Definitions of Transfer Capacities in liberalised Electricity Markets

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Table of contents

SUMMARY

ETSO worked out in 1999 definitions of transfer capacities that are since then used by the European TSOs for capacity calculations on a harmonised basis. Two important notions in these definitions are the **Total Transfer Capacity TTC** and the **Net Transfer Capacity NTC**.

The ETSO definitions are the basis for the half yearly calculation of indicative NTC values by the TSOs that are also published on ETSO's webside as well as for additional or more frequent calculations needed by the TSOs for the allocation of interconnection capacities.

The practical application of the definitions raised some ambiguities in interpretation. Therefore, ETSO worked on an improvement of those definitions that is summarised in the present document.

The general concept of the definitions given by the notions of TTC and NTC was confirmed and maintained. It was enlarged introducing the aspects of transfer capacity assessments for different time frames: For the planning TTC and NTC assessment are the main objectives of TSOs. Market actors need these values to anticipate and to plan their transactions.

During the allocation phases, that can cover according to the rules applicable at each cross-border or "flowgate" time frames from year ahead to day ahead or even hour ahead, a set of new notions is introduced. These are the **Already Allocated Capacity AAC** and the still **Available Transfer Capacity ATC.**

All these values are to be interpreted in terms of exchange programmes between adjacent areas.

In the highly meshed interconnected transmission networks in Europe programmed exchanges and physical flows differ often considerably. The ETSO work confirmed that the physical complexity is so big and needs always a complete view on the European load flow scenarios that it would not be useful for market actors to try to make public additionally physical values beside the above mentionned data. However, a separate set of notions of physical flows was established in which every notion relates to one of the above mentionned definitions for exchange programmes. This approach helps to easier agree between TSOs about concrete values, to check their global consistency and to ensure, in a best way, transparency towards decision-making or supervisory bodies like Regulators.

ETSO considers that the new set of definitions improves considerably the transparency in this complex technical field and that the new definitions are in line with all used capacity allocation mechanisms through out Europe. The new definitions will also allow work further on new methods like a sophisticated auctioning mechanism.

1. INTRODUCTION

ETSO presented at the fourth Electricity Regulation Forum at Florence in November 1999 definitions of transfer capacities that are used between the European TSOs for capacity calculations on a harmonised basis. They include the following notions:

- Net Transfer Capacity (NTC)
- Available Transfer Capacity (ATC)
- Transmission Reliability Margin (TRM)
- Notified Transmission Flow (NTF).

NTC and ATC are important indicators for market participants to anticipate and plan their cross-border transactions and for the TSOs to manage these international exchanges of electricity. 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" [1].

Additionally, ETSO edited in March 2000 a paper titled "Information for users" [2]. It provides to the actors in the Internal Market of Electricity in Europe some basic explanations related to the transfer capacity definitions and answers to frequently asked questions. Other complementary documents were worked out and are at the disposal of the TSOs to calculate NTC values, such as a technically oriented NTC/ATC user's guide and a note on TRM evaluation. All documents were presented at the different Electricity Regulation Forums at Florence.

Given the fact that the assessment of transfer capacities in highly meshed interconnected transmission networks like that in Europe is a very complex task and includes extensive load flow calculations done by the TSOs, the "Information for users" tries to make this process understandable also for non specialists.

However, as transfer capacities are one important factor that determines the possibilities of access to market regions in Europe and thus of the international trade, it remains critical that the TSOs do their calculations and assessments in the most transparent way, and that the used definitions are well understood by all actors and well applicable by all decision making bodies.

Therefore ETSO has worked since last year on improving the existing transfer capacity definitions. This document summarises the results and provides an enlarged set of definitions for transfer capacities. ETSO focussed its work on two aspects:

- The practical application of the existing definitions showed that they could lead to misunderstandings, even by specialists of TSOs. The reason was that the distinction between programmed transactions (scheduled exchanges) and physical flows was not always clear.
- The possibilities for import/export transactions in the European transmission systems between two countries depend on all realised transactions – also between others than the two considered countries – due to the so called parallel flows which are the direct consequence of physical laws of electrical flows in the interconnected networks. Thus the maximum possible use of the capacity between two given countries depends to some extent on all local as well as on all distant transactions, because they rely on the European production plans and on the consumer loads.

