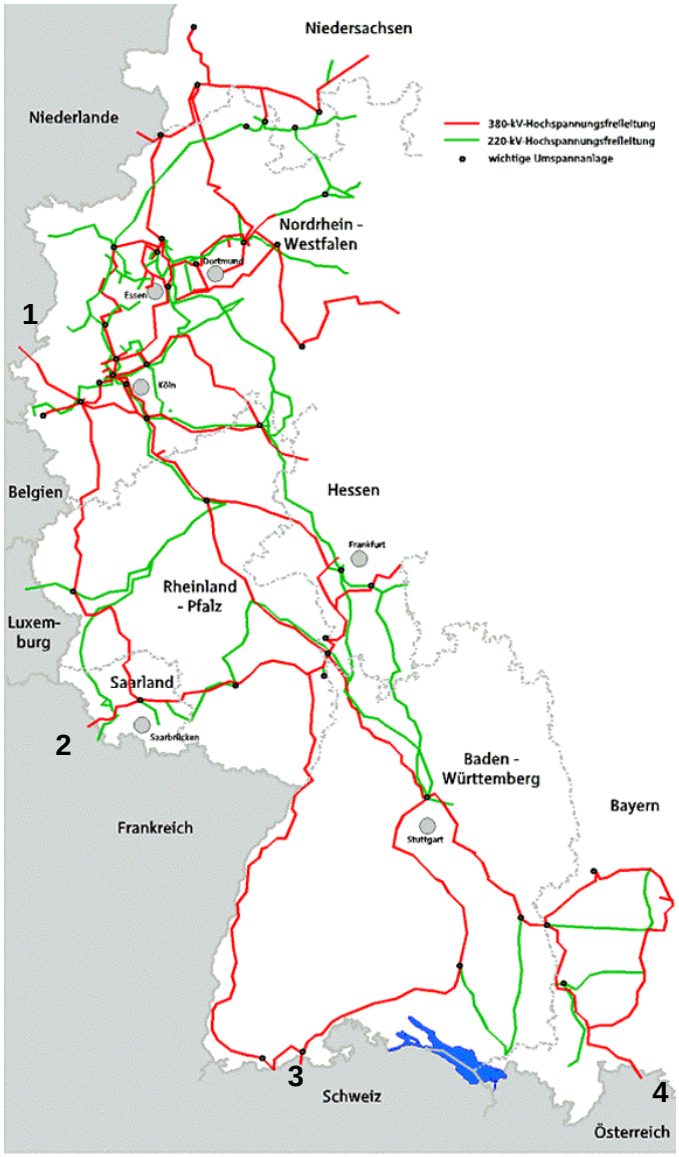
Calculation of transmission capacities between partner-grids

20th May 2015

In co-operation with its interconnection partners Amprion determines the transmission capacities for the interconnections to France, the Netherlands, Switzerland and Austria. This determination is limited to the interconnectors of the 220-/380-kV-grid. Figure 1 outlines the present Amprion grid including all these interconnectors.



1	NL
2	FR
3	CH
4	AT

Figure 1: 220-/380-kV-transmission-grid of Amprion

As a first step for the capacity calculation the ENTSO-E NTC-value-determination is applied. Further to this bilateral calculation, a co-ordinated capacity calculation and allocation via a technical profile is carried out in co-operation with the adjacent TSOs. The available capacities are determined for the following time-frames:

- Long-term (Yearly auction)
- Mid-term (Monthly auctions) and
- Short-term (daily, day-ahead).

The associated specific procedures are further explained below.

In Table 1 all interconnections (incl. Luxembourg) are listed.

