Explanatory note to the Italy North TSOs proposal for a common D-2 capacity calculation in accordance with Article 21 of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management

November 2019

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 D-2 capacity calculation methodology in accordance with Article 21 of the Regulation 2015/1222 of 24 July 2015 establishing a Guideline on Capacity Allocation and Congestion Management.

Table of contents

1 Introduction

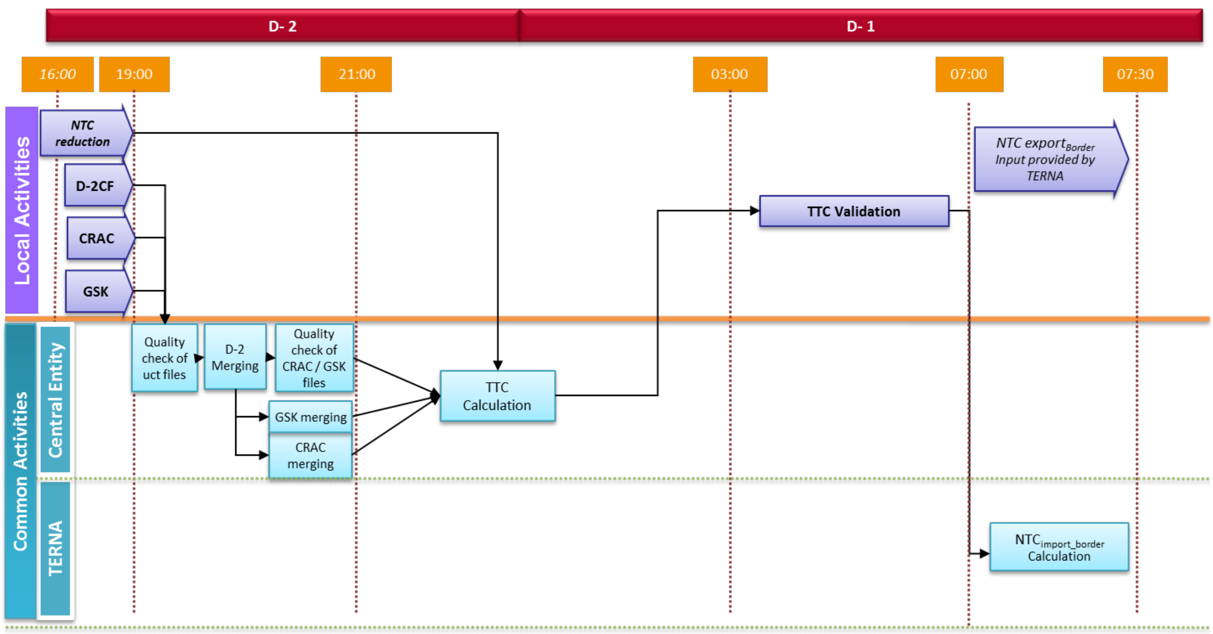
This technical document sets out the main principles for the coordinated capacity calculation methodology for the day-ahead market timeframe applied in Italy North region. It contains a description of both the methodology and the calculation process in compliance with the Capacity Allocation and Congestion Management guideline (hereafter CACM).

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

2 D-2 Capacity Calculation Approach

This document describes coordinated NTC approach to determine the cross-border capacities for each border of the Italy North (IN) CCR. The NTC of each border are calculated in two scenarios, one with Italy importing from all the borders of the Region at the same time and one with Italy exporting to all the borders of the Region at the same time.

The D-2 Capacity Calculation process is composed of several sub-processes as shown on the process scheme below. Each sub process is associated to a role and linked with all the other sub processes that depends on it.



The process starts with a data gathering sub-process, followed by quality control & merging sub-process, capacity calculation (optimization) sub-process, validation and finally NTC calculation sub-process. The full description of the whole process and its sub-processes is presented in the following chapters.

3 Italy's import direction

3.1 Capacity calculation input

3.1.1 Transmission Reliability Margin (TRM)

3.1.1.1 General principles

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

- uncertainties of the forecast between D-2 capacity calculation studies and real time,
- unintended deviations on the whole Northern Italian Interconnection.

Therefore, the RM probability distribution function can be obtained by the convolution of the two probability distribution functions corresponding to the described variables (TRM_1 for the uncertainties of the forecast and TRM_2 for the unintended deviations).

The TRM refers to the whole Northern Italian Interconnection.

The TRM shall be calculated every year for the next year. Until the TRM will not be calculated according to this methodology, the TRM value is equal to 500 MW.

Uncertainties in TTC computation

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. Differences between forecasts and real time situations may lead to insecure TTCs given to the markets endangering the security of supply.

Unintended load-frequency regulation deviations

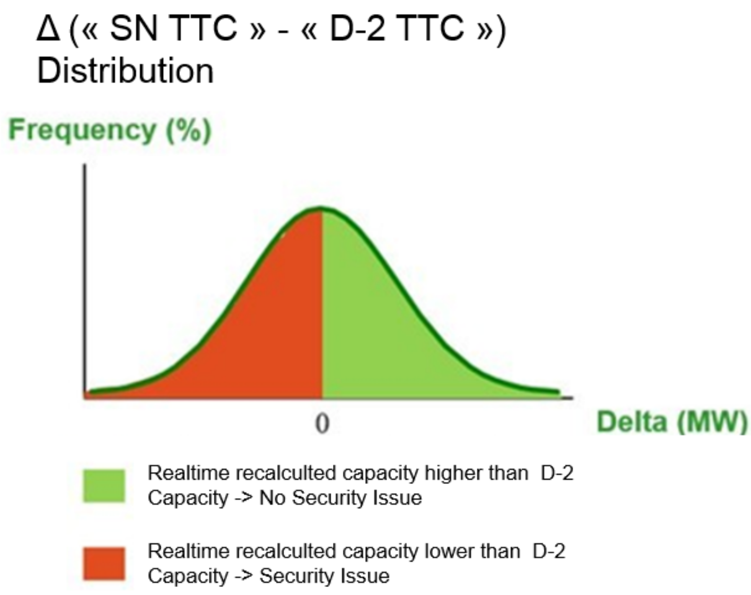
For control-related reasons, in an AC interconnected system, deviations continuously occur between the scheduled exchange values and the actual physical flows between neighbouring control areas. This implies that at any moment the physical exchange between two control areas can be significantly higher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

3.1.1.2 TRM figure computation

The process for the TRM_1 determination could be described as follows:

- step 1: define the statistical period: one full year.
- step 2: discard the timestamps (TSs) of the statistical period not useful for the study (e.g. TS where no capacity calculation has been performed, TS with the capacity limited by Additional Constraint, etc.). step 3: retrieve the following data for all the selected TS:
  - D-2 TTC without cap/floor (referred as "TTC D-2"),
  - the Real time CGM for the selected TS,
  - reduced Splitting factors.