ETSO tried first to work out new definitions in order to make the physical parallel flow effect explicit. However, this would lead to complex notions that are not useful for the current capacity allocation mechanisms and non transparent for market actors.

Therefore ETSO maintained the general concept for the existing transfer capacity definitions and included the following improvements:

- Clear distinction between programmed values and physical flows: The new set of definitions includes only notions that are to be interpreted as energy programmes. Market actors are interested to plan the trade between regions or countries and do not like to worry about load-flow problems. It is on the other hand the task of TSOs to manage physical flows and to maintain at every moment the security in their networks. This complex task should be handled inside the TSOs and not be an obstacle for the market.
- Improvements concerning the transfer capacity assessment methods used by the TSOs: It is necessary to have a harmonised basic procedure between TSOs for calculating transfer capacities. This means that the basic scenarios have to be commonly agreed and that the calculation procedures of all TSOs are comparable. This approach helps to easier agree between TSOs about concrete values, to check their global consistency and to ensure in a best way transparency towards decision-making or supervisory bodies like Regulators.
- Definitions well suited for planning of trade as well as for capacity allocation procedures: The market needs first of all information for planning purposes. The NTC-tables published by ETSO are a first important step. On the other hand, a clear set of definitions is needed in order to calculate the transfer capacities (e.g. at weekly or daily time frames) that are the basis for the different allocation procedures already implemented or on the way to be implemented, such as auctions and market splittings.
- Applicability of the transfer capacity definitions for new allocation procedures. ETSO has worked out in November 2000 a first vision about a future large-scale capacity allocation scheme, so called “Co-ordinated auctioning of transmission capacity in meshed networks” [6]. The new definitions should fit also for a future implementation of such a mechanism.

Based on these considerations ETSO proposes to use on a European-wide level the following transfer capacity definitions and assessment guidelines. This document replaces the previous ETSO-paper on definition of transfer capacities [1].

Additionally ETSO will publish two other papers on this subject:

- A document on the procedures for transfer capacity assessments. This document will give the detailed guidelines for the TSOs on how to construct realistic base cases, and how to perform the calculations and the capacity evaluations.
- An updated version of the information for users [2].

2. TRANSFER CAPACITY DEFINITIONS

ETSO proposes to strictly distinguish between commercial and physical values. Thus, two sets of definitions exist, one related to programme values, the other to physical flows. The definitions that refer to programme values are presented in this document in detail. These values are important for market actors to prepare their commercial transactions. The physical complexity however should be dealt with by the TSOs. TSOs are responsible towards Regulators, Authorities etc. to carry out this work in a fair and non-discriminatory matter. Market actors should not be involved in this process.

Some basic explanations concerning the relations between transfer capacities in terms of exchange programmes and physical flows are given in chapter 4.2.

The fundamental notions in ETSO’s transfer capacity definitions were not changed and are:

The Total Transfer Capacity TTC, that is the maximum exchange programme between two areas compatible with operational security standards[1] applicable at each system if future network conditions, generation and load patterns were perfectly known in advance.

TTC is always related to a given power system scenario, i.e.: generation schedule, consumption pattern and available network that constitute the data allowing to build up a mathematical model of the power system (load flow equations). The solution of this model leads to the knowledge of the voltages at the network nodes and the power flows in the network elements which are the parameters being monitored by a TSO to assess system security. The solution of this model is the so-called base case and is the starting point for TTC computation. Thus evaluation of TTC between two electrical areas requires:

- To make a choice of a local power system scenario
- To define a base case[2], which involves the sharing of full information amongst TSOs to build up the global load flow model
- To apply an agreed procedure for carrying out the calculations.

