Explanatory note to the Italy North TSOs proposal for a common balancing capacity calculation in accordance with Article 37 of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing within Italy North CCR

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Disclaimer: This explanatory document is submitted by the TSOs of the Italy North region for information and clarification purposes only accompanying the TSOs' proposal for a common balancing capacity calculation methodology in accordance with Article 37 of the Regulation 2017/2195 of 23 November 2017 establishing a Guideline on Electricity Balancing.

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1 Introduction

This technical document sets out the main principles for the coordinated capacity calculation methodology for the balancing timeframe applied in Italy North region. It contains a description of both the methodology and the calculation process in compliance with Electricity Balancing Guideline (EB GL).

The participating TSOs for this calculation are TERNA (IT), RTE (FR), Swissgrid (CH), APG (AT) and ELES (SI). The following borders are considered Italy – France, Italy – Switzerland, Italy – Austria, and Italy – Slovenia.

This document describes the coordinated NTC approach to determine the cross-zonal (CZ) capacities for each border of the Italy North (IN) Capacity Calculation Region (CCR).

1.1 Balancing Timeframe Capacity Calculation Scenarios

The NTCs of each border are calculated in two scenarios, one with cross-zonal power exchanges being in the direction of Intra-Day (ID) CZ schedules after ID Cross Zonal Gate Closure Time (CZGCT) and one with cross-zonal power exchanges in the opposite direction of the ID CZ schedules. These scenarios are hereafter called “main power exchange direction” and “opposite power exchange direction” respectively.

1.2 Overview of BTCC Business Process

The BTCC process is composed of several sub-processes as shown on the process schema below. Each sub-process is linked with all the other sub-processes that depend on it. The BTCC, ID IGM Merging and ID CROSA lanes are activities performed by the RSCs.

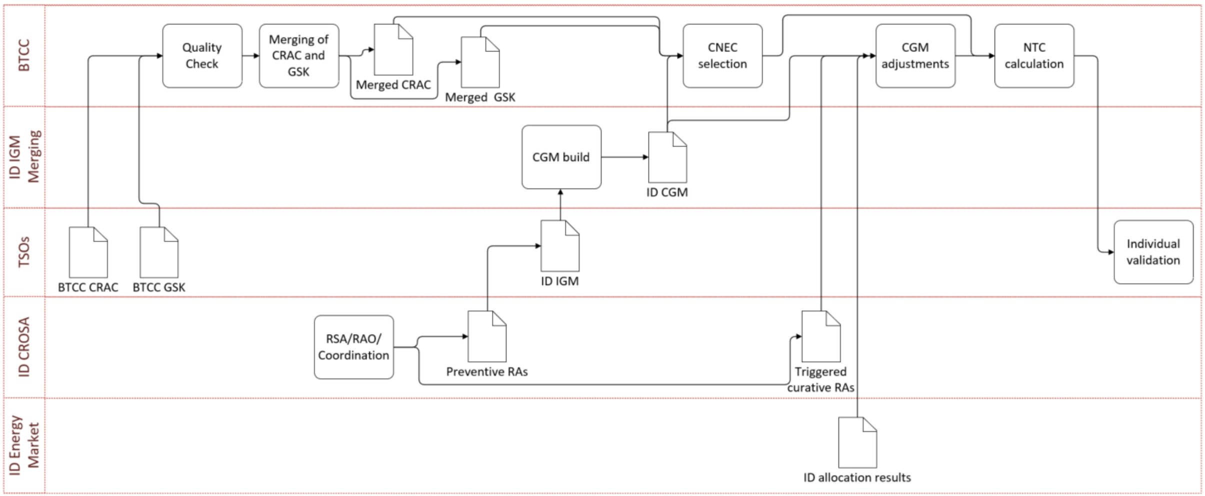

Figure 1 BTCC HLBP

A brief description of the sub-processes that comprise BTCC process is provided in Table 1. For the sake of understanding, a short description of processes on which BTCC depends is provided. The full description of the BTCC process and its sub-processes is described in detail in the following chapters.

