# Capacity Calculation Methodology on Northern Italian borders

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**Previous versions**

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| 1.0 | 02/01/2014 | CSE TSOs | First draft version |
| 1.1 | 22/01/2014 | CSE TSOs | General update |
| 1.2 | 09/05/2014 | CSE TSOs | Update |
| 1.3 | 22/09/2014 | CSE TSOs | Update |
| 2.0 | 06/07/2015 | CSE TSOs | Update |
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**Related documents**

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| REGULATION (EC) No 714/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCILof 13 July 2009 |
| Working draft of 14 January 2014 of: Regulation establishing a Network Code on Capacity Allocation and Congestion Management and a guideline on Governance supplementing Regulation (EC) 714/2009 |

The structure of this document is based on requirements of article 22 of current CACM NC draft.

Words with capital letters are defined in CACM or other NC.

# Capacity Calculation Region

The « Italian north borders » region – later also being established as a Capacity Calculation Region in the sense of the Capacity Allocation and Congestion Management Guideline - includes the borders:

* France – Italy
* Luxembourg/Germany/Austria – Italy
* Slovenia – Italy
* Switzerland - Italy

The TSOs collaborating within this region are:

* APG
* ELES
* RTE
* Terna
* Swissgrid

# Capacity Calculation Approach

This document aims at describing the capacity calculation methodology used for providing capacity values for the daily allocation in the import direction (for Italy) only.

The general approach is based on coordinated NTC, and is performed in two main steps:

1. Calculate a single TTCtotal corresponding to the overall transmission capacity over the northern Italian border, using AC load flow calculations. This step is later referred as TTCtotal determination;
2. Calculate and split NTCtotal into NTCborder, applicable on each bidding zone border (CH-IT and AT-IT are composed of both merchant lines and regulated network). This step is later referred as NTCborder calculation.

The operational coordinated process is depicted in Figure 1:

* « local activities » refer to activities performed individually by each TSO;
* « common activities » are performed either by the two « coordinating entities » in parallel or by Terna. These « coordinating entities » are TSCnet and Coreso.

19:00

DACF

D

-

2CF

GSK

**D**

**-**

**2**

NTC

import

\_border

Calculation

**03:00**

TTC Validation

D

-

2

Merging

**Local Activities**

CRAC

*16:00*

07:30

TTC Calculation

CRAC merging

GSK merging

***NTC***

***reduction***

Quality check

of CRAC /

GSK files

***NTC***

***export***

***Border***

*Input*

*provided by TERNA*

**Central Entity 1**

**Central Entity 2**

**TERNA**

**Common Activities**

The same than CE1

TTC Selection

**02:30**

07:00

**D**

**-**

**1**

21:00

Quality

check of

uct

files

Figure 1 - Operational coordinated process

The process has been designed to guarantee security and at the same time transparency. The two CEs are in fact committed to apply the same business process, but with independent algorithms and trace the application of GSK and Remedial Actions.

Comparisons of the results presented by both CEs are part of the process, at the end of the TTC Calculation, in order to choose the TTC value which will be validated, based on agreed criteria.

TSOs are bound to feed the process with the best forecast, consistent with their internal operational planning processes.

## TTCtotal determination

A day is divided into two periods for the daily capacity calculation (hours in Continental Europe Time):

* peak: from 7:00 until 23:00;
* off peak: from 00:00 until 7:00 & from 23:00 until 24:00.

For each period, a single timestamp is used to represent the whole period: for peak period it is 10:30, for off peak period it is 03:30.

The later objective of the project is to increase the number of timestamps up to 24.

### Providing inputs sub process

The main inputs for the capacity calculation are the Generation Shift Keys, the individual D-2 Congestion Forecasts (grid models), the Critical Network Elements, the Critical Outages and Remedial Actions and additional constraint (the four latter are included in a so called « CRAC » file). Each TSO of the region has to provide these inputs for both timestamps. All of them are results of the best prediction made by the TSO for the day D.

### Merging sub process

Each coordinating entity assesses the quality of the inputs and merges the individual data for each timestamp.

### TTC calculation sub process

Each coordinating entity performs, for each timestamp, a capacity assessment to calculate the TTCtotal by combining the inputs and applying the capacity calculation methodology detailed in chapter 4. 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 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 TTCtotal);
* TTCtotal;
* Limiting elements of TTCtotal (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 TTCtotal is the additional constraint itself), otherwise limiting elements always exist.
* results of security analysis with preventive and curative Remedial Actions

### TTC Selection sub process

Terna receives the results of both coordinating entities and selects a single set of result per timestamp in accordance with the general prudent security approach which foresee to always consider the smallest of two values. Exceptions are done when one or both values are outside a predefined range and, in such cases, the values are capped or floored by the range limits themselves. The range will be subject to periodic adjustment, based on a statistical approach, in order to take into account the increasing accuracy of the results and the higher confidence with the process in operation.