Voltage level (kV)	TSO	Station	Adjascent TSO	Station
380	Amprion	Gronau	NL TENNET	Hengelo
380	Amprion	Gronau	NL TENNET	Hengelo
380	Amprion	Siersdorf	NL TENNET	Maasbracht
380	Amprion	Rommerskirchen	NL TENNET	Maasbracht
380	Amprion	Ensdorf	FR RTE	Vigy
380	Amprion	Ensdorf	FR RTE	Vigy
220	Amprion	Ensdorf	FR RTE	St-Avold
380	Amprion	Kühmoos	CH swissgrid	Laufenburg
380	Amprion	Tiengen	CH swissgrid	Laufenburg
380	Amprion	Tiengen	CH swissgrid	Beznau
220	Amprion	Tiengen	CH swissgrid	Beznau
220	Amprion	Memmingen	AT APG	Westtirol
380	Amprion	Leupolz	AT APG	Westtirol
220	Amprion	Bauler	LU Creos	Flebour
220	Amprion	Bauler	LU Creos	Roost
220	Amprion	Trier	LU Creos	Heisdorf
220	Amprion	Quint	LU Creos	Heisdorf

Table 1: International interconnectors of Amprion

Calculation of the NTC-values in accordance with ENTSO-E

Database

Twice a year all TSOs of the ENTSO-E Regional Group Continental Europe (RG CE) area generate and exchange planning data bases. These datasets contain the grid-topology, generation patterns, agreed export/import situations and a German wind- and solar forecast. The German Control Block (GCB) currently consists of four control areas. The national partners send their agreed datasets to the Amprion Control Centre in Brauweiler. Their individual datasets are then aggregated into a co-ordinated and consistent dataset for the German Control Block (GCB). In a subsequent step Amprion determines the so-called RG CE reference case for summer and winter out of all RG CE datasets. This reference case represents a typical pan-European load flow setting for summer and winter respectively.

NTC calculation

The determination of NTC-values is compliant with the ENTSO-E calculation methodology. The NTC-value is the most appropriate bilaterally determined limitation for the physical load flow between adjacent grid areas.

The simulations are carried out based on a forecast dataset by increasing still available generation capacity in Germany. To ensure a balanced state of the power system the generation in a second grid area (Netherlands, France, Switzerland, Austria) needs to be reduced by the same level as it has been increased in Germany. The calculations are carried out iteratively, i.e. after adjusting the power exchange situation (BCE - base exchange in the dataset) by e.g. + 500 MW (ΔE) more export from Germany to France, a reassessment of the (n-1) secure operation of all network elements in the German control block and of all interconnectors is carried out. The power exchange between these two areas is then further increased/ decreased until the (n-1)-criterion is violated. This exchange limit is referred to as Total Transfer Capacity (TTC). It contains no security-reserves in the grid. Therefore, the TTC-value is reduced by a security margin (the so called TRM - Transfer Reliability Margin).

$$TTC = BCE + \Delta E$$
$$NTC = TTC - TRM$$
$$TRM = \sqrt{n} \cdot 100MW$$

In the above calculation formula for the TRM, the letter n is the number of interconnection lines between two adjacent control areas or blocks (DE-FR: n = 4, DE-NL: n = 6, CH-DE: n = 15, AT-DE: n = 14). The TRM is a security margin covering primary control energy exchanges in case of power plant outages, unintentional physical power flow due to load-frequency control, security reserves between TSOs as well as imprecise data and metering.

After completion of all calculations by adjacent TSOs the following matching is performed (Figure 2).