Sub-process	Description	Inputs	Outputs
Quality Check	The inputs are checked against the quality rules.	-BTCC CRAC -BTCC GSK	-Validated CRAC -Validated GSK
Merging of CRAC and GSK files	The individual CRAC and GSK files of IT, FR, CH, AT, SI are merged.	-Validated CRAC -Validated GSK	-Merged CRAC -Merged GSK
RSA/RAO/Coordination	Security assessment is performed on CCR level. In case of congestions, RAO is performed, and the resulting RAs are coordinated and validated by the involved TSOs.	Not relevant for BTCC	Among others: -Preventive RAs -Triggered curative RAs
CGM build	The ID IGMs are merged into ID CGM	-ID IGMs	-ID CGMs
CNEC selection	Filtering of CNECs to be considered in the CC.	-Merged CRAC and GSK files -ID CGM -Triggered curative RAs	-Final CNEC list
CGM adjustments	The triggered curative RAs are processed to be considered in the BT CC. The NPs of all BZs are set based on ID allocation results after ID CZGCT.	-ID CGM -Triggered curative RAs -ID allocation results	-Adjusted BTCC CGM
NTC calculation	The BT NTC is computed based on zone-to-zone PTDFs. An AC LF is performed to validate the result.	-BTCC ready CGM -CNECs -TRM	-BT NTC -Final BTCC CGM
Individual validation		-BT NTC -Ex post BT CC CGM	-Final BT NTC

Table 1 Overview of sub-processes

2 Main power exchange direction

2.1 Capacity calculation input

2.1.1 Transmission Reliability Margin (TRM)

2.1.1.1 General principles

The Reliability Margin can be modelled as a probability distribution function resulting from taking into account three variables:

- uncertainties of the forecast between balancing timeframe capacity calculation studies and real time,
- unintended deviations on the whole Northern Italian Interconnection,
- deviation of assumptions on CZ power exchanges considered in ID CROSA where the RA are optimized and the assumption for the CZ exchanges in BTCC based on which the BT NTC is calculated.

Therefore, the RM probability distribution function can be obtained by the convolution of the three probability distribution functions corresponding to the described variables.

The TRM refers to the whole Northern Italian Interconnection.

The reliability margin shall be defined as a fixed value initially based on experience from IDCC, to be reassessed based on experience from BT CC, when this experience is available.

Uncertainties in TTC computation

The Coordinated NTC calculation methodology is based on different inputs provided by TSOs which 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. Differences between forecasts and real time situations may lead to unsecure TTCs given to the markets, endangering the security of supply.

Unintended load-frequency regulation deviations

For control-related reasons, in an AC interconnected system, deviations continuously occur between the scheduled exchange values and the actual physical flows between neighboring control areas. This implies that at any moment the physical exchange between two control areas can be significantly higher than the scheduled exchange, endangering the security of supply.

2.1.2 Operational security limits, contingencies and allocation constraints

Operational security limits, contingencies and allocation constraints in capacity calculation on Italy North are provided daily by all TSOs of the Italy North region in form of the contingency list, list of critical network elements and additional allocation constraints.

The Contingency list describes the contingencies to be assessed during capacity calculation. A contingency can be a trip of a line, a cable or a transformer or a set of the aforementioned contingencies. This list, called “reference outages”, contain all Italian interconnectors as well as internal lines of 5 TSOs which are affected by CZ exchanges in Italy North and is predefined. However, the list can be updated unilaterally as soon as it is required. All participating TSOs shall be informed timely for any change in the list.

Critical network element (CNE) is a network element either within a bidding zone or between bidding zones taken into account in the capacity calculation process, limiting the amount of power that can be exchanged. Each participating TSO is required to provide a list of critical network elements (CNEs) of its own control area based on operational experience along with its operational security limits. A critical network element can be an interconnector, an internal line or a transformer. The operational security limits used in the common capacity calculation are the same as those used in operational security analysis. CNEs are independently associated with relevant contingencies. Additionally, for each CNE and its associated contingency, zero or more remedial actions that relieve the CNE is/are defined. As selection of monitored elements might have an impact on the total calculated capacity, it is defined that CNE can only be an element that is consistent with the real time security rules and at the same time its loading is significantly impacted by CZ exchanges in Italy North CCR.

To this end, as a preparatory step to the CC, the participating TSOs create the list of CNEs to be considered in the CC. This process is called CNEC Selection. Initially, each CNE(C)'s sensitivity on CZ exchanges in Italy North CCR are calculated. The sensitivities are in essence the zone-to-zone PTDFs. CNE(C)s with sensitivities below a specific threshold are filtered out. Adhering to the studies performed in the framework of DA and ID CCs for the determination of the threshold, the threshold for the BT CC shall be x%. It is expected that this threshold will ensure all important critical elements are included, but on the other side ensure exclusion of elements not impacted by CZ Italy North exchanges. The resulting list is called Initial CNEC list.

