Determination of Transfer Capacity at trade relevant Cross-Border Interconnections of TenneT TSO GmbH

At TenneT TSO GmbH (TTG), the transfer capacity of the cross-border interconnections

- Denmark (DK), neighbouring system operator Energinet.dk (EnDK)
- Czech Republic (CZ), neighbouring system operator CEPS
- Netherland (NL), neighbouring system operator TenneT TSO B.V.(TTB)

managed in context of capacity allocations is determined.

1. Current Standards

At TTG, the capacity calculation method relies on the so-called ENTSO-E NTC procedure[1].

The following terms will be used in this context:

TTC: Total transfer capacity
TRM: Transmission reliability margin
NTC: Net transfer capacity
ATC: Available transfer capacity
NTF: Notified transmission flows

The following applies: NTC = TTC – TRM and ATC = NTC – NTF, whereas the TTC is a result of the capacity calculation.

The capacity is calculated individually for the annual, monthly and daily auction. The auction is based on the respective numerical minimum of the NTCs determined by the neighbouring system operators. Accordingly, the NTC calculated by the TTG for the TTG grid area will only then correspond to the offered capacities, if

[1] https://www.entsoe.eu/fileadmin/user_upload/_library/ntc/entsoe_proceduresCapacityAssessments.pdf

the respective neighbouring grid operator did not find lower NTC numbers. The n-1 principle will be used as business security rule. Detailed descriptions can be found in "Transmission Code 2007, Netz- und Systemregeln der deutschen Übertragungsnetzbetreiber“ (in German, August 2007)[2] as well as in UCTE Operation Handbook Policy 3 Chapter A (version 03/19/2009)[3].

In context of the TTC calculation, additional transfer tasks are simulated among the neighbouring transmission grids. Thereby, on the one side of the relevant border the generated power performance will proportionally be increased and on the other side it will be lowered accordingly. The limit of the grid transfer capacity is achieved, if the n-1 principle can be just preserved with respect to the grid.

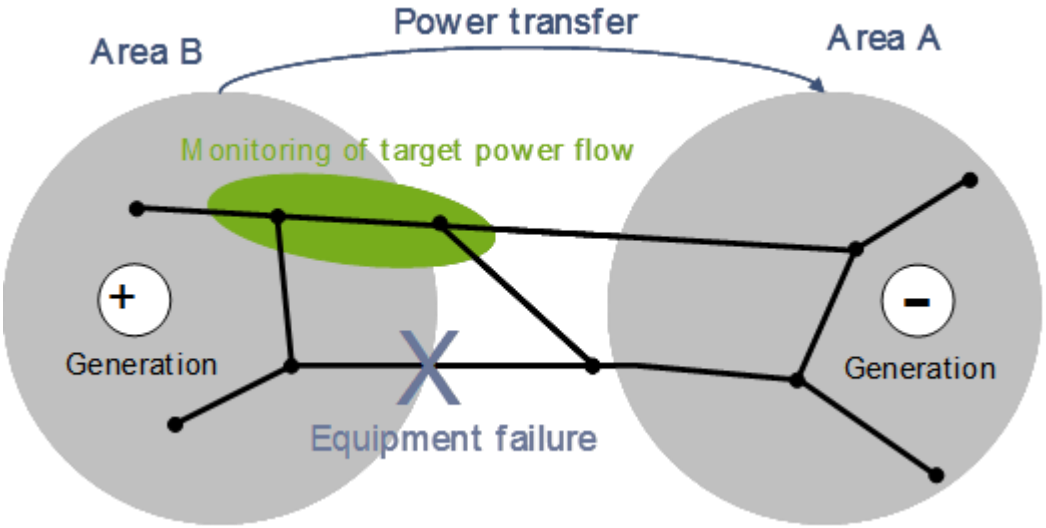

Figure 1 shows this principle.

The TTC numbers are given by technical and operational limits of the operational power flow permitted for the operating equipment in the interface of the neighbouring transmission grids, including connecting cables. In addition, the specific load and generation situation of the interrelated region will be considered.

[2] http://www.bdew.de/internet.nsf/id/DE_NetzCodes-und-Richtlinien
[3] https://www.entsoe.eu/resources/publications/system-operations/operation-handbook/

2. Further Developments of Capacity Calculation Methods

In addition to the pure bilateral capacity calculation, procedures were established by means of praxis, which aim at considering the influence of other regions. Here, it is relevant not to exceed a so-called profile as total values of the bilateral NTC at the borders of Germany to Poland and Czech Republic as well as the so-called C function, which is used in the Western part of Germany at the borders towards the Netherlands, France and Switzerland. Also, the direct consideration of other factors such as generation or load situation needs to be understood as further development of this method.