As the result of this procedure, TTC equals the maximum exchange programme between the two areas being considered, if the generation and load pattern in these areas and in other areas strongly interconnected to these two would exactly correspond to the assumptions made in the evaluation steps, namely the ones implicit in the base case.

The uncertainties associated to the forecast of the power system state, for a given time period in the future, may decrease according to the selected time frame. Therefore the TTC value may vary (i.e. may increase or decrease) when approaching the time of programme execution as a result of a more accurate knowledge of generating unit schedules, load pattern, network topology and tie-lines availability.

The Transmission Reliability Margin TRM which is a security margin that copes with uncertainties on the computed TTC values arising from:

a) Unintended deviations of physical flows during operation due to the physical functioning of load-frequency regulation
b) Emergency exchanges between TSOs to cope with unexpected unbalanced situations in real time
c) Inaccuracies, e. g. in data collection and measurements

TRM is then associated to the real-time operation and its value is determined by each TSO, in order to guarantee the operation security of its own power system. TRM may vary seasonally or may be updated according to possible modifications occurred in the power system.

[1] The security standards are stated into each TSO ‘grid code’.
[2] The agreed procedures for building the base cases to be used by TSOs and to evaluate the transmission capacities are detailed in a separate ETSO document ‘Procedures for Transfer Capacity Assessments’ [3].

The Net Transfer Capacity NTC that is defined as:

NTC = TTC-TRM

NTC is the maximum exchange programme between two areas compatible with security standards applicable in both areas and taking into account the technical uncertainties on future network conditions.

TTC, TRM and NTC may vary along different time frames (year ahead to day ahead).

NTC may be allocated in different time frames to match the need for securing longer term trading and to provide room for shorter term trading. One may distinguish, as the result of the allocation procedures in each allocation time frame, two notions:

The Already Allocated Capacity AAC, that is the total amount of allocated transmission rights, whether they are capacity or exchange programmes depending on the allocation method.

The Available Transmission Capacity ATC, that is the part of NTC that remains available, after each phase of the allocation procedure, for further commercial activity. ATC is given by the following equation:

ATC = NTC- AAC

AAC and ATC are thus a result of each stage of the allocation procedure.

The following figure 1 gives an overview over the transfer capacity definitions.