During the operational phase of BTCC, the TSOs will have the possibility to reassess the sensitivity threshold if deemed necessary.

TSOs have the possibility to add or remove specific CNECs from the Initial CNEC list. This will be realized by the Black and White lists. The White list shall contain CNECs which shall be considered in the CC even if they are not selected in the Initial CNEC list. White list shall cover two cases. Firstly, a participating TSO may choose to provide the CNEC for the CC directly via White list rather than via the Initial CNEC selection. Secondly, White list mitigates the risk that a CNEC is sensitive in particular situation but is filtered out by the Initial CNEC selection. The Black list shall contain CNECs which shall not be considered in the CC even if they are selected in the Initial CNEC list. The Black list shall cover cases of CNECs for which there are local RAs which are not available in BT CC process. Essentially, the Black and White lists reflect the operational experience in the BT CC process. The reflection of the operational experience becomes increasingly important as we approach closer to RT. The Black and White lists allow for the operational experience to be reflected despite the tight time window of Italy North BTCC process.

The list of CNECs after the application of Black and White lists is the one that will be considered in the BT CC and is called final CNEC list hereafter.

In case there is any CNE whose power flow is influenced by cross-zonal power exchanges in different Capacity Calculation Region, before including it in the Capacity Calculation process, the TSOs have to define rules for sharing the power flow capability of the CNE among the different Capacity Calculation Regions in order to accommodate this flow.

Allocation constraints are typically used to take into account additional security constraints that cannot be expressed with CNEC combinations. In Italy North, such constraints are related to Special Period and currently only used by Italian TSO to limit the maximum value of Italian import for the whole Northern Italian Interconnection. It reflects Italian operational constraints related to the control of voltage profiles and dynamic stability of Italian system, especially in presence of low consumption. These two kinds of constraints are needed to maintain the transmission system within secure operations but cannot be transformed efficiently into maximum flows on critical network elements. Furthermore, they require additional data and more complex calculations, which shall be adapted to cover specific and different cases, and cannot be described into standard and automatic procedures.

When the additional constraint is applied, the TTC will be no higher than the value TTCmax, at the end of the calculation.

Low demand can lead to Security issues:

- High voltage values on the transmission grid;
- Low system inertia;
- Dynamic instability.

The size of the additional constraint depends on the minimum number of power plants needed on the grid for supplying those dispatching services necessaries to cope with dynamic instability and avoid violation of voltage limits.

The additional constraints are quantified basing on particular scenarios, that characterize the Italian power system, in conditions of extremely low demand. These scenarios are peculiar of some periods of the year which can be summarized as follows:

- Bank holidays common to other Countries (i.e. Christmas, Easter, May 1st);
- Bank holidays related to National Feasts (i.e. April 25th , June 2nd , etc.);
- Summer period.

With reference to Summer, the most critical days are typically the ones where the industrial load is not relevant for the National consumption (weekends) or when the temperatures are still not very high and the air conditioning absorption is limited.

The low-consumption periods have become more and more relevant since 2008, also in relation to the economic and industrial crisis. The import from neighbouring Countries is limited in these periods in order to create a sufficient room for the conventional power plants that guarantee the security of the Italian system.

In order to determine the value of maximum import sustainable in secure conditions, the process can be described as follows:

1. Identification of the critical periods

Basing on the feasts' occurrence on the calendar and depending on the day of the week, the low-consumption period is identified. The day of the week is quite relevant indeed, since, to give an example, Christmas can occur on Sunday, and the impact is not relevant in this case, or can occur on Wednesday, and in this case the bank holiday is made of several days.

2. Identification of the typical system conditions

Once the potential low consumption periods are identified, the typical system conditions, mainly in terms of consumption are analyzed. The analysis takes into account the historical data referred to similar situation, considering that the information of the preceding year is not necessarily the most significant because the feasts occurrence can be subject to variation. For example, in 2015 Christmas was on Friday while the following year, being bissextile, Christmas occurred on Sunday.

3. Information refreshment

The historical data are updated according to the most recent information and the forecasted trend. Among other elements, the refreshment involves the consumption forecast and the level of water in the reservoirs of the hydro power plants.

4. Scenarios building

On the base of the historical data, properly updated, typical scenarios are built by means of a simulation tool.