### TTC extrapolation sub process

As at the moment only for two timestamps the TTCtotal is calculated, the missing 22 values have to be extrapolated according to the grid situation. This holds, if in the not-calculated hours a grid element goes out or comes back into operation, which was not considered in the two calculated timestamps.

For instance, a planned outage from 7:00 to 18:00 will be considered in the grid model of the 10:30 timestamp and then TTCtotal remains untouched for the period from 7:00 to 18:00, but on the period from 18:00 to 23:00 an adjustment is performed to reflect the new transmission capacity of the network.

This sub process will disappear, when the process switches to a 24 timestamp calculation.

### TTC validation sub process

For each hour, the obtained TTCtotal has to be validated by each TSO. If a TSO judges a TTCtotal as unsecure, it can send a red flag with a lower value of TTCtotal.

After validation of all TSOs, the lowest proposed TTCtotal will be used. The reason of limiting TTCtotal is then red flag activation by a TSO.

## NTCborder calculation

The general principle is described hereafter.

For each hour, a NTCtotal is determined by removing the TRM from the final TTCtotal. The NTCtotal is split across the different Bidding Zone borders according to the following splitting algorithm: the sum of the NTC of all the merchant lines is removed from the NTCtotal and the remaining NTC (referring only to the public lines), NTCpublic, is split between the borders according to Weight Coefficients, calculated just considering the public lines, thus obtaining the NTC of each border which is due to public lines only. The total NTC of each border is obtained by adding the NTC of its merchant lines to the NTC of its public lines.

# Inputs for the Capacity Calculation

## Grid model

The D-2 grid model is obtained by merging:

* D-2 Congestion Forecasts (D2CF) of the networks of the 5 TSOs of the region;
* D-1 Congestion Forecast (DACF) of the networks of the remaining relevant part of Continental Europe.

## Generation Shift Keys

Each TSO can decide how to represent its best generation shift. Several methods are supported by the process:

* Proportional: the shift is done in proportion of the active power, either of the load or of the generation, connected in the grid model for nodes judged relevant by the TSO (usually all);
* Participation factors: each node selected by the TSO has a explicitly specified participation (percentage) to the generation shift;
* Reserve: shift is done proportionally to the remaining available capacity of each generation unit (remaining available capacity being the difference between current active power and min or max active power of generation units);
* Merit order: the generation shift is done in a sequence of generation units representing their economic merit order of activation.

## Critical Network Elements & Critical Outages

Each TSO is responsible to select the Critical Network Elements & associated Critical Outages to be monitored during the capacity calculation. Generally the following rules apply:

* they are consistent with the real time security rules;
* change in northern Italian import has a significant impact on the load of the Critical Network Element, but no quantified criteria is defined.

## Operational Security Limits

During the TTC calculation sub process, the maximum current on grid elements is monitored.

During the Validation sub process each TSO can take into account operational security limits impossible to model in the D-2 algorithm and which cannot be activated by the proposed solution.

For instance, Terna has grid stability and voltage control issues in some low consumptions periods and therefore it has to limit the import of Italy and this is normally taken into account by the Additional Constraint.

## Additional Constraint

One additional constraint is identified: Maximum value of TTC for the whole Northern Italian Interconnection.

This TTCmax corresponds to Italian operational constraints related to the control of voltage profiles and dynamic stability of Italian system, due to the high integration of renewable energy.

If this additional constraint is indicated, TTCtotal will be equal or lower to this value TTCmax, at the end of the calculation.

## Remedial Actions

According to the N-1 curative criterion different kind of Remedial Actions can be used during the calculation:

* as pre contingency Remedial Actions: it could be a change of taps of a PST on a given range, or a change of state (open / close) of a circuit breaker;
* as post contingency Remedial Actions: it could be a change of taps of a PST on a given range, or a change of state (open / close) of a circuit breaker, or a redispatching of generation units.

For each Remedial Action, each TSO chooses for which kind of constraint it can be used:

* to solve congestion only on a specific Critical Network Element;
* to solve congestion on any Critical Network Elements being part of its Control Area;
* to solve congestion on any Critical Network Element of the northern Italian border region.

Remedial Actions are discussed among the TSOs in terms of effectiveness and secure applicability by the Operators.

## Reliability margin

The transmission reliability margin (TRM) used for the whole Italian borders is 500 MW.

# Detailed description of the Capacity Calculation Approach

## Detailed description of how inputs are combined

### General principles

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

* using Alternate Current (AC) load-flow algorithm, considering reactive power capability limits of generators;
* based on merged D-2 and DACF grid models;
* the modification of exchanges is realized according to GSKs and Splitting FactorBorder (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 TTCtotal by respecting the above mentioned constraints, especially by combining efficiently the given Remedial Actions.

### 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 followings:
	+ - 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).