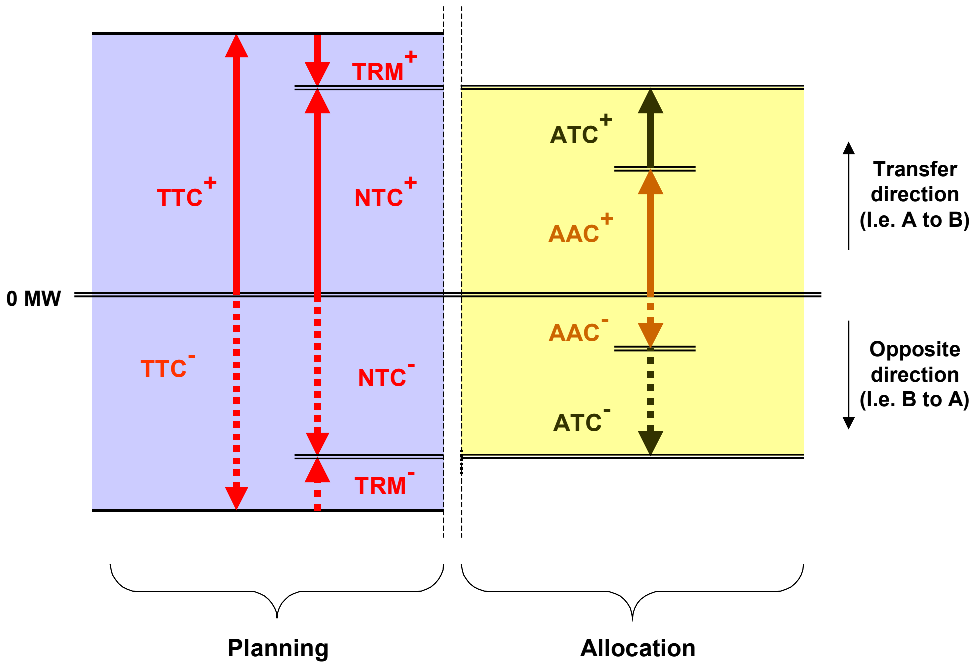

Figure 1: Transfer capacity definitions

3. USE OF THE DEFINITIONS

3.1 DIRECTIONAL AND TIME DEPENDENCIES.

As noted in the previous chapter, TTC computation starts establishing a base case. This base case will already contain exchange programmes between any pair of neighbour control areas. These are the various transactions (long term to spot contracts) likely to exist – according to what has been observed in the past – in the forecasted situation. In figure 2 for a given pair of neighbour control areas, A and B, for which capacities are to be computed, there exists in the base case a global exchange programme of magnitude BCE (Base Case Exchange).

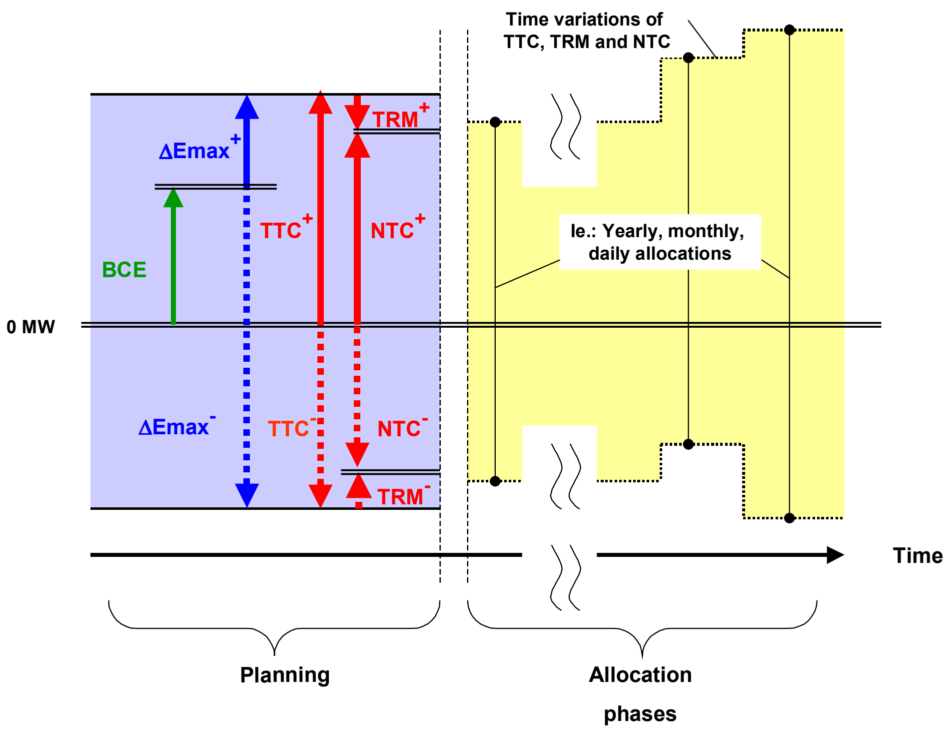

Figure 2: Transfer capacities in planning and for allocation phases.