2.1 C Function[4]

The profile, which is used to calculate the short-term and final capacity numbers for a business date, must meet the criteria described in the following. The calculation is conducted coordinately and on a large-scale. Crucial parameters are in particular wind generations in Germany, which are predictable on a short-term basis. Thus, the market has access to maximal capacity and at the same time grid security is maintained. On the profile, the derivations between physical load flow and scheduled programs should be minimal for the sum of the individual borders. This way, it is secured that the capacity numbers for the profile are determined without being influenced by other borders.
The German C (border DE-NL/BE, GE-FR and DE-CH) was therefore selected as technical profile, whereas according to newer information the numbers for "export as well as import from / to DE via the German C" refer to the relevant capacity numbers with France, the Netherlands and Switzerland.

Due to the changes of the grid caused by the accelerated end of the nuclear energy program, the German TSOs had to adjust the C function with respect to the above mentioned target numbers. Here, the basis refers to scenarios with winds and heavy load which show that in addition to the traditional wind dependency of export, an extension of the import from the Netherlands is required as well as a fundamental adjustment of the C function to the status of the wind generation extension in Germany. Before winter 2011/2012, TTG bilaterally agreed on the NTC with the Dutch grid operator. This number was taken by the other TSOs participating in the C function as basic number for using the C function. Now, based on the C function agreed on with all participating TSOs, the bilateral capacity is calculated at the border to the Netherlands.

The results of the calculation based on the C function are used as basic numbers in the subsequent "coordinated ATC procedure". Based on D-2CF data sets, an evaluation is conducted together with the grid operators RTE (France), ELIA (Belgium), TenneT TSO BV (the Netherlands), CREOS (Luxembourg), Amprion and Transnet BW (both Germany) in the CWE region since November 2010, whether the above mentioned basic NTC numbers lead to an overload of the upfront specified critical branches.

[4] Description partly taken from:
http://www.amprion.net/berechnung-gesamtuebertragungskapazitaet \ Approved capacity model

2.2 Further Development of the Capacity Calculation at the Border to Denmark

Analogously to the C function, at the border to Denmark the day-ahead capacity released is dependent on load and wind. This reflects in particular the consideration of wind power expansion in Schleswig-Holstein while possible trading will be optimised at the same time.

Because of missing meshing at this border, further coordination with other partners is not required. However, an optimisation of the bilateral NTC is possible by considering shutting down local power plants and using phase shifters. Phase shifters will optimise the use of the different cross-border interconnectors.

3. Approach at the Individual Cross-Border Interconnections

3.1 Topography

The following Figure 2 illustrates the structure of the TTG transmission grids as well as the position of the interconnectors. The blue lines outline the interface areas with structural congestions towards the neighbouring transmission grids.