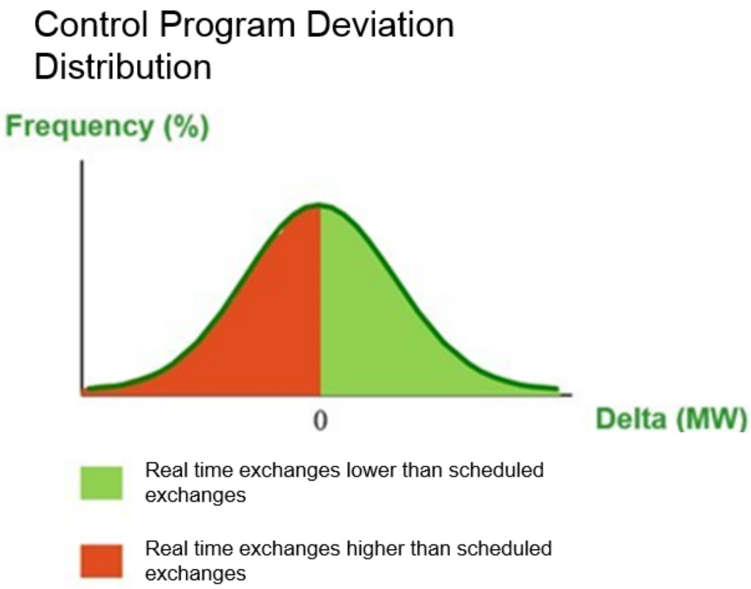
- step 4: estimate the TTC on the real time CGM (referred as "TTC RT") selected after step 3 for all the selected TS. The estimation will be based on a linearised approach checking the operational security limits of a fixed set of CNECs. Then compute all the difference between D-2 and real-time estimated TTCs ("TTC RT" – "TTC D-2") and plot those deltas in a distribution curve.



TRM_1 distribution function= uncertainties of the forecast

The process for the TRM_2 determination could be described as follows:

- step 1: define the statistical period: one full year.
- step 2: for the statistical period retrieve the control program error for the Italian control area (difference between the scheduled program and the actual physical exchange at the Northern Italian interconnection). One-minute average values could be used.
- Step 3: plot those deltas in a distribution curve:



TRM_2 distribution function= unintended deviation

Once TRM_1 and TRM_2 distribution functions have been calculated (f_{TRM1} and f_{TRM2}, respectively) the TRM distribution function (f_{TRM}) can be calculated as convolution of above-mentioned distribution functions:

$$f_{TRM} = f_{TRM1} * f_{TRM2}$$

The TRM shall be defined as the percentile of the convolution of the probability distribution functions of the two variables TRM_1 and TRM_2, with risk level kept below 10% (e.g. 90 percentile means 10% risk, 99 percentile 1% risk). When defining the percentile and the risk level, the historical experiences (i.e. TRM of 500 MW) should be taken into account.

3.1.2 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 critical network element contingency (CNECs) list, list of critical network elements (CNEs) and additional allocation constraints.

The critical network element contingency (CNEC) 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”, contains all Italian interconnectors as well as internal lines of the 5 TSOs which are affected with Italian import and is predefined and agreed among the participating TSOs; however, the list can be updated as soon as it is required and agreed among the participating TSOs.

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 as well as 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 and individually associated with relevant outages. Additionally, for each CNE for each outage, zero or more remedial actions that relieve the CNE is/are defined. As the selection of CNEs might have an impact on the total calculated capacity, it is defined that CNEs 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 the Italian import.

For that, at the beginning of the process, TSOs have to create an initial list of CNEs for each calculated timestamp. There will be a so-called "selection" of CNEs, based on sensitivity of exchange, in order to avoid that pre-congested grid elements whose loading is almost not influenced by cross borders exchanges could limit the exchanges at the Italian Northern Border. For the moment, this methodology is not yet implemented, but under testing phase, with a sensitivity equal to 5%. According to the initial experimentation, it is expected that this threshold will ensure all important critical elements are included, and also ensure the exclusion of elements not impacted by the Italy North import. At the end of this experimentation phase the TSOs will have the possibility to reassess the sensitivity threshold. TSOs have the possibility to add a specific CNE if it is sensitive in a particular situation but would not be detected by the pre-processing with an ex-post justification.

In case there is any CNE whose power flow is influenced by cross-zonal power exchanges in a 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 CO/CNE combinations. In the Italy North CCR, such constraints are typically referred as "Special Periods". They are currently defined by the Italian TSO and shared with the other TSOs and CCC as a maximum value of acceptable import at the whole Northern Italian Interconnection in order to cope with operational security constraints related to voltage control and dynamic system stability. These two kinds of constraints are needed to maintain the transmission system within secure operations but cannot be translated efficiently in form of 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.

Such Italian operational constraints related to the control of voltage profiles and dynamic stability of Italian system, which are needed to maintain the transmission system within operational security limits but cannot be transformed efficiently into maximum flows on critical network elements, shall be expressed via allocation constraints in the market coupling algorithms pursuant to Article 2(6) of CACM Regulation.

With reference to the specific request to investigate on the alternative solutions to the constraint for voltage and stability issues, IN TSOs identified several possible measures to mitigate such constraints, distinguished in curative solutions (i.e. solution to be put in operation once the market results are known) and preventive solutions (i.e. measures that can be adopted before the day-ahead market gate closure time).

With reference to the preventive solutions, the IN TSOs will focus in particular on market measures: a procurement of certain dispatching resources in Italy before the day-ahead market would allow to mitigate the impact on the NTC. Terna will evaluate, together with the Italian NRA, the possibility to implement this process – and its compliance with the regulatory framework in force also at European level - in the context of the Italian ancillary service market evolution.

In addition, with regard to infrastructure investments, Terna's strategic plan foresees investments on synchronous condensers and highlights the need of new storage systems. These assets may contribute to mitigate the voltage stability issues and will be taken into account in the definition of constraints as soon as they will be available. However, the realization of such infrastructures takes several years, and it is not possible to benefit from them in the near future.

In theory a co-optimization of the energy and balancing market would allow a more efficient management of the electric system. However, the gained efficiency and the application of this process has to be evaluated at European level and according with the current and future regulatory framework.

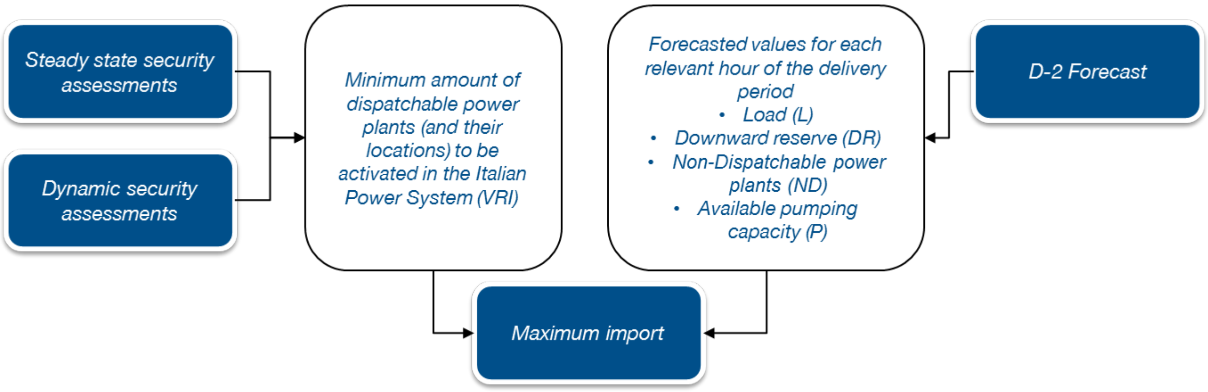
Concerning the curative solution, the IN TSOs already have in place emergency procedures in order to reduce import flows for activating internal generation able to provide ancillary service. However, since it is not guaranteed that the required reduction could be accepted by neighbouring TSOs (due to lack of resources in the intra-day or real-time time frames), TSOs cannot trust on such measures. IN TSOs could investigate in signing bilateral contracts (or improving the existing ones) that would allow emergency energy exchange in real-time and in day-ahead time-frame (MEAS and Downward MEAS contracts).