From this starting situation, when computing TTC from area A to area B, generation is stepwise increased in control area A and decreased in control area B giving rise to a power flow from area A to area B .The shifts of generation are named in figure 2 as ΔE^+ and ΔE^- for the increase and the decrease respectively. This process is carried out up to the point, where security rules in either system A or B[3] are breached ($\Delta Emax^+$ / $\Delta Emax^-$). The maximum exchange from A to B compatible with security rules without taking into account uncertainties and inaccuracies – TTC from A to B – is then BCE + $\Delta Emax^+$. This procedure is reversed – decrease of generation in system A and increase of generation in system B – when computing TTC from area B to area A leading to a maximum increase of generation of

[3] The breaching of security rules may happen internally in any of these two systems or in the tie lines between them. It has to be beared in mind that the interconnector is not just the tie lines crossing the control areas borders but any network element which has a real impact upon the real transfer possibilities i.e., which may limit the exchange programmes.

$\Delta Emax^-$ and thus to a maximum exchange from B to A of $\Delta Emax^-$ - BCE, as shown in figure 2. In a next step TRM is deducted from the TTC values for both directions resulting in the corresponding NTC values.

The values of TTC, TRM and NTC are therefore directional. They are to be computed for a given interconnection in both directions of the energy exchange. Generally, the values of TTC, TRM and NTC in both directions are bound to be different. The values of AAC and ATC are as well directional; they are nothing else that a split of NTC established through the allocation procedure.

The scope of the transfer capacity definitions covers two sets of power system scenarios: One associated with the planning phase and another associated with the capacity allocation phases. The former is based on estimates of typical situations of the power system. The latter takes into account the exchange programmes already allocated in a given time frame (one year ahead until one day-ahead) and updates of the assumptions made on network topology, load and generation pattern. Starting from calculations for the operational planning and approaching the horizon of programme execution, the base cases normally vary with the consequence that also the values of TTC, TRM and NTC may vary. Thus the transfer capacities are also time dependent. These time dependencies are further discussed in the following chapters.

3.2 PLANNING PHASE

For the planning phase, which is the one leading to the seasonal capacities published by ETSO, the scenario corresponds to two typical peak periods, one in winter and the other in summer. The corresponding base cases are built according to observed states of the power system in the past ('snapshots' or recorded load flows of the power system in these situations) and are adapted according to a set of agreed guidelines to the expected system states corresponding to the forecasted situation.

The calculations of TTC and TRM lead then to NTC values that are indicative and non-binding. These values are just the best estimate by TSOs, providing a signal for market participants who should understand it as a reference value which will, sometimes, have to be adapted when approaching the programming horizon accordingly to the prevailing system conditions and in the extent these differ from the forecasted system conditions built in the base cases.

3.3 ALLOCATION PHASES

Interconnection capacity is allocated in different time frames in an attempt to match the needs of market parties for securing longer term trading and to provide room for shorter term trading. The split of capacity into different time frames may also reflect the fact that transmission capacities, being estimates based on power system forecasts, may vary following unexpected changes of power flows derived from the results of each allocation stage. The time frames considered (i.e.: year ahead to day ahead or even hours ahead) and the split of transmission capacity between them is a matter of 'capacity products' and is embedded into the allocation procedures applied by the concerned TSOs and, when applicable, of concerned PXs.

For the allocations, which are carried out regionally by the TSOs involved in a congested flow gate, the selected scenarios vary depending on the time frames considered. For the long-term allocation phases (year-ahead) the scenarios may be the same as those considered for the planning phase. For shorter time frames (month ahead to day ahead) the scenarios correspond to the expected situations for peak and off-peak system conditions for the next day or even to hourly scenarios. The corresponding base cases have to be built integrating the results of the previous allocation phases and the expected system states corresponding to the forecasted horizon, i.e.: Once, for example, the one year ahead allocation mechanisms have provided access rights to a set of transactions these have to be integrated into the base cases allowing computation of the TTC for, for example, the month ahead allocation process.

In most cases, when the allocation procedure reaches the day ahead all the exchange programmes with allocated capacity have to be confirmed (‘use or lose it’ principle). The confirmed programmes define CE (‘Confirmed Exchanges’) in both directions of exchanges. Whether these CE values are to be ‘netted’ or not in order to define ATC is a matter of the allocation procedure not of capacity definitions.

