PROCEDURES FOR CROSS-BORDER TRANSMISSION CAPACITY ASSESSMENTS

Table of contents

SUMMARY

The European Transmission System Operators Association (ETSO) has issued common definitions of cross-border transmission capacities for international exchanges of electricity within the Internal Market of Electricity of Europe (IEM) [1]. They offer an harmonised basis to assess the Net Transfer Capacities among interconnected countries, suitable for allocating commercial exchanges to market actors.

The NTC assessments are performed by the TSOs through load flow calculations.

This document summarises the main guidelines that ETSO proposes to be applied by each concerned TSO during this process. It provides a harmonised framework and ensures that calculated values relay on comparable principles and practices resulting in an improvement of the consistency of cross-border transmission capacity calculations.

TSOs are responsible for calculating cross-border transmission capacities, as they have always to guarantee the secure operation in their networks. This task is performed by the TSOs on the basis of the national Grid Codes and/or additional guidelines issued by National Authorities or Regulators.

The proposed guidelines for cross-border transmission capacities assessments include the following main aspects:

- The calculations are based always upon the best available input data coming from the best estimates. Each TSO is responsible to provide for its own network area the necessary input data sets.
- The load flow calculations are performed using a real network representation as wide as possible.
- The TSOs exchange the input data sets in order to start from the same scenarios (base cases). To be realistic the base cases have to rely on historical recorded data (snapshots of network conditions in the past), adapted in order to take into account the foreseeable electric system changes.
- Several possibilities exist on how to simulate the power exchanges between two areas. The choice has to be done by each TSO. He will also take into consideration the security constraints and the transmission reliability margin. The aim is always to reach the most realistic results.
- The needs of transparency regarding the exchange of technical input data and assumptions as well as of co-operation in order to agree the relevant studied scenarios are outlined.

ETSO publishes twice a year indicative and non-binding NTC-values on its website in order to provide a general European overview. TSOs are responsible for calculating and publishing net and available cross-border transmission capacities more frequently, as often as requested by national rules, market actors or allocation mechanisms. The principles described in this document will form a basis also for these assessments.

1 INTRODUCTION

ETSO has issued a set of definitions of cross-border transmission capacities for international exchanges of electricity within the Internal Market of Electricity of Europe (IEM) [1] that gives a harmonised instrument for the TSOs to manage the electricity transactions over their networks. The definitions are applicable for the planning and as well as for the allocation phases for different time frames, from year ahead to day-ahead.

The most important definitions are the Net Transfer Capacities (NTC) and the Available Transfer Capacities (ATC). Both values are important for market participants to anticipate and plan their cross-border business and to participate in the different capacity allocation processes. ETSO has thus decided to publish twice a year in its Intranet system (www.etso-net.org) a table "Indicative Values for Net Transfer Capacities (NTCs) in Europe" [2]. TSOs publish more frequently information on transfer capacities, i.e. as a basis for the capacity allocations at their respective borders.

The proposed procedures described in this document aim at ensuring as much as possible consistency of NTC assessments by TSOs all through the IEM. They detail how to calculate the NTC values in Europe. The procedure follows the principle of providing the best information to market participants considering the present state of the art in this matter in constant progress in the whole world. The following procedure is therefore related to the experience of the TSOs in this field up to now and to the resulting practice recommended at present within ETSO members considering methodological, technical and organisational possibilities. It will be updated and revised as much as necessary to take into account any future progress or to overcome any unforeseen difficulty that may occur in its implementation.

NTCs are calculated by couples of neighbouring areas[1] for all commercially significant directions. In case of stronger electrical interdependencies in addition to values between two areas/countries TSOs may provide further information by calculating cross-border transmission capacities between one area and a group of areas/countries[2]. ATC's are worked out from NTC values through allocation mechanisms that are out of the scope of this paper that is entirely dedicated to the assessment of the maximum cross-border transmission capacity values.