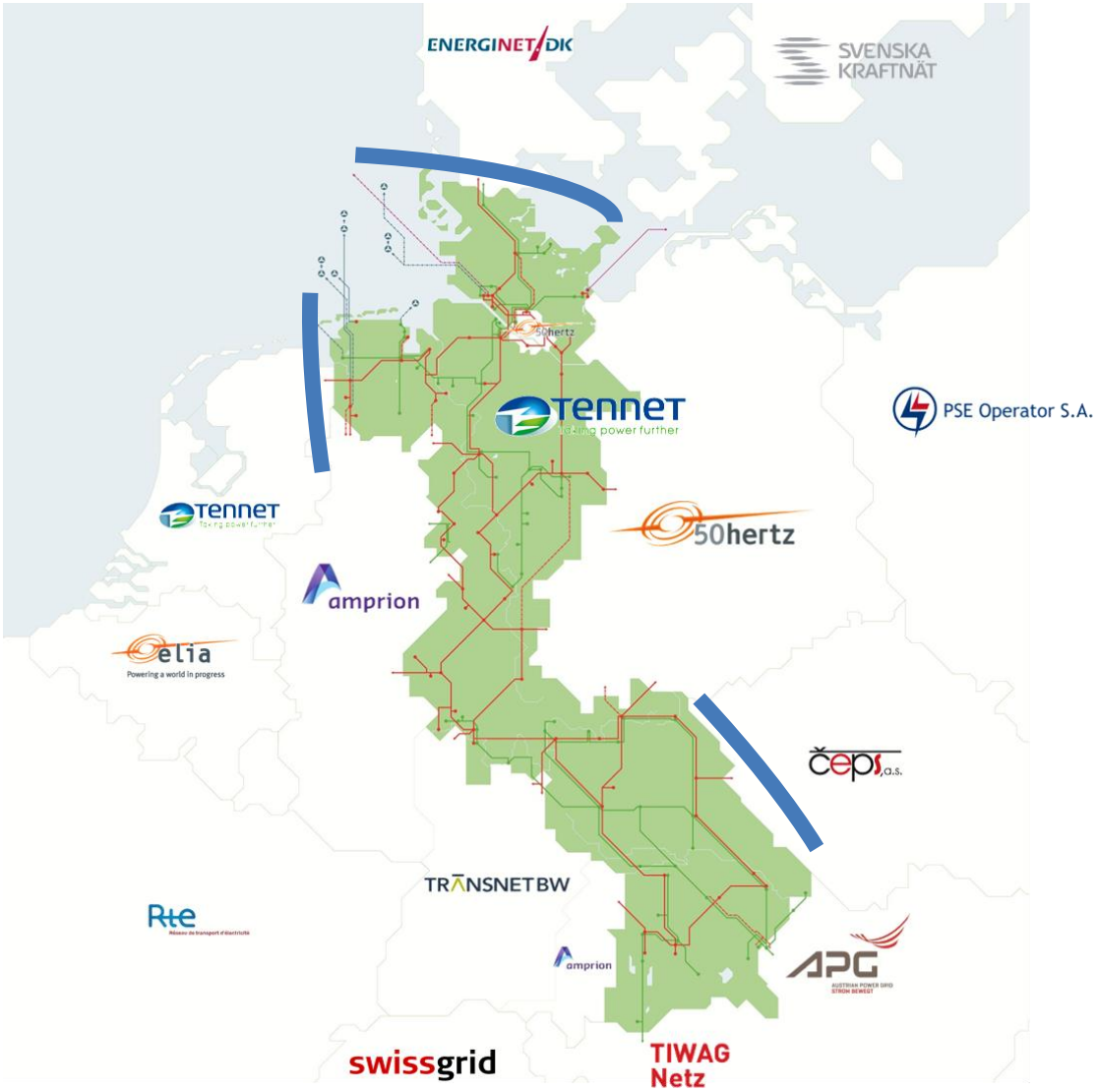

Figure 2: Topography and interfaces to neighbouring grids

3.2 Overview of All Cross-Border Interconnections at Structural Congestions

Below you will find in Table 1 all cross-border interconnections of the congested borders with their respective names.

no.	partner	voltage level	name of networkelement TenneT D
1	CEPS	380 kV	SK Etzenricht-Hradec 441
2	CEPS	380kV	SK Etzenricht-Prestice 442
3	TTB	380 kV	Diele-Meeden schwarz
4	TTB	380 kV	Diele-Meeden weiß
7	EnDK	380 kV	Audorf-Kassö blau 2, Flensburg
8	EnDK	380 kV	Audorf-Kassö grün 1, Flensburg
9	EnDK	220 kV	Flensburg-Kassö rot
10	EnDK	220 kV	Flensburg-Ensted gelb

Table 1: Cross-border interconnections

3.3 Cross-Border Interconnection CZ

TTG determines the maximal capacity number (TTC) for the transfer direction CZ – DE on a regular basis. However, the capacity in the opposite direction DE – CZ will only be determined in context of the calculation of the annual capacity. Up until now, this annual number was significantly higher than the number found by CEPS - possibly also in a shorter period of time - and therefore does not determine the result of the auction. This is why from the viewpoint of TTG there is no need for a high frequently determination, that is monthly or daily.

The following explanations refer to the capacity calculation CZ - DE: In addition to the interface between TTG and CEPS, the capacity number for the combined cross-border interconnection between Poland/Czech Republic and Germany also comprises the border sections between 50 Hz Transmission and CEPS as well as between 50 Hz Transmission and PSE-O (Poland). TTG first determines the NTC number assuming an n-1 secure grid operation for the complete German border mentioned above and then splits it up into equal parts for both German interface portions of 50 Hz Transmission and TTG. When calculating the NTC, a TRM of 100 MW is assumed for the complete German border. Here, the TRM can be lower than the result calculated with the ENTSO-E root formula since a precise analysis of the underlying uncertainties was conducted. Regarding the database for determining the TTC number, see Section 3.6.