Before that alternative reliable measures/procedures will be implemented compared to the current situation, TSOs will request, through the change control procedure of the Multi-Regional Coupling (MRC) and the Cross-Border Intra-Day (XBID) projects, the implementation of such allocation constraint in the market coupling algorithms (day-ahead and intraday). The time needed for the implementation is not known in advance, it depends on the impact that it has on the coupling systems, on the algorithm performance and on the other changes that are already on-going on the algorithms.

As a temporary solution, this additional constraint will be directly applied to the TTC calculation process according to the following process.

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

The procedure applied by the Italian TSO is described in the following chart:



In particular, during low demand/high renewable infeed periods, the Italian Power System has to be properly managed in order to avoid:

- Voltages above the operational security limits;
- Low system inertia;
- Dynamic instability.

Hence, a minimum amount of dispatchable power plants able to provide system services according to the criteria of System Operation Guidelines (e.g. voltage regulation, primary reserve…) has to be activated.

This minimum set of power plants is quantified performing:
- Weekly steady-state security assessments;
- Dynamic assessments on several scenarios considered representative of the expected system conditions.

Once this minimum set of power plants is defined, the maximum amount of import at the Northern Italian Border for each market time unit is computed considering demand and generation forecast available in D-2: the scope is to make the Italian TSO able to activate the needed set of power plants, applying redispatching actions at national level. This maximum amount is computed according to the following formula:

$$Import_{max}^{h} = [L^h - DR^h] - [ND^h + VRI^h] + P^h$$

Where:

- *L: hourly load forecast*
- *DR: downward reserve defined according to the uncertainties related to load and RES forecasts*
- *ND: infeed expected from non-dispatchable power plants*
- *VRI: is the infeed from the minimum set of dispatchable power plants*

- *P: available pumping capacity*

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.

TSOs of Italy North performed an analysis on the impact that the allocation constraints may have on the revenue adequacy associated to the remuneration of the not used long term transmission rights issued according to Regulation 2016/1719 (FCA Regulation). In particular, the analysis has been performed on the data related to the year 2018, simulating the effect of the application of the Allocation Constraint on the borders involved on the Day-Ahead Market Coupling ("DAMC" – Italy-France, Italy-Austria and Italy-Slovenia). The simulation has been performed under the following hypothesis:

- The Market Spread has been considered unchanged and not influenced by the application of the Allocation Constraints
- The planned unconstrained NTC used for the calculation does not take into account the results of the day-ahead capacity calculation process.

The following table provides a summary of the simulation results. In particular, it is reported:

- the total capacity allocated in LT, not used and not allocated in DAMC due to Allocation Constraint [MW]
- the cost of the uncovered remuneration of the not used long term transmission rights (UIOSI) [€]

Simulated results	Total capacity allocated in LT, not used and not allocated in DAMC due to Allocation Constraint [MW]	Cost of Uncovered remuneration of the UIOSI [€]
FR->IT	29.196	604.126
AT->IT	7.310	98.210
SI->IT	53.501	427.710
TOT	**90.007**	**1.130.046**

In order to mitigate such impact, Italy North TSOs propose to take into account in the methodology pursuant to art. 61 of the FCA Regulation (Cost of ensuring firmness and remuneration of long-term transmission rights) the possibility to share the congestion rents among the involved borders in order to cover the cost related to the not used long term transmission rights.

3.1.3 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%).

Definition of GSK and LSK Nodes:

The list of GSK nodes contains one or more node defined by:

- the name of UCTE Node
- the maximum power production of the node (optional for prop and fact, mandatory for the other methods)
- the minimum power production of the node (optional for prop and fact, mandatory for the other methods)

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:

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

- **Reserve**:

All power plants, which are chosen for the shift, are modified proportionally to the remaining available capacity, as presented hereafter in these equations (1) and (2).

$$P_i^{inc} = P_i + \Delta E . \frac{P_i^{max} - P_i}{\sum_{i=1}^{n}(P_i^{max} - P_i)} \quad (1)$$

$$P_i^{dec} = P_i + \Delta E . \frac{P_i^{min} - P_i}{\sum_{i=1}^{n}(P_i^{min} - P_i)} \quad (2)$$

Where:

P_i = Actual power production.

P_i^{min} = Minimal power production.

P_i^{max} = Maximal power production.

ΔE = Power to be shifted.

P_i^{inc} = New power production after positive shift.

P_i^{dec} = New power production after negative shift.

- **Merit order**

The chosen generation nodes shift up or down according to the correspondent merit order list GSKup or GSKdown, as described following:

- upward list contains the generation nodes which performs the total positive shift.
- downward list contains the generation nodes which performs the total negative shift.

Merit order factor defines the number of generation node to be shifted simultaneously.

It means that the first group (number defined with Merit order factor) of generating nodes are shifted together and if it is not sufficient, the next group generating nodes are used to complete the total shift, and so on.

The total shift is distributed to the last group of Merit order factor generation nodes proportionally to their available margin as defined for Reserve shift.

Generation shift keys in Italy North region are determined by each TSO individually on the basis of the latest available information about the generating units and loads.

- Italy: Terna uses Merit Order GSK, which gives the best forecast of the Italian generation pattern that can be used for the capacity calculation process. For each selected unit, all the available upward/downward margin within its capability is given for the calculation.
- Switzerland: Swissgrid will use in its GSK flexible and controllable production units which are available inside the swiss grid (they can be running or not). Units unavailable due to outage or maintenance are not included as well as nuclear power stations, which are considered to be run at base load. The methodology used by Swissgrid is the Reserve methodology. This methodology allows to have all units reaching their limits at the same time. Pmax and Pmin are defined according the maximal and minimal capability of the generator. Remaining power plants in the CH GSK are only hydro power plants. It means that marginal production prices are more or less the same for all units. Therefore, it is difficult to apply a merit order list for CH GSK.
- Austria: APG's method only considers market driven power plants in the GSK file which was done with statistical analysis of the market behaviour of the power plants. This means that only pump storages and thermal units are considered. Power plants which generate base load (river power plants) are not considered. Only river plants with daily water storage are also taken into account in the GSK file. The list of relevant power plants is updated regularly in order to consider maintenance or outages.
- France: The French GSK is composed of all the flexible and controllable production units connected to RTE's network in the D-2 CGM. The variation of the generation pattern inside the GSK is the following: all the units which are in operation in the D-2 CGM will follow the change of the French net position based on the share of their productions in the D-2 CGM. In other words, if one unit represents n% of the total generation on the French bidding zone in the D-2 CGM, n% of the shift of the French net position will be attributed to this unit.
- Slovenia: GSK file of ELES consists of all the generation nodes specifying those generators that are likely to contribute to the shift. Nuclear units are not included in the list. In addition also load nodes that shall contribute to the shift are part of the list 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). At the moment GSK file is designed according to the participation factors, which are the result of statistical assessment of the behaviour of the generation units infeeds.

3.1.4 Remedial Actions

The term "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 uses two types of remedial actions:

- 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.

Preventive and curative actions in Italy North region may be declared as shared or declared to be used only locally by TSO.

All types of remedial actions can be used in preventive and/or curative state.

Only 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. For lines equipped with SPS, three loadings have to be checked compared to just two for typical N-1 states: the one directly after outage (typically around 140 %), one after application of automatic remedial actions by the SPS (typically 120 %) and current after application of all other remedial actions (typically 100 %).

Remedial actions are defined by each TSO of the region daily as a part of individual CRAC file. Each remedial action has a pre-agreed name so other TSOs can refer to it. The remedial actions are used by CC if they have a positive impact on capacity of import of Italy. New preventive remedial actions can be added by a TSO in its daily CRAC file and some others can be removed depending on the forecasted situation.

