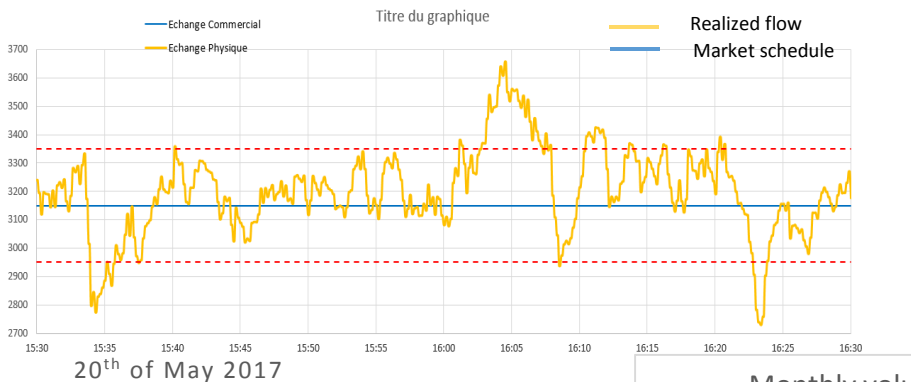
For FR-ES border, in both directions, the reliability margin for the capacity calculation performed in D-2 is calculated as the maximum value between **200 MW**, covering the **unintended deviation** part of the reliability margin, and **7.5% of the TTC value**, covering the **uncertainties of the forecast** part of the reliability margin based on a preliminary analysis of the concerned TSOs.

Basis for these values

The unintended deviation

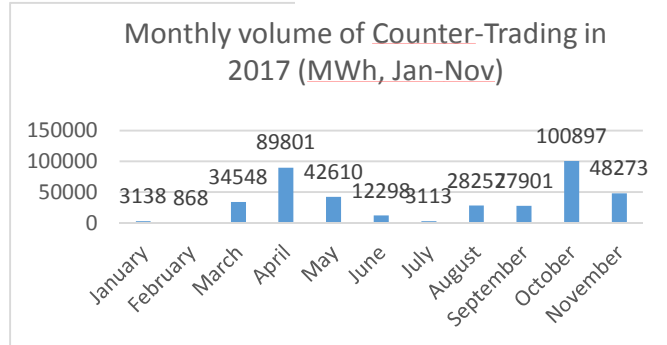
Currently, on the FR-ES border, one of the most frequent CNEC is the Argia-Hernani 400kV line in N-State. The frequency of this CNEC has even raised since the commissioning of the Arkale PST, allowing us to increase the flow on Argia-Hernani 400kV line.

The primary frequency regulation systems of any loss in the Spanish/Portuguese system leads to a flow going from continental Europe through France to the Iberian peninsula of around 85% of the loss. In addition to that, a 50 mHz frequency deviation of the central Europe (which can happen several times per day) leads to a 200 MW variation of the flow on the FR-ES border.



The uncertainties of the forecast

When commissioning the HVDC in October 2015, the foreseen NTC was around 2800 MW. In 2016 and 2017 the capacity frequently exceeded 3000 MW, witnessing new behaviors of the grid linked to this new level of exchange. The impact of a forecast error then leads to significant change in the available capacity.



Conclusion

The 200 MW fix value in order to cover the unintended deviation is already too low to cover the different limitations of the peninsula and we currently use counter trading in order to cope with most of the too risky cases in real time. We think that the D-2 computation should help us having better forecast and a more precise use of counter-trading.

Portugal-Spain border

Reminder

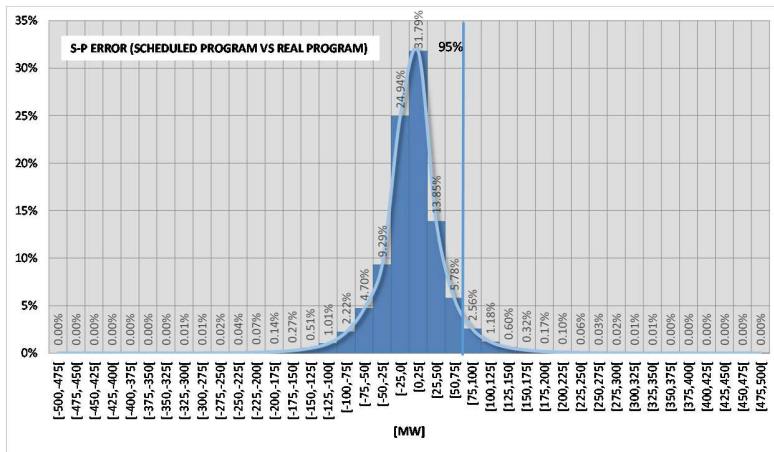
In the CCM for the SWE CCR, SWE TSOs ask for the following transitory TRM values:

For ES-PT border, in both directions, the reliability margin for the capacity calculation performed in D-2 is calculated as the maximum value between **100 MW**, covering the **unintended deviation** part of the reliability margin, and **10% of the TTC value**, covering the **uncertainties of the forecast** part of the reliability margin based on a preliminary analysis of the concerned TSOs.

Basis for these values

The unintended deviation

For covering the unintentional deviation between the Spanish and the Portuguese system in more than 95% of the time, it is considered 100 MW as a minimum TRM.



The uncertainties of the forecast

The huge amount of RES production in Portugal and Spain, their locations (high wind penetration in Galicia, in Spain, and in Minho region in Portugal) and the high difficulty of forecasting their production in advance (in the previous years the error of the wind production, done before the day-ahead market, exceeded 20 % in Portuguese System and 10 % in Spanish System) makes the NTC between both countries extremely sensible to changes in the profile of this generation, reason why the 10 % of the TTC value has been considered for cover these uncertainties.

To reinforce the previous sentence should be notice that currently, on the ES - PT border, the most frequent CNEC is the Alto Lindoso - Cartelle 400kV line in N-2 State. CNEC that is extremely sensible to the generation in Galicia in Spain and in the Minho region in Portugal.