The value of using European wide the harmonised ETSO-definitions of cross-border transmission capacities will only become effective for the market if the assessment procedures are as well harmonised in the necessary degree. The procedures described in this document are therefore one important element for the well functioning electricity market in Europe.

1 Neighbouring areas (often but not necessarily neighbouring countries) means that the networks of the respective TSOs having a common interconnected electrical border

2 An aggregation of two or more areas.

2 GENERAL GUIDELINES

Cross-border transmission capacity assessments are performed through load flow calculations.

The main prerequisites are:

- A suitable network model that allows determining the influences of the neighbouring areas.
- Estimated generation and load patterns to simulate cross-border exchanges (base case).
- A procedure to harmonise and to agree the input data among the concerned TSOs
- Guidelines to perform the simulations of cross-border exchanges in a most realistic and understandable way.

The responsibilities for cross-border transmission capacity assessments rely on the TSOs. According to national Grid Codes or to national regulatory frameworks TSOs are bound legally to operate the transmission networks, always respecting operational security, to monitor its network conditions and cope with congestions. Often the TSOs have the task to implement and to execute capacity allocations as well.

Therefore the subsidiarity principle is applied in some step during the cross-border transmission capacity assessment process.

Each concerned TSO is thus responsible to provide the necessary input data for the load flow calculations for its network:

- Relevant network model and topology
- Technical network data
- Estimated generation and load patterns
- Technical and operational limits

The capacity assessments are based on common data sets, the so-called commonly agreed base cases. They have been until now established by TSOs or TSO-organisations like NORDEL and UCTE. NORDEL and UCTE are currently issuing at least twice a year a European load flow forecast for winter and summer peak hours. Additional snapshots of load flow situations may be provided if requested. In order to reach a sufficient level of consistency and harmonisation the TSOs organisations will provide interconnected network base cases.

The TSOs will treat all data as confidential in accordance with the Code of Conduct established within ETSO

The assessment procedure shall guarantee that each NTC value is reachable without compromising the security of the European electrical network.

The TTC/NTC-assessments are performed for each pair of electrical adjacent countries. In case of strong interdependencies among different groups of countries (zones), calculations between these zones and the neighboring countries will be performed. It has to be borne in mind that in these cases the pairwise computed TTC/NTC values can not all be reached simultaneously without compromising system security.

3 BASE CASE CONSTRUCTION

As outlined in the general guidelines, cross-border transmission capacity calculations require a set of data, common for all IEM countries. This set of data, called ”base case”, includes a network model and input data describing load and generation patterns forecast and network topology at the studied time frame.

The TSOs or a TSO organisation would provide the harmonisation of the TSO’s individual inputs in order to set up the common data sets in due time.

3.1 NETWORK MODEL

The network model should as far as possible contain a full representation of the network elements. It can be split in several geographical parts: One for the NORDEL area, one for Continental European countries synchronously interconnected network (first and second synchronous area of UCTE) and one for each of the countries connected by DC links (Great Britain, Greece, Ireland).

The studied area has to be as wide as possible to allow an accurate comprehension of physical flows distribution on tie-lines resulting from international exchanges since some important part of the power flowing from one area to another can circulate through third countries depending on the interconnection.

For instance, the Continental European base case part corresponds to the interconnected European network file provided yearly by UCTE.

The effect of DC links with other part of IEM, is represented through injection or sinks at the relevant nodes.

The calculation area (i.e.: the subset of the network model) for NTC assessment between two neighbouring countries, or zones, will be determined case by case following the above principles. Each partner can ask for an extension of the calculation area if necessary.

3.1 INPUT DATA

Load-flow calculations have to be performed using an AC load flow model.

For cross-border transmission capacity assessments for each time frame being considered the following input data are needed:

- The thermal ratings of network elements as well as the electrical parameters. Thermal ratings shall be addressed in Amps, not in MW. According to the time frame studied, the corresponding seasonal values of thermal ratings are to be used.
- The maximum and minimum output power values for the generating units being included into the network model.
- The intended network topology at the time frame considered. The generation pattern by the means of the net injection at each node at the time frame considered.
- The load pattern by the means of the net sink at each node at the time frame considered.
- The common set of programs of cross-border transactions and the net balances of each TSO area at the time frame considered. The common set of cross-border transactions considered in the base case (BCE) relates to the best forecast for exchanges at the time frame considered.