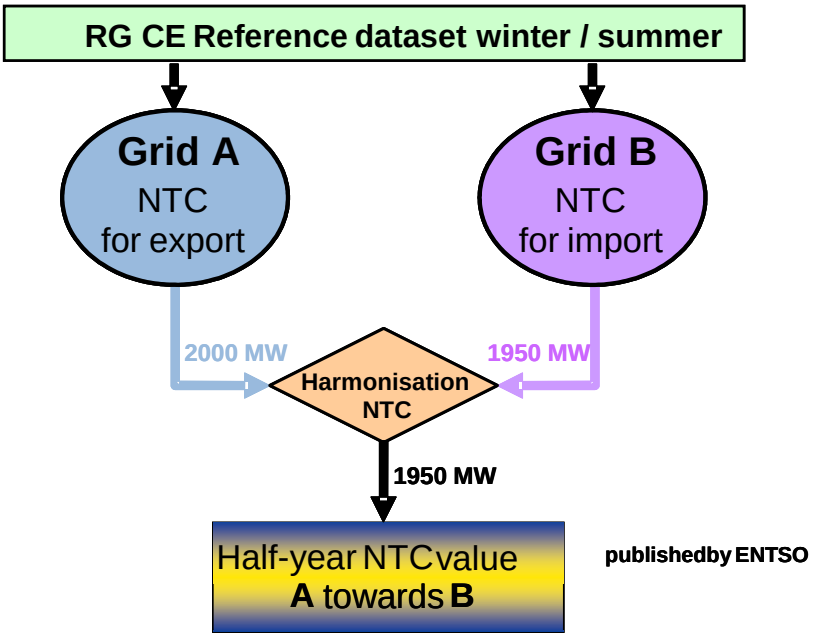


Figure 2: matching of NTC-values

The bilaterally calculated NTC-value is the theoretical maximum capacity value. All NTC-values submitted to the ENTSO-E are maximum values which may not occur simultaneously. Otherwise, overloads may occur and as a result the security of the grid would be at risk. This benchmark is the maximum exchange limit between two adjacent electrical grids provided that the exchange scenario of the other ENTSO-E partners remains unchanged.

Technical profile of the C-function

Background

Since the end of 2004, congestions have occurred frequently although the energy traded never exceeded the predetermined NTC-values. The reason for these increasing congestions is inter alia the volatile liberalized energy market. Generation companies sell their capacities on a wider scale, i.e. across control areas. Simultaneous exports from DE towards NL, FR and CH cause simultaneous load flows which lead to congestions in these regions. A regional balance of load and generation no longer exists and increasingly high loop-flows (discrepancies between physical flows and schedules) arise on interconnection lines towards international partners. These events with relevance for the overall system security show that a bilateral approach is no longer sufficient. A more co-ordinated allocation of capacities following technical profiles is essential.

Therefore, the C-Function was developed as a new capacity calculation concept for the short term (daily capacities) in consideration of wind energy forecasts in addition to the ENTSO-E-methodology for the control area boundaries between Germany, the Netherlands, France and Switzerland.

With the introduction of the CWE Market Coupling on 9 November 2010, an additional new process of NTC verification and adjustment based on the approved C–Function was adopted (the so called “16 Corner Process”). This process helped to increase coordination and adjustment between CWE partners: All NTC values submitted by TSOs are merged and examined in a security calculation in the context of an extreme value analysis. For CWE borders 2^4= 16 calculation combinations are thereby created.

The C-Function methodology will be replaced, for the trading day 21st May ongoing, for the short term capacity calculation on the borders DE-NL and DE-FR by the flow based capacity calculation in the CWE region. Respective details can be found on: http://www.casc.eu/en/Resource-center/CWE-Flow-Based-MC/Approval-Documents

BNetzA has approved this methodology on based on the document “Genehmigungsantrag zur lastflussbasierten Kapazitätsberechnung (FBKB) in der CWE-Region gemäß Art. 15 Abs. 2 EU-VO 714/2009“.

The German C-Profile for export and import situations

The profile for calculating short-term and final capacity values for delivery day d must be compliant with the following criteria: The calculation of capacity is coordinated and takes a wide area into account. The critical parameter is the generation of wind in Germany which can only be forecasted on short notice. Consequently, the largest possible capacities under the given grid security constraints are made available to the market. For the profiled region deviations between physical and scheduled flows shall be minimal. This ensures that the capacity value for the profile can be determined without impacting other cross border capacities.

In compliance with these criteria the “German C-profile” (border Germany-Netherlands / Belgium, Germany-France, Germany-Switzerland) has been selected as the relevant technical profile (see figure 3). The value for “Export over the German C” is the overall capacity value towards France, the Netherlands and Switzerland.