Each TSO within the Italy North Region shall coordinate with the other TSOs of the Region regarding the use of remedial actions to be taken into account in capacity calculation and their actual application in real time operation.

Each TSO shall ensure that remedial actions are taken into account in capacity calculation under the condition that the available remedial actions remaining after calculation, taken together with the reliability margin referred to in Article 5, are sufficient to ensure operational security.
The use, during the real time, of remedial actions defined during capacity calculation process will be described in the implementation of security analysis according to the SO GL Article 75 and 76.
Preventive Remedial Actions are implemented in the final CGM of the capacity calculation. Their application in during later operational security timeframes (DACF, IDCF and real time) is evaluated based on the Security Analysis taking into account the latest grid information.

Example:
Let assume the activation of the preventive remedial action, 2 nodes in Substation A, during the D2CC to relieve congestions on axis A-B.

In real time, due to other market situation, the violation is not monitored by the TSO X, most probably, the opening of the busbar coupler will not be performed, in order to avoid loss of meshing of the grid. But, in case this violation really occurs in Real Time, then the remedial action will be activated and implemented.

3.1.5 Creation of Common Grid Model

A Common grid model (CGM) is used for capacity calculation. The detailed structure of the model, as well as its content is described in the Common Grid Model Methodology (CGMM), which was developed in accordance with Article 17 of CACM and is common for the entire ENTSO-E area.

As the CGMM is not implemented yet, this chapter describes a temporary regional methodology which will be used until 6 months after the implementation of the CGMM at the latest, provided that the necessary tools are developed, and compatibility is ensured.

The CGM used for capacity calculation represents expected state of ENTSO-E interconnected grid for selected timeframe. CGM is obtained with merging of individual grid models (IGMs) provided by the TSOs.

All TSOs of the region are obliged to provide D-2 IGMs for selected timestamps (currently 12 timestamps per day) prior to the calculation. The D-2 IGMs (known also as D2CF) have to contain the following information:

- Best estimation for:
  - the planned grid outages;
  - the outages of generating units and the expected output power of the running generating units;
  - the forecasted load pattern;
  - the forecasted RES generation.
- Have the balance compliant with a reference day balance on the day-ahead reference Website (Vulcanus).

For TSOs outside Italy North region, D2CFs are typically not available; therefore, their DACF files are used instead.

Once all IGMs are available, the merging entity starts the process of merging them into CGM. If non-participating TSO's inputs are missing, a predefined back-up procedure is applied replacing the missing IGMs with the most appropriate alternative ones. If any D2CF by a TSO of the region is missing, merging process is interrupted immediately, as replacing an IGM of a TSO of the region with one of an older topology can have a significant influence on power flow distribution and as consequence on performed security analysis results.

The merging process itself is split into the following sub-processes:

- Data pre-treatment (each participating IGM is checked for compliance with the rules, check of convergence and balance);
- Building of control blocks corresponding to the day-ahead reference Website data;
- Balance adjustment on control blocks or TSOs;
- Merging of the ENTSOE wide data set;
- Final balance adjustment of the ENTSOE data set.

The result of merging process is a common grid model used for capacity calculation in the Italy North region.

3.2 Capacity Calculation Methodology

Each Coordinating Capacity Calculator (CCC) performs, for each timestamp, a capacity assessment to calculate the TTC_{total} by combining the inputs and applying the capacity calculation methodology as detailed in the next chapters.

3.2.1 General principles

The Total Transfer Capacity (TTC_{total}) for the whole northern Italian border is assessed using the following principles:

- based on the merged D2CF and DACF grid models;
- all calculations are performed using Alternate Current (AC) load-flow algorithm, considering reactive power capability limits of generators;
- Italian import maximization is divided into multiple steps (latter described in the dichotomy approach section); for each step Italian import is increased more until maximum import is found;
- the modification of exchanges is realized according to GSKs and Splitting $Factor_{Border}$ (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 additional constraint (corresponding to low consumption periods);
- aiming at maximizing the TTC_{total} by respecting the above-mentioned constraints, especially by combining efficiently the given Remedial Actions.
- optimization of remedial actions is performed using combination of heuristic search and linear optimization

3.2.2 Principles to perform the Generation Shift

- For any modification of total import on the northern Italian border, the modification of balance shall be shared among TSOs according to splitting factors.
- Exchanges through some particular lines are kept constant and equal to predetermined values given by the TSOs. Are considered as particular lines the following:
    - Lines not represented in the grid model, whose flows are conventionally considered as fixed;
    - Those of the Merchant lines which are operated at a fixed flow during real time for operational reasons.
- When during the calculation a GSK is exhausted (cannot provide additional shift), then a load redistribution is allowed to continue the calculation (based on the load of the related country).
- For all types of GSK except MERIT ORDER, in case, some generating nodes are reaching their maximum or the minimum limitations, this node is set to P_{max} or P_{min}. The rest of the power to be shifted in the CGM should be distributed to the other nodes being contained in the GSK files, without taking into account the node which is at the saturation.

The mathematical formulation is the following one, where:

- ***Exchange*** represents commercial exchanges. Therefore, they include all exchanges to be transmitted through the grid, either TSO-owned or merchant lines;
- ***ExchangeTSO*** represents the part of exchanges that will be transmitted through TSO-owned grid (as opposed to merchant lines);
- ***ExchangeML*** represents the part of exchanges that will be transmitted through merchant lines;
- $_{Border}$ index stands for one of the four north Italy borders: **CH-IT**, **FR-IT**, **AT-IT**, and **SI-IT**;
- ^{ref} index refers to quantities from the reference day, implemented in the merged ***CGM.***

For each border we have by definition the identity:

$$Exchange_{Border} = ExchangeTSO_{Border} + ExchangeML_{Border}$$

During TTC calculation, only ***ExchangeTSO*** shall vary, for each border, according to ***Reduced Splitting Factors***.

$$ExchangeTSO_{Border} = Reduced\ Splitting\ Factor_{Border} \,.\, ExchangeTSO_{North\ Italy}$$

$$\Delta Exchange_{Border} = \Delta ExchangeTSO_{Border} = ExchangeTSO_{Border} - ExchangeTSO^{ref}_{Border}$$

$$\Delta Balance_{TSO} = \sum\nolimits_{TSO\ Borders} \Delta Exchange_{Border}$$

Variations are applied on the merged CGM for which exchanges values are given by the reference day values. **Exchanges through ML are assumed equal to their daily Fixed Flow provided as input data.**

$$ExchangeTSO^{ref}_{Border} = Exchange^{ref}_{Border} - \sum\nolimits_{Border} Fixed\ Flow_{ML}$$

Summary

This may be summarized as:

$$\Delta Balance_{TSO} = \sum\nolimits_{TSO\ Borders} Reduced\ Splitting\ Factor_{Border} \,.\, ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{Border}$$

$\Delta Balance_{TSO}$ shall be implemented from the initial merged CGM, according to GSK handling rules, for each participating TSO. Generation shift handling is described below.

The formulas below are used to calculate the Italian import applied in the model to assess the grid security. The initial model already contains schedules of a reference day. In order to modify the Italian import, it is required to adjust the net positions of FR, CH, AT, SI and IT. The adjustment of the net positions is done with the help of the formulas below.