4. EXCHANGE PROGRAMMES AND PHYSICAL FLOWS

4.1 THE “PARALLEL FLOW” PHENOMENA

The above set of capacity parameters are in terms of bilateral exchange programmes between two neighbour areas. They would be closely connected to the power flows through the cross borders only in the ideal case of a peninsular system and its neighbour if both were interconnected through a single tie line. However, in a widely interconnected network like for example the UCTE network the power flow through the cross border tie lines between two neighbour areas A and B may be interpreted as a superposition of a direct flow, which is related to exchanges between A and B and a parallel flow, which is related to all the other exchanges in the meshed network and to the location of generations and loads in the several grids. Therefore there would be a parallel flow even if all the exchanges in the interconnected system were set at zero[4].

The ‘parallel flows’ are dealt with implicitly in the capacity assessment procedure in the sense that the base cases already contain scheduled cross-border exchanges and the corresponding load flow situations contain the associated power flows.

Thus the figures provided about capacities for highly meshed systems are limited in scope, in several senses:

- TTC and NTC values are computed between neighbour areas; these values are the result of assuming that only the transactions between these two areas are modified and the rest (‘third parties’ transactions) remain unaltered. This fact has two consequences:
  - The published values cannot be used for an exact planning of transactions if these do not correspond to generation and to consumption in the pair of control areas for which capacities are defined. I.e.: NTCs cannot be combined to derive possibilities of executing transactions according to a given transaction path (contract path).
  - If the pattern of ‘third party transactions’ differs noticeably from that taken into account in the forecast, TTC values may significantly differ. That may have a important impact upon the NTC value.

[4] Exchanges between A and any other system than B, between B and any other system than A, exchanges between any other pair of control areas and the sometimes so called ‘natural flows’, which appear even in the case of no exchanges between any pair of control areas due to the generation and load pattern of the grids.

- NTC values between pairs of control areas in meshed network systems are interdependent. For planning and for the sake of simplicity normally only one set of NTC values, that do not reflect NTC interdependencies between several borders, is published. In case of strong NTC interdependencies, better information can be provided by additionally computing values of transfer capacities for groups of areas. I.e., if there is a strong physical coupling between areas A and B regarding exchanges to area C, NTC would be provided from area A to area C, from area B to area C and from areas A + B, considered as a whole, to C. However, during the allocation phases the coupling between the areas has to be respected. Allocation thus may lead to new restrictions as shown in the following figure 3.

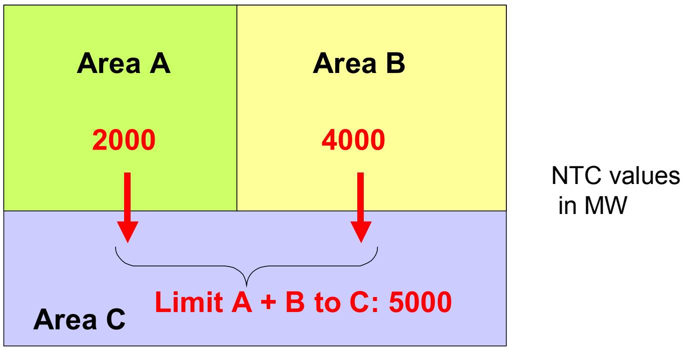

Figure 3: Interdependencies of NTC between two araes

In the figure it is assumed that in the planning phase the NTC value between areas A and C was assessed to 2000 MW and that idenpendently from this the calculation of NTC between areas B and C lead to a value of 4000 MW. For planning purposes the TSOs thus have given to market participants maximum values, not reflecting the interdependencies between the areas. Indeed the sum of import to area C may be limited to only 5000 MW. Then, at least during the allocations this fact has to be taken into consideration. It is out of the scope of this document to define the criteria for the split of this total value into the capacity for allocation from A to C and from B to C.