- The maximum power expected available at the time frame considered.

Each TSO commits itself to provide always the best estimated available input data for its own area, reflecting as much as possible realistic scenarios, previously agreed within its country or, with reference to the observed reality, being the best possible assumption and according to their experience and knowledge of the national market behaviour and of the availability of primary energy sources.

The base case can be built up starting from:

- Real observed operation situations
- Forecasts.

While the observed operation situations offer a true scenario of the electrical system behaviour, forecasts can give a better database because they include the expertise of each TSO about the expected behaviour of generation and load in its own country and the knowledge about the scheduled maintenance works on the transmission network/generators. These two alternative views on base case construction may be combined in the following way. The base case would be built starting from a real observed situation (snapshots of the power system at selected scenarios). Then each TSO will update the information regarding his system taking into account foreseeable differences about:

- Load level, according to the demand forecasts over the time frame being analysed
- Generation pattern based on forecasts of primary energy sources (i.e.: hydro reserves, fuels availability…);
- Network and generation planned or forced (long lasting) outages.

No definite rules may be set up to perform these tasks that can only be carried out according to the best practices of each TSO. Then it is left to subsidiarity the specific procedure that each TSO uses to modify the starting base case provided that these modifications are consistent at control area level (i.e. real generation limits/possibilities) and at the control block level (i.e. base case exchanges). However each TSO has to explain the nature and extent of any modification performed on the starting base case when sending to the other partners the results of modifications which shall be integrated into the common base case used for NTC computations.

4 GUIDELINES FOR LOAD FLOW CALCULATIONS

4.1 CROSS-BORDER EXCHANGES SIMULATION

In order to determine the cross-border transmission limit between two neighbouring countries or zones, cross-border exchanges are gradually increased while maintaining the loads in the whole system unchanged until security limits are reached.

Starting from the common base case exchanges, the additional exchange is performed through an increase of generation on the exporting side and an equivalent decrease of generation on the importing side. This generation shift is to be made stepwise until a network constraint is violated.

The generation increase/decrease has to be performed according to some predefined criteria. The general criteria as well as any exceptions are to be known by the TSOs, involved in the calculation of a given cross border capacities. Some possible ways to distribute the generation increase/decrease in a given control area or zone over the different generating sets in this area are the following:

- Proportional increase/decrease: For example, the factor which distributes the generation increase/decrease in a given control area over the different generators in this area could be the ratio of base case schedule of each generator to the total of internal generation scheduled and involved in the shift.
- Increase/decrease according to previously observed behaviour of generators. For example, the factor which distributes the generation increase/decrease in a given control area could take into account the usual response pattern of generation to different system loads.
- Increase/decrease according to a well-known merit order: Whenever economic dispatch is applied the increase/decrease of generation shall be applied according to the merit order.

The shift is to be performed taking into account the technical operation constraints of each generator and its technical limits (maximum/minimum power, optimal use of a power plant, water or fuel available).

The choice among different shift possibilities or even a combination of shifting strategies is left to the responsibility of each TSO but has to be explained and communicated to the other TSOs involved in computing a given cross border capacity.

The party who is making the calculations is responsible at least for the contingency analysis in its transmission system and cross-border tie lines including some well known contingencies in the neighboring system, which influence the security of its own system.

4.2 LIMITATION DUE TO SECURITY CONSTRAINTS

The cross-border exchanges increase/decrease goes on until security rules are violated in the network and the interconnection tie-lines of the TSO performing the calculation or inside another country at least regarding the respect of thermal ratings of network elements. Security problems can result in thermal, voltage, or stability limitations that are to be defined by the country which performs the calculation, and must be coherent with the rules published in its grid code.