For each country, this translates into:

$$\Delta Balance_{FR\text{-}IT} = Reduced\ Splitting\ Factor_{FR>IT} \,.\, ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{FR>IT}$$

$$\Delta Balance_{CH\text{-}IT} = Reduced\ Splitting\ Factor_{CH>IT} \cdot ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{CH>IT}$$

$$\Delta Balance_{AT\text{-}IT} = Reduced\ Splitting\ Factor_{AT>IT} \cdot ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{AT>IT}$$

$$\Delta Balance_{SI\text{-}IT} = Reduced\ Splitting\ Factor_{SI>IT} \cdot ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{SI>IT}$$

$$\Delta Balance_{IT} = -\Delta Balance_{FR\text{-}IT} - \Delta Balance_{CH\text{-}IT} - \Delta Balance_{AT\text{-}IT} - \Delta Balance_{SI\text{-}IT}$$

Concretely, the import level used inside the calculation to check the grid security is split to all borders according to the ***Reduced Splitting Factor*** in order to know what the schedules would be, if the calculation would be over at this import level. In the initial merged model, reference schedules $\boldsymbol{ExchangeTSO^{ref}}$ are already present inside this one. It means to know how much the model should be shifted inside the model to reach this import level, the difference between the hypothetical schedules and the initial schedules should be performed.

Example with an expected TTC of 8000 MW:

	FR-IT	CH-IT	AT-IT	SLO-IT
Reduced Splitting Factor	0.35	0.5	0.05	0.1
Schedules for 8000 MW	2800	4000	400	800
$\boldsymbol{ExchangeTSO^{ref}}$	2000	3000	200	500
ΔBalance	800	1000	200	300

3.2.3 Dichotomy approach

The capacity calculation step can be described as a calculation by dichotomy. The CCC 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. The process is described in detail in the technical Annex of the D-2 capacity calculation methodology.

3.2.4 Handling of Remedial Actions

The scheme below summarizes the conditions to be fulfilled with this combination of remedial actions to state that all security constraints are respected. Each rounded square represents a different network state.

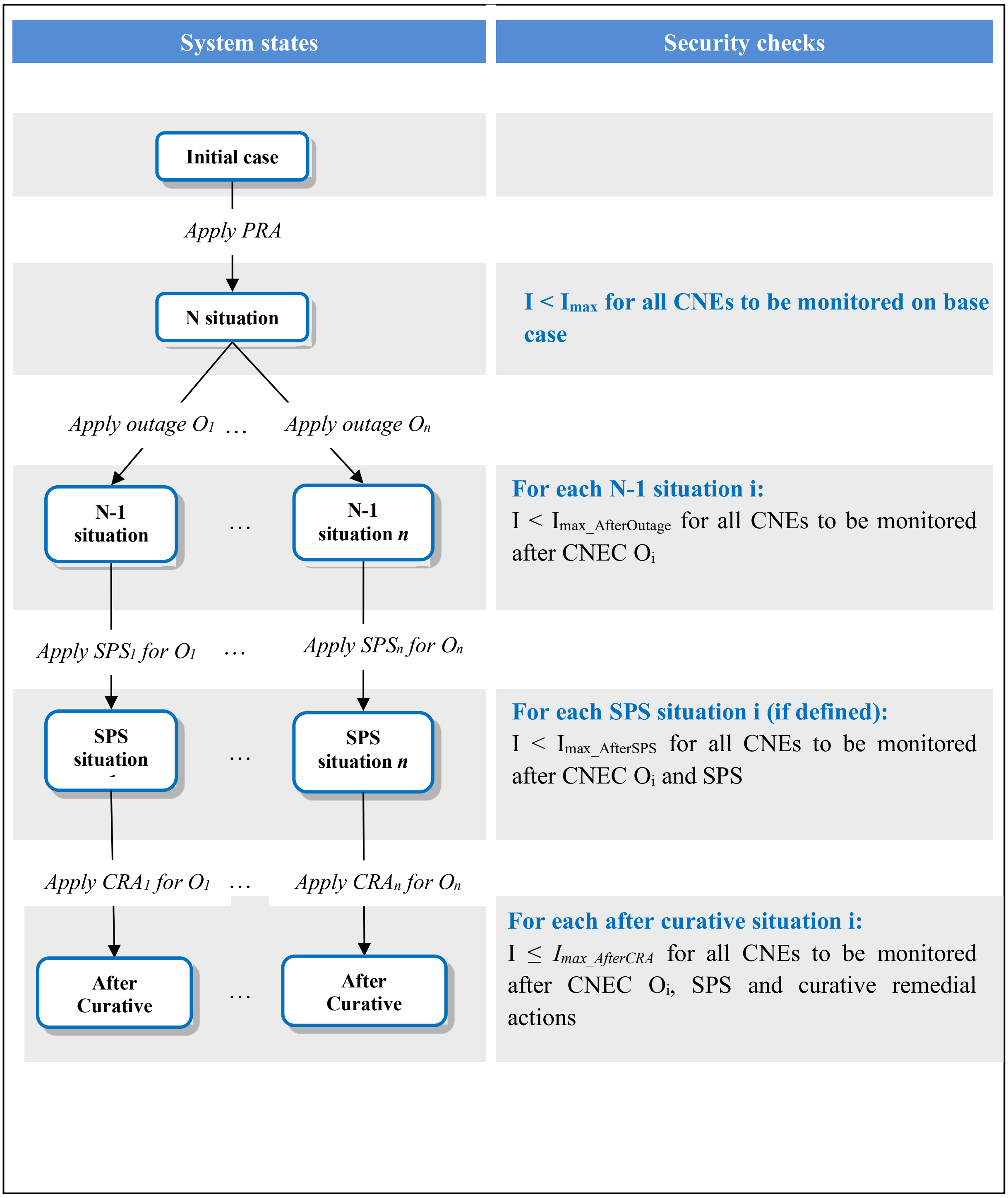
On N state, preventive remedial actions are implemented and Imax of "base case" branches are monitored.

On N-1 states, CNECs are applied and Imax_AfterOutage are monitored. They represent transient admissible current on the monitored branches. Transient current can exceed permanent admissible current provided that available SPS and curative remedial actions are sufficient to keep permanent current not greater than permanent admissible current.

On After Curative states, outage, SPS and curative remedial actions are implemented and Imax_AfterCRA are monitored. They represent permanent admissible current on the monitored branches.

If an outage or a remedial action leads to an unbalance situation due to a modification of generation or load pattern, this unbalance has to be compensated inside the concerned country, by using the GSK of this one.

On SPS states, outage and SPS are applied, Imax_AfterSPS are monitored. Imax_AfterSPS represent transient admissible current on the monitored branches after SPS. Transient current can exceed permanent admissible current, provided that available curative remedial actions are sufficient to keep permanent current not greater than permanent admissible.



3.2.5 Extrapolation algorithm

This chapter describes how the TTC is calculated for those timestamps for which no direct calculation is performed during the transitory period in which only few timestamps will be taken into account as references for the whole day.

For each hour H, be Href the reference hour for TTC calculation (i.e. if 10:30 is the only studied timestamp for the period 07:00-23:00, Href=10:30 for all the hours h in the interval 07:00-23:00). The

TTC value for hour H is calculated according to the following table depending on the "type" of hours H and Href:

		H_{ref}	
		LC/Ramp	**No LC**
H	**LC**	$TTC_H=min(TTC_{Href}+\Delta TTC_{P,H-Href}, AC_H)$	$TTC_H=min(TTC_{Href}, AC_H)$
	Ramp	$TTC_H=min(max(TTC_{P,Hi}, TTC_{Href}), AC_H)$ Where $H_i \in$ (interval with the same H_{ref})	$TTC_H=min(TTC_{Href}, AC_H)$
	No LC	$TTC_H=min(max(TTC_{P,Hi}, TTC_{Href}), AC_H)$ Where $H_i \in$ (interval with the same H_{ref})	$TTC_H=min(TTC_{Href}+\Delta TTC_{P,H-Href}, AC_H)$

Where:

- Type "No LC" means that the hour is in a normal period, without Low Consumption NTC;
- Type "LC" means that the hour is in a Low Consumption period;
- Type "Ramp" means that the hour is in a ramp period (e.g. connecting Low Consumption NTC to Normal NTC);
- TTCHref is the Computed TTC of the reference hour Href;
- TTCP,Hi is the scheduled TTC (the TTC defined in the programming stage taking into account all the reductions for planned maintenances and low consumption period) of the generic hour Hi which has Href as reference hour;
- ΔTTCP,H-Href = TTCP,H - TTCP,Href;
- ACH is the Additional Constraint defined for hour H.