5. Security check

The power system security is assessed for the above-mentioned scenarios aiming at verifying:

- The system stability in terms of voltage profile;
- The system security in terms of minimum inertia;

Moreover, it is necessary to take into account that in case of permanent fault on a network element, it is necessary to guarantee a minimum margin in terms of tertiary reserve in order to re-modulate the power flows in case of need in order to guarantee system security.

6. Definition of the maximum import

The NTC is the output of the above described process and is limited by the technical minimums of the conventional plants that are considered in operation in order to guarantee the power system security and controllability.

7. Import profiling

The maximum import is profiled for the different hours of the day according to the variations of the demand curve. The import for the low consumption is shaped in order to take into account the different conditions in the hours of the day.

8. Management of low-consumption periods

The NTC is shaped at yearly, monthly and daily level, on the base of the most accurate forecasts. Before the ID calculation process starts, the NTC value assessed at yearly level is reconsidered according to the new data and information. In case of significant variations, the value is reconsidered and, in case this happens, usually an additional NTC is released to the daily market. The additional constraint is forwarded to the RSC as input for the capacity calculation process.

All the data above is included in a so called “individual CRAC” file of each TSO. Prior to calculation, individual CRAC files of all TSOs are merged.

2.1.3 Generation and Load Shift Keys (GLSK)

GSK file is defined for:

- an area
- a time interval: GSK is dedicated to individual daily hours in order to model differences between peak and off-peak conditions per TSO.

Generation and Load shift keys are needed to transform any change in the balance of control area into a change of injections in the nodes of that control area. In order to avoid newly formed unrealistic congestions caused by the process of generation shift, TSOs define both generation shift key (GSK) and load shift key (LSK), where GSKs constitute a list specifying those generators that shall contribute to the shift and LSKs constitute a list specifying those load that shall contribute to the shift in order to take into account the contribution of generators connected to lower voltage levels (implicitly contained in the load figures of the nodes connected to the 220 and 400 kV grid). Each TSO can decide how to represent its best generation shift.

If GSK and LSK are defined, a participation factor is also given:

- G(a) Participation factor for generation nodes
- L(a) Participation factor for load nodes

The sum of G(a) and L(a) for each area has to be to 1 (i.e. 100%).

Several methods are supported by the process:

- **Proportional**:

Shift in defined generation/load nodes, proportionally to the base case generation/load.

- Pg(n) Active generation in node n, belonging to area a (nodes n defined in GSK list) or
- Pl(n) Active load in node n, belonging to area a (nodes n defined in LSK list)

The participation of node n in the shift, among selected gen. nodes (GSK) is given by:

$$Kg(n,a) = G(a) \cdot \frac{Pg(n)}{\sum_n Pg(n)}$$

The participation of node n in the shift, among selected load nodes (LSK) is given by:

$$Kl(n,a) = L(a) \cdot \frac{Pl(n)}{\sum_n Pl(n)}$$

- **Participation factors**:

Shift in defined generation/load nodes (PV or PQ nodes), according to the participation factors:

- kg(n) Participation factor for generation in node n, belonging to area a
- kl(n) Participation factor for load in node n, belonging to area a

The participation of node n in the shift, among selected gen. nodes (GSK) is given by:

$$Kg(n,a) = G(a) \cdot \frac{kg(n)}{\sum_n kg(n)}; 0 \leq kg(n) \leq 10$$

The participation of node n in the shift, among selected load nodes (LSK) is given by:

$$Kl(n,a) = L(a) \cdot \frac{kl(n)}{\sum_n kl(n)};\ 0 \leq kl(n) \leq 10$$

2.1.4 Remedial Actions

Remedial action refers to any measure applied in due time by a TSO in order to fulfil the n-1 security principle of the transmission power system regarding power flows and voltage constraints. Capacity calculation in Italy North region considers tree types of remedial action:

- Preventive Remedial Actions (PRAs) are those launched to anticipate a need that may occur, due to the lack of certainty to cope efficiently and in due time with the resulting constraints once they have occurred;
- Curative Remedial Actions (CRAs) are those needed to cope with and to relieve rapidly constraints with an implementation delay of time for full effectiveness compatible with the Temporary Admissible Transmission Loading. They are implemented after the occurrence of the contingencies.
- SPS (Special Protection Schemes) will act in curative stage, after tripping of grid elements. SPS refers to special protection scheme application that automatically applies remedial actions in the grid (for example line disconnection) if predefined set of conditions is fulfilled (for example if outage of parallel line occurs). The SPS protection equipment is located in the relevant substations and reacts within several seconds.