- Finally the NTC values itself do not provide the basis for a co-ordinated method of allocating cross border trade over several borders in a meshed network. A vision for a co-ordinated approach was already presented in a separate ETSO document [4]. It would relay on the same computation principles as outlined in this paper, but the allocation of transfer capacities would be effected on the basis of the consequences in terms of load flows and not directly using the bilateral values of NTC. *Therefore, the importance that NTC values actually have in the transaction based concepts of the international trade in Continental Europe will diminish.*

4.2 NOTIONS FOR PHYSICAL FLOWS

Figure 4 provides an example of the relationship between exchange programmes and physical flows.

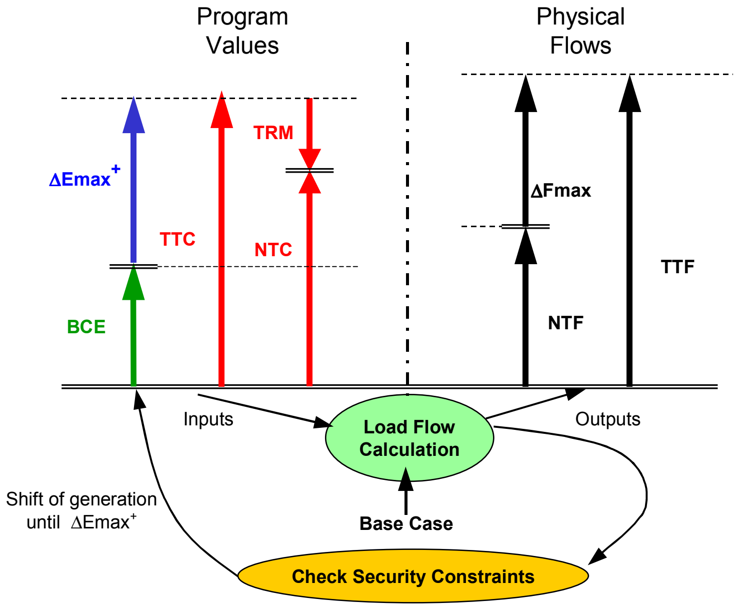

Figure 4: Definitions of transfer capacities and physical flows

This relationship is established through the load flow model of the whole interconnected system. All the terms that appear on the right hand side of this figure are net values of physical power flows. By net values is meant the sum of individual tie line power flows. The following terms define cross-border capacities as physical flows:

The Total Transfer Flow TTF is the net physical flow across the border associated with a programme exchange of magnitude TTC, provided that no other exchanges have been modified with respect to the ones existing in the base case. In this limited context – the one which applies to TTC computation – TTF may be understood as the physically maximum cross-border flow compatible with security standards in each control area[5]. TTF may be greater or smaller than TTC.

TTF can be split into two terms:

- **The Notified Transmission Flow NTF,** which is the physical flow over the tie lines between the considered areas observed in the base case prior to any generation shift between the areas. It results from the flow originated by the base case exchange (BCE)

[5] The breaching of security rules may happen internally in any of these two systems or in the tie lines between them. It has to be beared in mind that the interconnector is not just the tie lines crossing the control areas borders but any network element which has a real impact upon the real transfer possibilities i.e., which may limit the exchange programmes.

and from the parallel flows. It is extremely difficult and often even impossible to identify the different origins of parallel flows that lead to the NTF value and to separate them into distinguished terms (such as loop flows, natual flows) because of non-linear physical phenomena in the networks. On the other hand, a split of NTC is technically not necessary for the procedure of transfer capacity assessments and would also not be relevant for market actors.

- **The physical flow ΔFmax** that is the physical flow over the tie lines between the considered areas induced by the maximum generation shift ΔEmax.

Thus, the total transfer flow can also be expressed as:

TTF = NTF + ΔFmax

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[3] Procedures for Transfer Capacity Assessments, ETSO, in elaboration

[4] Co-ordinated Auctioning of Transmission Capacity in Meshed Networks, Discussion paper, ETSO, November 2000