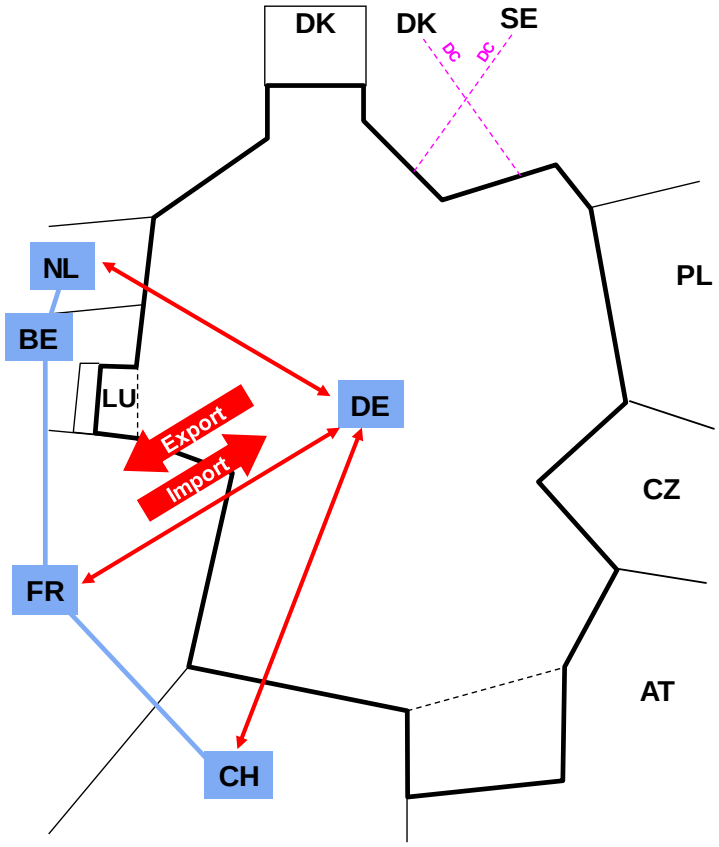


Figure 3 Adjusted German C-Profile (Border DE-NL/BE, DE-FR und DE-CH)

For the overall capacity “Export from Germany over the German C“ a maximum of 7,449 MW has been determined. Recent operational experience and simulations have demonstrated that from this amount of commercial power exchange in this grid area, significant congestion occurs. Dependent on wind generation in Germany and where necessary other influencing factors, a reduction of this maximum value of export may be required. The C-Function capacity values range between 3,468 MW and 7,449 MW for export and between 7,268 MW and 8,249 MW for import (see table 2).

Long-, mid- and short-term capacities

Capacities are allocated to the market for different time horizons. The reason for this cascaded allocation is that closer to the time of capacity usage the predictability of factors which are relevant for grid security increases (grid topology, disposability of power plants, environmental influences). Additionally, energy market actors require different products, (long-, middle- and short term).

The coordination and capacity determination takes place between TenneT (NL), RTE (FR), Swissgrid (CH), TenneT GmbH (DE), EnBW TNG (DE) and Amprion (DE). For the co-ordinated allocation, the cross border capacity values determined by different interconnection-partners are set to the lowest calculated value. This ensures a secure grid operation.

The overall capacity Germany-Netherlands is subdivided between Amprion and TenneT GmbH according to the installed interconnector capacities.

Long-term capacities (yearly capacities)

The above mentioned ENTSO-E reference data-set for summer and winter is updated taking into account additional data for the following year, i.e. disposability of power plants and important interconnection lines. If available, planned yearly outage schedules of national and international partners as well as power plant maintenance and inspection plans known to Amprion are integrated into the calculation. Thereafter, the available capacity for the yearly auction is determined and allocated to the different borders. The C-Function is not used for the determination of available capacity for the yearly auction. Yet, the sum of long-term capacities at a border (yearly and monthly capacity) must be smaller than the minimum of bilateral capacities (at highest wind level) resulting from the C-Function.

Mid-term capacities (monthly capacities)

The co-ordinated allocation of capacities for the monthly auction is processed in coherence with the yearly capacity allocation. Additional information for the following month on grid topology changes and power plant availabilities is taken into account.

Short-term capacities (day ahead)

Since May 2015 the so-called flow based capacity calculation and allocation is applied in Belgium, France, the Netherlands and Germany for the allocation of maximal capacity in exporting and importing directions in Central Western European Region (CWE-Region).

The C-Function (see table 2) will be further used for capacity calculation on the border DE-CH.

Determination of the level and partitioning of the C-Function:

Wind forecast d-2, [MW]	**0 – 7,000**	**7,000 – 11.000**	**11,000 – 14,000**	**14,000 – 18,000**	**> 18,000**
C-function [MW] Export DE	**7,449**	**6,749**	**5,649**	**4.500**	**3,468**
C-Funktion [MW] Import DE	**8,249**	**7,987**	**7,727**	**7,465**	**7,268**

Table 2: Determination of the level and partitioning of the C-Function