If the constraint occurs within the control area of the country that runs the calculation, first it shall be checked if the congestion is in real operation condition effective or if it could be relieved, e. g. by corrective measures, without reducing the electric system security level. If the constraint remains, then the limit is directly effective.

If the constraint occurs in another country, its effectiveness has to be confirmed by the TSO in which network the congestion takes place, before the limit is considered as effective (see diagram in appendix). Thus, the TSO running calculations has to:

1) Notify other involved TSO
2) Have some discussions about the physical reality of this constraint,
3) Take it into account in its security analysis only if the involved TSO agrees on its consistence.

In other words, to have a NTC value limited by a security constraint within another TSO's grid implies an explicit agreement with this latter TSO on the reality of this constraint. Once all constraints are recognised by both partners, they have to be taken into account.

The last value of additional exchange that does not involve any security problem forms the value ΔE. It represents the extra amount of power over the base case that can be exchanged continuously from one country to another while ensuring the safe operation of both interconnected electricity systems. This value, added to the initial transaction value

BCE taken in account between the concerned countries or zones, gives the total transfer capacity (TTC) between these countries or zones:

$$\mathbf{TTC = BCE + \Delta E = NTC + TRM}$$

Where:

- TRM is the transmission reliability margin defined in the following paragraph.
- NTC is the net transfer capacity.

If the whole physical generation shift between the two concerned countries or zones according to their really available generation is reached and no security rules breaching has occurred, no realistic limitation to the cross-border transmission capacity for the base case studied is found. If this is the case, the NTC between these two countries would take the meaning of a realistic attainable value (NTC equals to the shift of available generation).

5 TRANSMISSION RELIABILITY MARGIN

Some cross-border transmission capacity margin related to the deviations occurring both in real operation state and in the capacity assessment process has to be considered.

This capacity refers particularly to the unintended deviations due to power-frequency (secondary) control (Ur) and frequency (primary) control, needs for common reserve and emergency exchanges to cope with unbalanced situations (U_E). These sources of uncertainty are used to calculate the TRM factor for a given direction of transfer. Each TSO calculates its own TRM values according to the need of ensuring its network operation security.

Finally, each pair of neighbouring countries should agree on a unique value for the TRM factor for a given direction of transfer. In case of disagreement, each TSO will maintain its final value of TRM in operation according to the safeguard of its own electric system for which it is the solely responsible.

5.1 TRM EVALUATION

TRM is determined by unintended load-frequency regulation deviations and needs for common reserve and emergency exchanges.

Load-frequency control margin can be estimated through statistical analysis of past data using the estimated variance of a one or more years deviation historical series. These time series have to be previously filtered to avoid the bias which may be introduced by large deviations occurring as the result of sudden load imbalances (like the ones induced by generator trips), that have to be considered in the emergency exchanges. The assumption that the result is independent of the volume of programmed exchanges seems to be reasonable because these deviations are rather dependent on the ‘quality’ of the spinning reserve acting for load frequency control in each control area considered.

As far as common reserve and emergency exchanges are concerned, their amount is to be previously evaluated and agreed by the involved countries; in some cases, they have the form of reserve contracts or mutual assistance agreement.

5.2 TRM FIGURE COMPUTATION

Let U_r be the considered margin for the regulation deviations. If U_r is a statistical estimate it can be expressed in terms of the respective pdf variance estimates σ^2_r. Then $U_r = K \times \sigma_r$ being a choice depending on the probability threshold considered (usually K=3). Let U_E be the margin for common reserve and emergency exchanges which is known beforehand.

To combine margins into a TRM value several rules might be applicable:

i. To add margins (worst case combination):

$$TRM_i = U_r + U_E$$

ii. To take the maximum of the retained uncertainty margins (i.e. assuming that these cannot happen simultaneously) plus the common reserve margin:

$$TRM_{ii} = \max (U_r, U_E)$$

Obviously $TRM_{ii} < TRM_i$. The choice of the appropriate criteria to combine the two terms of TRM remains a matter of subsidiarity. However the combination criteria as well as the retained values for U_r and U_E are part of the information exchanged amongst the TSOs involved in the computation of a given cross border capacities.