The BT CC process is carried out close to Real Time. Therefore, only RAs with very short activation time would be suitable for BTCC and consequently a limited number of RAs could be considered in BT CC. Moreover, the process of optimization, coordination and validation of RAs is time consuming and does not fit in the BT CC time window as defined in Italy North CCR. Therefore, BT CC process shall rely on the RAs coordinated and validated in the DA/ID CROSA which precedes BT CC and no RAO will be carried out within the BT CC process. In this way BTCC benefits from preceding processes with sufficient time to perform elaborate calculations and achieves a reliable calculation in the tight BT time window. In particular, the RAs to be considered in the BTCC are:

- all preventive remedial actions as determined, coordinated and validated during day-ahead and intraday Coordinated Regional Operational Security Assessment (CROSA) process. The preventive RAs are included in the CGM that shall be used in the BTCC and therefore no actions are required for their consideration.
- all triggered curative remedial actions as determined, coordinated and validated during day-ahead and intraday Coordinated Regional Operational Security Assessment (CROSA) process. These RAs shall be provided by ID CROSA of Italy North and potentially of other CCR whose RAs might have an impact in IN BTCC.
- SPSs (Special Protection Scheme) shall be provided by the participating TSOs via the CRAC file.

The use of remedial actions in real time during the BT CC process is defined according to Articles 75 and 76 of the SOGL regulation.

2.1.5 Common Grid Model

The ID Common grid model (CGM) is used for capacity calculation. 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.

2.2 Capacity Calculation Approach

Article 37(3) of EBGL requires the EB CCM to be consistent with ID CCM. Therefore, the BTCC is an NTC based CC approach that is adjusted to fit in the tight time window of the BT.

2.2.1 General principles

The Total Transfer Capacity (TTC) for the whole northern Italian border is assessed using the following principles:

- based on merged ID common grid models;
- all calculations are performed using Direct Current (DC) load-flow algorithm, except from the final validation of the TTC which is performed using AC LF;
- the modification of exchanges is realized according to GSKs and Splitting Factor per border (which take into account the impact of planned outages near a specific border, assessed through NTC reductions);
- the maximum current for the network security of Critical Network Elements is respected (taking into account effects of remedial actions used);
- being not higher than the allocation constraint (corresponding to low consumption periods);

2.2.2 Preparatory sub-processes

The preparatory sub-processes are illustrated in Figure 1and will be described in chronological order.

The CRAC and GSK files of the participating TSOs are merged into a single CRAC and a single GSK file.

The ID CGM along with the list of triggered CRAs from ID CROSA are available for the BTCC process.

The CNEC selection sub process is performed based on the aforementioned inputs. In particular, the zone-to-zone PTDFs for all potential CNECs are calculated. The power shifts between BZs during the zone-to-zone PTDF calculation is performed based on the GSKs. The final CNEC list is created as described in 2.1.2.

The BTCC shall be performed having as starting point the allocation results after ID CZGCT. To this end, the ID CGM is updated in order to reflect the allocation results as soon as they are available.

2.2.3 NTC calculation

The Capacity calculation step can be described as a calculation based on Remaining Available Margin (RAM) per CNE(C).

The CC is performed for the main power exchange direction. This means that only the zone-to-zone PTDFs in the directions of power exchanges indicated by the allocation results are considered in the computation. For instance, if the netted allocation results are in the following directions, FR→IT, CH→IT, IT→AT, IT→SI, then the following PTDFs per CNEC will be considered in the calculation: $PTDF_{FR-IT}, PTDF_{CH-IT}, PTDF_{IT-AT}, PTDF_{IT-SI}$.

The reference flow (F_{ref}) per CNE(C) is computed. The computation relies on the Adjusted BTCC CGM and the RAs as described in 2.1.4. The reference flow is the active power flow on a CNE(C). In case of a CNE, the F_{ref} is directly computed from the Adjusted BTCC CGM whereas in case of a CNEC, the F_{ref} is computed with the specified contingency. The F_{ref} can be either a positive or a negative value depending on the direction of the monitored CNE(C). Its value is expressed in MW.