These rules are valid until ramping constraints and Additional Constraints are directly applied during the computation (temporary solution).
As soon as these constraints will be implemented in Euphemia, the TTC value for hour H will be calculated only according to the following rule:

$$TTC_H = TTC_{Href} + \Delta TTC_{P,H-Href}$$

3.2.6 Results

For each Coordinating Capacity Calculator 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 import. In this final state, all preventive ("pre-fault") Remedial Actions are implemented;

- 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). In case the calculation stops to an import level equal to the additional constraint, there is no limiting element (the reason of limiting TTC_{total} is the additional constraint itself), otherwise limiting elements always exist;
- Results of security analysis with preventive and curative Remedial Actions.

3.3 Methodology for the validation of cross-zonal capacity

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 failed to consider a particular constraint.

Those constraints could be, but not limited to, dynamic behaviour of the grid, unplanned outage that occurs after the deadline to update the inputs.

The TSO requesting a capacity reduction is required to provide a reason for this reduction, its location (all borders or only one border with the reason for selecting one of the options) and the amount of MW to be reduced in accordance with article 26.5 of CACM regulation

Where several TSOs of a bidding zone border request a capacity reduction on their common border, TERNA 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.

If there is an unplanned topology, e.g. one TSO is informed of an unplanned outage at 04:00 am. Coordinated capacity calculator does not have enough time to perform a recalculation but TSOs have time to take it into account in the validation phase and to analyse if a reduction in the capacity is needed.

For particular grid situations that occur not very often, some contingencies or critical network elements could be missing in the lists provided to the capacity calculator if these particular outages were not taking into account. In these cases, TSO could take into account those elements during the validation until the lists for the capacity calculator are updated by sending red flag with a new value of the TTC (justification of the reduction amount must be given on the border(s) concerned by the reduction).

In case TSOs expect different flow patterns as a result of different market situations compared to the assumption of the Capacity Calculation process, the TSOs shall assess and validate a secure capacity value

3.4 Methodology of bilateral splitting among borders

This part of the document describes the algorithm for the NTC calculation and its splitting. It also describes how the NTC is calculated for those timestamps for which no direct calculation is performed.

The final NTC values for each hour and each border are calculated following the steps described below:

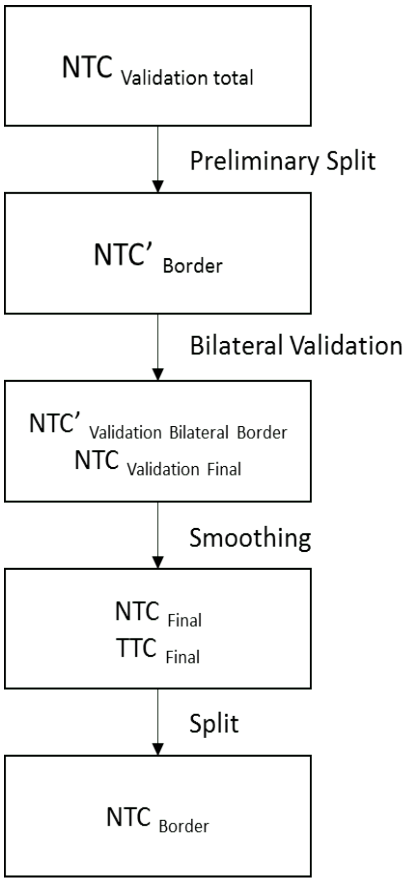


Figure 1 : NTC Calculation diagram

3.4.1 Preliminary NTC calculation

For each hour h, the Preliminary NTC is calculated from the result of extrapolation, and Validation on the total Northern Italian Border.

$$NTC_h = TTC_h - TRM$$

3.4.2 Preliminary Split

The preliminary NTC is split between the borders taking into account the merchant lines on the North Italian Border and the splitting factors. The splitting factors are calculated according to the NTC values defined in the programming stage by the programming departments of the TSOs taking into account the NTC yearly values and the planned maintenances, which affect the security of the Italian import.

3.4.3 Bilateral Validation

For each hour, the preliminary NTC values are subject to the bilateral validation. If a TSO sends a lower bilateral NTC value than the previously calculated (red flag), this value is taken into account for the final NTC calculation. Then all bilateral NTC values in the respective hour are summed and the NTC profile throughout the 24 hours is smoothed, in order to avoid large variations between one hour and the next, as described below.

3.4.4 Exchange programs profile smoothing

Large variations of exchange programs between one hour and the next may endanger the grid security during real time operations. Additionally, variations of exchange programs between one hour and the next cause higher area control error of the involved load-frequency control blocks thus lowering the system frequency quality. For both reasons, a ramping constraint will be set as allocation constraint in the market coupling algorithms pursuant to Article 2(6) of CACM Regulation.

TSOs will request, through the change control procedure of the Multi-Regional Coupling (MRC) and the Cross-Border Intra-Day (XBID) projects, the implementation of the ramping constraint in the market coupling algorithms (day-ahead and intraday). The time needed for the implementation is not known in advance, it depends on the impact that it has on the coupling systems, on the algorithm performance and on the other changes that are already on-going on the algorithms.

As a temporary solution, the ramping constraint will be directly applied to the NTC calculation process as an NTC profile smoothing according to the following process.

NTC values of the 24 hours (whether they are calculated or extrapolated from reference timestamps), coming from the bilateral validation process, are subject to the following iterative process:

1. Detect all hours h for which:
    - $NTC_{h+1} > NTC_h$ + Max_NTC_Stepupward
    - or $NTC_{h-1} > NT_{Ch}$ + Max_NTC_Stepdownward
2. Start analysing from the hour H, within those ones detected at point 1, with the minimum NTC
3. Step forward as long as NTCh+1 > NTCh + Max_NTC_Stepupward:
    - Set $NTC_{h+1} = NTC_h$ + Max_NTC_Stepupward
    - Step forward (h=h+1)
4. Step backward as long as $NTC_{h-1} > NTC_h$ + Max_NTC_Stepdownward
    - Set $NTC_{h-1} = NTC_h$ + Max_NTC_Stepdownward
    - Step backward (h=h-1)
5. Go back to step 1 (until no NTC value has to be changed)

The results of the smoothing process are the $\mathbf{NTC_{Final}}$ of each hour. The $\mathbf{TTC_{Final}}$ of each hour are calculated as:

$$\mathbf{TTC_{Final,h} = NTC_{Final,h} + TRM}$$

3.4.5 Final NTC splitting

The NTC after smoothing (NTC Final) is split between the borders taking into account the merchant lines on the North Italian Border and the splitting factors. The splitting factors take into account the possible bilateral red flags and the NTC values defined in the programming stage by the programming departments of the TSOs taking into account the NTC yearly values and the planned maintenances which affect the security of the Italian import.