6 UNCERTAINTIES IN TTC COMPUTATION

During the process of calculating TTC the physical model inaccuracies, i. e. in data collection and measurements, as well as uncertainties arising from unintended deviations of physical flows due to the load-frequency-regulation and emergency exchanges are taken into consideration [1].

Uncertainties regarding the bases case exchanges BCE, which means uncertainties on a scenario regarding the expected behavior of market participants, may translate into more substantial uncertainties about cross-border transmission capacities. TTC and NTC assessments are based always on calculations taking into account specific assumptions regarding base case exchange scenarios. Uncertainties in base case scenarios may be considered when allocating NTC in different time frames. Separately from the assessment of cross-border transmission capacities and the calculation of the transmission reliability margin TRM, TSOs may decide whether additional margins have to be considered, i.e. in cases of strong uncertainties in generation scenarios.

I. e. in a yearly planning procedure the uncertainties on the scenarios may be quite substantial allowing only a partial allocation of NTC in advance. When getting closer to the operating horizon these uncertainties may diminish gradually with the consequence that further parts of cross-border transmission capacities may be allocated to market participants. Generally subsequent calculations of TTC and NTC at different time frames (yearly, monthly, weekly, day ahead) will be necessary to allocate at each moment the maximum value of cross-border transmission capacities. Further remarks concerning the allocation phases are given in [1].

7 TREATMENT OF DIFFERENT RESULTS AMONG TSOS

UCTE recommends the N-1 security deterministic criterion to perform the contingency effects assessment. This criterion should be adopted by all TSOs who are members of UCTE.

In the case that national Grid Codes and/or additional guidelines issued by National Authorities or Regulators oblige TSOs to different security criteria, the concerned TSOs have to apply them; so decisions in this matter are taken according to the principle of subsidiarity.

Before applying the TTC assessment procedure, each TSO has to declare which are the security rules (security criteria and security thresholds) adopted, the worst outage case it has to take into account in order to safeguard its own system security and the technical constraints limiting the power shift to assess the NTC value for a given direction.

Each TSO is responsible to decide on its own network topology and the way it intends to perform the generation shift from its side, that is to be declared previously.

In case of agreement on the previous items, the two countries (or zones) A and B who calculate capacities should come to the same or very similar result.

7.1 DIFFERENCES CONCERNING TECHNICAL ASPECTS

If the involved TSOs reach different TTC results, no deviation - concerning the interpretation of the security rules, the network contingency or topology, or the exchange scenarios from those previously declared - will be accepted. The only difference may come from the way to perform its own generation shift while searching the TTC limit. Indeed, according to the principle that each TSO may have its own appreciation about the most probable generation move in its country.

In these cases the concerned TSOs have to exchange the information allowing them to recognise that the base case is the same, to identify the units in which the generation shift has been performed, the contingency or set of contingencies which set the computed TTC values, the security limit which has been breached and the corresponding network element. This information is the minimum required to start a discussion leading to a possible agreement.

If during the calculation process, deep changes somewhere in the whole interconnected electric system studied occur, the concerned TSO can ask for taking them into account.

7.2 DIFFERENCES CONCERNING LEGAL ASPECTS

If different results come from legal matter, due to national law obligations, national Grid Codes regulations and/or decision issued by National Authorities or Regulators the concerned TSOs have to decide according to the principle of subsidiarity. If no final agreement is reached, both NTC values calculated on the same border will be taken for the ETSO publication.

REFERENCES

[1] Definitions of Transfer Capacities in liberalised Electricity Markets, ETSO, March 2001

[2] Indicative values for Net Transfer Capacities (NTC) in Europe, winter and summer, working day, peak hours, ETSO-publication twice a year

[3] NTC an ATC in the IEM, information for user, ETSO, March 2000

Appendix 1

Scheme of A to B NTC assessment when TSO A runs calculations