Depending on the sign of the PTDF per CNE(C) the increase of the cross-zonal exchanges can result in increasing the flow of the CNE(C) in the positive or negative direction. For instance, if the direction of the CNEC is defined from node 1 (n_1) to node 2 (n_2) and the PTDF is positive for the A to B border ($PTDF_{A-B}$) then the increase of cross-zonal power exchange from A to B will result in increased flow in the positive (n_1 to n_2) direction. In case the PTDF is negative then the increase of cross-zonal exchange from A to B will result is increase of the flow of the CNE(C) in the negative direction (n_2 *to* n_1). For this reason, depending on the sign of the PTDF per CNEC, the RAM shall be calculated in the positive (RAM_{pos}) or negative (RAM_{neg}) direction respectively. Subsequently the positive and negative RAMs per CNE(C) are computed as following.

$$RAM_{pos}^{CNEC_i} = F_{max}^{CNEC_i} - F_{ref}^{CNEC_i}$$

$$RAM_{neg}^{CNEC_i} = -F_{max}^{CNEC_i} - F_{ref}^{CNEC_i}$$

Some examples are provided in the table below.

			A→ B	C→B	B→D

	F_{max}	F_{ref}	$PTDF_{A-B}$	RAM	$PTDF_{C-B}$	RAM	$PTDF_{B-D}$	RAM
$CNEC_{n_1 to\, n_2}$	1000	800	0.1	200 RAM_{pos}	-0.1	-1800 RAM_{neg}	0.2	200 RAM_{pos}
$CNEC_{n_3 to\, n_4}$	1000	-600	0.1	1600 RAM_{pos}	-0.1	-400 RAM_{neg}	-0.2	-400 RAM_{neg}

Table 2 Example of positive and negative RAM

Therefore, each CNE(C) will be associated to:

- $RAM_{pos}\ or\ RAM_{neg}$ in case it has only positive or negative PTDFs respectively for all borders
- or $RAM_{pos}\ and\ RAM_{neg}$ in case it has both positive and negative PTDFs in the various borders.

The RAM per CNEC is split among Italy North borders according to the splitting factors. Particularly,

- if a CNE(C) is associated only to RAM_{pos} or RAM_{neg} the splitting factors are applied to RAM_{pos} or RAM_{neg} respectively in order to define the RAM per border of the Italy North CCR,
- if a CNE(C) is associated to RAM_{pos} and RAM_{neg} the splitting factors of the borders with positive PTDFs are applied to RAM_{pos} and the splitting factors of the borders with negative PTDF are applied to RAM_{neg}.

Subsequently the potential cross-zonal increase of exchange beyond the starting point is calculated. For each CNEC and each border, its RAM is divided by the corresponding PTDF. In this way, the cross-zonal increase of power exchange (e.g. ΔTTC_{C-B}) per border is calculated so that the split RAM is fully utilized.

The minimum ΔTTC respects all CNE(C) limits and therefore is selected. These ΔTTC are reflected in the model and an AC LF is performed in order to confirm the validity of the result. The calculated increase of the cross-zonal power exchange has as starting point the netted allocation results. Therefore, the final TTC per border is calculated as

$$TTC_{X-Y} = \min(\Delta TTC_{X-Y}) + Schedule_{X-Y}$$

The Total Transfer Capacity of all Italy North CCR borders is checked against the Allocation Constraints and reduced accordingly if necessary.
The final BT NTC is calculated as

$$NTC_{X-Y} = TTC_{X-Y} - TRM$$

The BT NTC is provided to the TSOs in order to perform individual validation.

2.2.4 Results

For each coordinating entity and each timestamp, the set of results is:

- The initial (merged) grid model and the final (merged) grid model corresponding to the final state of the network for a maximum secured northern Italian power exchange in the main direction;

- Concatenated GSKs, a concatenated CRAC files containing Critical Network Elements, Critical Outages, and Remedial Actions and additional constraint (maximum value of TTC_{total});

- TTC_{total};
- Limiting elements of TTC_{total} (Critical Network Elements and Critical Outages);

2.3 Fall back procedure

At the beginning and during every BT CC process the availability of all necessary files is constantly checked. For files that are missing or do not respect the formatting rules, automatic replacement is performed. If a necessary file is not received in time and no replacement is possible or the calculation dose not succeed, the process is ended and reported as failed. In case of process failure, TSOs shall use the cross-zonal capacity remaining after the ID cross-zonal gate closure time.

3 Italy's opposite power exchange direction

3.1 Approach

The TSOs of the Italy North Region do not perform a capacity calculation in the opposite power exchange direction because these scenarios are expected to be less likely market direction and there is in principle very high cross-zonal capacity available. The opposite direction CZCs are determined as the cross-zonal capacity remaining after the ID cross-zonal gate closure time reduced either to a predefined upper limit or by a percentage.