3.5 Fall back procedure

At the beginning and during every D-2 process the availability of all necessary files is constantly checked. For files that are missing or do not respect the formatting rules, a manual or automatic replacement is performed. Manual communication is done via Phone and via E-Mail. Manual data exchange is done via the ECP or E-Mail. Any new file update should be communicated to the Coordinated Capacity Calculator in due time. In case the Coordinated Capacity Calculator receives a new file within the given timeframe, the calculation should be restarted. 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, the commercial department will use the reduced yearly NTC.

4 Italy's Export direction

In this chapter a methodology is described to calculate the Export Capacity of Italy. At the beginning of the process, the most likely market direction to be optimized will be chosen based on the expected situation of the target day. The actual methodology will be detailed in the experimentation phase.

4.1 Capacity Calculation Input

The capacity calculation Input of Italy's Export direction is the same as for the Import direction. (Refer to chapter 3.1)

The only additional parameter are:

- a flag indicating the most likely market direction to be optimized. It defines the countries that are expected to import from Italy and to export to Italy,
- specific remedial action(s) (un)availability for each/both market directions (export/import),
- specific CNE(C) for each/both market directions (export/import).
- Monitored Network Element (MNE)
  A list of elements that are influenced by the application of cross-border-impacting remedial actions, but are not significantly influenced by the cross-zonal power exchanges. These MNE's shall be monitored during the RAO. The additional loading, resulting from the application of RAs, on these monitored elements may be limited during the RAO, while ensuring that a certain additional loading up to the defined threshold is always accepted. During the RAO, all the available transmission capacity of the MNEs can be used under the

condition that MNEs' operational security limits including contingencies are respected. Even in case this leads to overloads, at least 5% of each MNE's respective thermal capacity in contingency case shall be made available for the RAO.

4.2 Capacity Calculation Methodology

Each Coordinating Capacity Calculator (CCC) performs, for each timestamp, a capacity assessment to calculate the TTC_{import} in Italy's import direction of all countries exporting to Italy and the TTC_{Export} in export direction of all countries importing from Italy depending on the selected market position to be optimized.

Parallel to the calculation of Italy's Export direction described hereinafter, a calculation of Italy's Full Import direction (refer to chapter 3) will be performed in any case. The result of this calculation step is TTC_{total}.

4.2.1 General principles

The Total Transfer Capacity in Italy's import direction (TTC_{import}) of all countries exporting to Italy and the Total Transfer Capacity in Italy's export direction (TTC_{export}) of all countries importing from Italy will be assessed using the following principles:

- based on the merged D-2 and DACF grid models;
- all calculations are performed using Alternate Current (AC) load-flow algorithm, considering reactive power capability limits of generators;
- Italian import maximization for all countries exporting to Italy and Italian Export maximization for all countries importing from Italy is divided into multiple steps (latter described in the dichotomy approach section); for each step the import is increased in Italy and all countries importing from Italy and decreased in all countries exporting to Italy until a constraint is found;
- the modification of exchanges is realized according to GSKs and Splitting $Factor_{Border,}$ 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 additional constraint (corresponding to low consumption periods) and the Italian import calculated for the Full Import scenario;
- aiming at maximizing the TTC_{import} and TTC_{export} by respecting the above-mentioned constraints, especially by combining efficiently the given Remedial Actions;
- optimization of remedial actions is performed using combination of heuristic search and linear optimization.

- additional loading, resulting from the application of RAs, on MNE's may be limited during the RAO, while ensuring that a certain additional loading up to the defined threshold is always accepted.

4.2.2 Principles to perform the Generation Shift

- For any modification of total import and total export on the northern Italian border, the modification of balance shall be shared among TSOs according to splitting factors in import and export direction.

- Exchanges through some particular lines are kept constant and equal to predetermined values given by the TSOs. Are considered as particular lines the following:

  - Lines not represented in the grid model, whose flows are conventionally considered as fixed;

  - Those of the Merchant lines which are operated at a fixed flow during real time for operational reasons.

- When during the calculation a GSK is exhausted (cannot provide additional shift), then a load redistribution is allowed to continue the calculation (based on the load of the related country).

- For all types of GSK except MERIT ORDER, in case, some generating nodes are reaching their maximum or the minimum limitations, this node is set to P_{max} or P_{min}. The rest of the power to be shifted in the CGM should be distributed to the other nodes being contained in the GSK files, without taking into account the node which is at the saturation.

The mathematical formulation is the following one, where:

- ***Exchange*** represents commercial exchanges. Therefore, they include all exchanges to be transmitted through the grid, either TSO-owned or merchant lines;
- ***ExchangeTSO*** represents the part of exchanges that will be transmitted through TSO-owned grid (as opposed to merchant lines);
- ***ExchangeML*** represents the part of exchanges that will be transmitted through merchant lines;
- $_{Border}$ index stands for one of the four north Italy borders: **CH-IT**, **FR-IT**, **AT-IT**, and **SI-IT**;
- ^{ref} index refers to quantities from the reference day, implemented in the merged ***CGM.***

For each border we have by definition the identity:

$$Exchange_{Border} = ExchangeTSO_{Border} + ExchangeML_{Border}$$

During TTC calculation, only ***ExchangeTSO*** shall vary,

- for borders exporting to Italy:

$$ExchangeTSO_{Border} = Reduced\ Splitting\ Factor_{Border,\ import} \cdot ExchangeTSO_{North\ Italy}$$

- for borders importing from Italy:

$$ExchangeTSO_{Border} = Reduced\ Splitting\ Factor_{Border,\ export} \cdot ExchangeTSO_{North\ Italy}$$

In both cases $\Delta Exchange_{Border}$ is defined as follows:

$$\Delta Exchange_{Border} = \Delta ExchangeTSO_{Border} = ExchangeTSO_{Border} - ExchangeTSO^{ref}_{Border}$$

$$\Delta Balance_{TSO} = \sum_{TSO\ Borders} \Delta Exchange_{Border}$$

Variations are applied on the merged CGM for which exchanges values are given by the reference day values. Exchanges through ML are assumed equal to their daily Fixed Flow provided as input data.

$$ExchangeTSO^{ref}_{Border} = Exchange^{ref}_{Border} - \sum_{Border} Fixed\ Flow_{ML}$$

Summary

This may be summarized as:

- for countries exporting to Italy with the reduced splitting factors in Italy's import direction (I):

$$\Delta Balance_{TSO} = Reduced\ Splitting\ Factor_{Border,\ I} \cdot ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{Border}$$

- for countries importing from Italy and for Italy with the reduced splitting factors in Italy's export direction (E):

$$\Delta Balance_{TSO} = Reduced\ Splitting\ Factor_{Border,\ E} \cdot ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{Border}$$

$\Delta Balance_{TSO}$ shall be implemented from the initial merged CGM, according to GSK handling rules, for each participating TSO. Generation shift handling is described below.

The formulas below are used to calculate the Italian import applied in the model to assess the grid security. The initial model already contains schedules of a reference day. In order to modify the Italian import, it is required to adjust the net positions of FR, CH, AT, SI and IT. The adjustment of the net positions is done with the help of the formulas below.