3.4 Cross-Border Interconnection NL

An agreement between the neighbouring TSOs TenneT TSO BV (NL), TTG, Amprion (both DE) and Elia (BE), which follows the Dutch laws, exists for the maximal import and export of the Netherlands. The maximal NTC in total across all 3 NL border section is 3,850 MW. This number is the basic value for the determination of the bilateral NTC and the total capacity of the so-called "C function" for the German South-West border by the TSOs responsible for the grid. The distribution to the relevant borders always occurs according to a fixed ratio. If the maximal NTC number of the Dutch border is not available, the individual borders will be reduced proportionally. TenneT TSO BV manages the operational coordination of the capacity numbers relevant for the auction for all four TSOs.

Windprognose DE (MW)		Export DE (MW)			Import DE (MW)		
von	bis	C-Funktion	DE => NL	TTG => NL	C-Funktion	NL => DE	NL => TTG
0	7000	7449	2449	924	8249	2449	924
7001	11000	6749	2449	924	7987	2187	825
11001	14000	5649	2449	924	7727	1927	727
14001	18000	4500	1800	679	7465	1665	628
18001	∞	3468	1468	554	7268	1468	554

Table 2: Numbers of the C function

For the capacity number "Export from DE via the German C", the maximum of 7,449 MW was calculated. Newest operational experience and simulation calculations show that massive congestions occur in the relevant grid region above this maximum commercial power exchange. Dependent on the wind generation in Germany and possibly other factors, this maximal export number needs to be lowered. The current numbers of the C function are for the export between 3,468 MW and 7,449 MW, and for the import between 7,268 MW and 8,249 MW. Table 2 shows this dependency and the portions of the Dutch border and TTG.

In the case of the above mentioned maximal exchange of the Netherlands, an NTC portion of 924 MW per direction applies to the bilateral interface between TTG and TenneT TSO BV. This proportional NTC number follows the C function arithmetic described above (see Section 2.1 and Table 1). Of course, in the case of scheduled operational shutdowns, the calculated numbers will be adjusted depending on needs using load flow calculations. This wind dependency is typically only reflected in the released day-ahead capacities. The long-term capacities provided remain unaffected by the introduction of the C function.

Regarding the TRM, the ENTSO-E root formula will be used in relation to 6 interconnections provided by Amprion and TTG between Germany and the Netherlands. It results root (6)*100MW=244.9 MW, rounded to 250 MW as total number for Germany. Regarding the database for determining the TTC number, see

Section 3.6.

3.5 Cross-Border Interconnection DK

At the cross-border interconnection between Energinet.dk and TTG, a directed operation takes place because of the missing mesh structure of the grid. Thus, the numbers for the available transfer capacity is in general static for the current grid topology. After the grid was retrofitted, since 02/01/2007 the maximal NTC was 1,500 MW in direction DK West - DE and 950 MW in direction DE - DK West. These static numbers were adjusted accordingly in the case of scheduled shutdowns and specific constellations of the wind power generation.
By means of grid expansion, optimisation of the current usage of interconnections and the use of phase shifters, since September 2012 a maximal transfer capacity of 1,780 MW in direction DK-DE and 1,500 MW in direction DE-DK is possible. The increase of the maximal capacities can only be temporarily realised taking into account current wind generation dependency.

In the case of DK, the directed operation allows to determine the TRM more precisely and at a lower level than with the ENTSO-E root formula. The level of the TRM is 100 MW in both directions. Regarding the database for determining the TTC number, see Section 3.6.

3.6 Database for Determining TTC

Annual capacity:
The annual capacity calculation is based on semi-annual reference datasets agreed on by the UCTE members (summer, winter). In this context, the used 380/220-kV reference dataset will be complemented by critical 110-kV operation equipment and will be adjusted considering not only the annual outage planning known at the time of the calculations but also unfavourable overlapping scenarios. In Germany, a maximal wind situation will be postulated for the generation of wind power.

Monthly Capacity:
The calculation of the monthly capacity of the following month is based on a DACF dataset, which has been complemented by relevant 110-kV grid elements. For the border CZ - DE, typically the 10:30 a.m. dataset of the last Wednesday of the month before the previous month is used. For the borders NL – DE and DK - DE, the 10:30 a.m. dataset of the first Wednesday of the previous month is used. The used dataset will be adjusted to the current status quo of the outage planning and, if relevant, to unfavourable overlapping scenarios. In Germany, a seasonal maximal wind situation will be postulated for the generation of wind power.

Daily capacity:
Depending on the needs, a new calculation will be performed on a daily basis. In principle, the results for the monthly capacity calculation will be used and will be checked each workday on how changes of the topology or further load flow parameters modify the situation at the cross-border interconnections on a short-term

basis. Furthermore, current forecasts are considered for wind and PV generation as well as for the load. Optimising the capacity calculation requires further calculations.