For each country, this translates into the following formulas. The respective border can be either in import (I) or export (E) direction from/ towards Italy:

$$\Delta Balance_{FR\text{-}IT} = Reduced\ Splitting\ Factor_{FR>IT,I/E} \cdot ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{FR>IT}$$

$$\Delta Balance_{CH\text{-}IT} = Reduced\ Splitting\ Factor_{CH>IT,\ I/E} \cdot ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{CH>IT}$$

$$\Delta Balance_{AT\text{-}IT} = Reduced\ Splitting\ Factor_{AT>IT,\ I/E} \cdot ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{AT>IT}$$

$$\Delta Balance_{SI\text{-}IT} = Reduced\ Splitting\ Factor_{SI>IT,I/E} \cdot ExchangeTSO_{North\ Italy} - ExchangeTSO^{ref}_{SI>IT}$$

$$\Delta Balance_{IT} = -\Delta Balance_{FR\text{-}IT} - \Delta Balance_{CH\text{-}IT} - \Delta Balance_{AT\text{-}IT} - \Delta Balance_{SI\text{-}IT}$$

Concretely, the import level used inside the calculation to check the grid security is split to all borders according to the ***Reduced Splitting Factor*** in order to know what the schedules would be, if the calculation would be over at this import level. In the initial merged model, reference schedules $\boldsymbol{ExchangeTSO^{ref}}$ are already present inside this one. It means to know how much the model should be shifted inside the model to reach this import level, the difference between the hypothetical schedules and the initial schedules should be performed.

4.2.3 Dichotomy approach

The same approach which is applied for the full import calculation is used also for the Export Calculation. (Refer to chapter 3.2.3)

4.2.4 Handling of Remedial Actions

The same approach which is applied for the full import calculation is used also for the Export Calculation. (Refer to chapter 3.2.4).

Additionally, in order to prevent overloading of network elements that are influenced by the application of cross-border-impacting remedial actions during the CC in Export direction, these network elements can be included as monitored network elements (MNEs) in the RAO. For each MNE i in a contingency case, the following has to hold:

$$Loading_{after\ RAO,i} \leq max\left(OL_i; Loading_{before\ RAO,i} + Threshold\right)$$

$Loading_{before\ RAO\ i}$ … Loading of the MNE in a contingency case (based on max. thermal capacity) before RAO

$Loading_{after\ RAO\ i}$ … Loading of the MNE in a contingency case (based on max. thermal capacity) after application of a remedial action during the RAO

OL_i … Represents operational limits of the respective MNE in a contingency case

In words:
If $Loading_{before\ RAO}$ is over OL_i the $Loading_{after\ RAO}$ cannot become bigger than $Loading_{before\ RAO}$ plus the defined Threshold.

4.2.5 Extrapolation Algorithm

The same approach which is applied for the full import calculation is used also for the Export Calculation. (Refer to chapter 3.2.5)

4.2.6 Results

The same approach which is applied for the full import calculation is used also for the Export Calculation. (Refer to chapter 3.2.6)

4.3 Methodology for the validation of cross-zonal capacity

The same approach which is applied for the full import calculation is used also for the Export Calculation. (Refer to chapter 3.4)

4.4 Methodology of bilateral splitting among borders

This part of the document describes the algorithm for the NTC calculation and its splitting in case at least one border is expected to import from Italy. It also describes how the NTC is calculated for those timestamps for which no direct calculation is performed.

The final NTC values for each hour and each border are calculated following the steps described below:

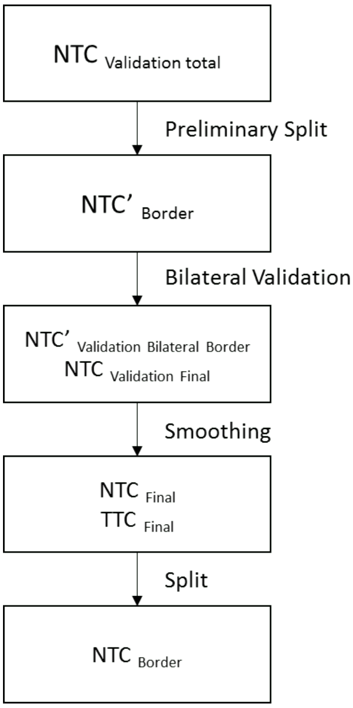


Figure 2 : NTC Calculation diagram

Preliminary NTC calculation

For each hour h, the Preliminary NTC is calculated from the result of extrapolation, and Validation on the total Northern Italian Border.

$$\mathbf{NTC_h = TTC_h - TRM}$$

Preliminary Split

The preliminary NTC is split between the borders taking into account the merchant lines on the North Italian Border and the splitting factors depending on the expected direction of each border (import or export). The splitting factors are calculated according to the NTC values defined in the programming stage by the programming departments of the TSOs taking into account the NTC yearly values and the planned maintenances, which affect the security of the Italian import and export.

Bilateral Validation

For each hour, the preliminary NTC values are subject to the bilateral validation. If a TSO sends a lower bilateral NTC value than the previously calculated (red flag), this value is taken into account for the final NTC calculation. Then all bilateral NTC values in the respective hour are summed and the NTC profile throughout the 24 hours is smoothed, in order to avoid large variations between one hour and the next, as described below.

Exchange programs profile smoothing

Large variations of exchange programs between one hour and the next may endanger the grid security during real time operations. Additionally, variations of exchange programs between one hour and the next cause higher area control error of the involved load-frequency control blocks thus lowering the system frequency quality. For both reasons, a ramping constraint will be set as allocation constraint in the market coupling algorithms pursuant to Article 2(6) of CACM Regulation.

TSOs will request, through the change control procedure of the Multi-Regional Coupling (MRC) and the Cross-Border Intra-Day (XBID) projects, the implementation of the ramping constraint in the market coupling algorithms (day-ahead and intraday). The time needed for the implementation is not known in advance, it depends on the impact that it has on the coupling systems, on the algorithm performance and on the other changes that are already on-going on the algorithms.

As a temporary solution, the ramping constraint will be directly applied to the NTC calculation process as an NTC profile smoothing according to the following process.

NTC values of the 24 hours (whether they are calculated or extrapolated from reference timestamps), coming from the bilateral validation process, are subject to the following iterative process:

1. Detect all hours h for which:
    - $NTC_{h+1} > NTC_h + Max\_NTC\_Stepupward$
    - or $NTC_{h-1} > NT_{Ch} + Max\_NTC\_Stepdownward$
2. Start analysing from the hour H, within those ones detected at point 1, with the minimum NTC
3. Step forward as long as NTCh+1 > NTCh + Max_NTC_Stepupward:
    - Set $NTC_{h+1} = NTC_h + Max\_NTC\_Stepupward$
    - Step forward (h=h+1)
4. Step backward as long as $NTC_{h-1} > NTC_h + Max\_NTC\_Stepdownward$
    - Set $NTC_{h-1} = NTC_h + Max\_NTC\_Stepdownward$
    - Step backward (h=h-1)
5. Go back to step 1 (until no NTC value has to be changed)

The results of the smoothing process are the $\mathbf{NTC_{Final}}$ of each hour. The $\mathbf{TTC_{Final}}$ of each hour are calculated as:

$$\mathbf{TTC_{Final,h} = NTC_{Final,h} + TRM}$$

Final NTC splitting

The NTC after smoothing (NTC Final) is split between the borders taking into account the merchant lines on the North Italian Border and the splitting factors corresponding to the expected import or export direction. The splitting factors take into account the possible bilateral red flags and the NTC values defined in the programming stage by the programming departments of the TSOs taking into account the NTC yearly values and the planned maintenances which affect the security of the Italian import or export.

4.5 Fall Back procedure

The same approach which is applied for the full import calculation is used also for the Export Calculation. (refer to chapter 3.6)

5 Implementation

A D-2 CCC process is already in operation in Italy North CCR on voluntary base. Since February 1st of 2016, individual values for cross-zonal capacity for each day-ahead market time unit have been calculated using the D-2 common capacity calculation methodology.

Some parts foreseen by this D-2 CCC methodology are not yet into operation in the current process. Their implementation will be performed in accordance with the terms reported in Article 12(3), except for some parts whose implementation is detailed in Article 12(6).