REPORT OF THE GERMAN TRANSMISSION SYSTEM OPERATORS ON AVAILABLE CROSS-ZONAL CAPACITY FOR THE YEAR 2021 PURSUANT TO ARTICLE 15(4) INTERNAL MARKET FOR ELECTRICITY REGULATION (EU) 2019/943

AS OF: 22/4/2022

CREATED BY

THE GERMAN TRANSMISSION SYSTEM OPERATORS WITH CONTROL AREA RESPONSIBILITIES

IN COLLABORATION WITH THE TRANSMISSION SYSTEM OPERATOR WITHOUT CONTROL AREA RESPONSIBILITY

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SUMMARY

The EU Electricity Market Regulation (EU) 2019/943, which entered into force on 4/7/2019, prescribes a minimum value for the capacity to be available for cross-zonal electricity trading of 70% as of 1/1/2020. With its “Bidding Zone Action Plan”[1], Germany is applying an exemption cause provided in Art. 15 of the EU Electricity Market Regulation and is increasing the capacity for cross-zonal electricity trading from the level of 2020 by a linear trajectory to a minimum of 70% by 31/12/2025. Implementation of an action plan is associated with an obligation to carry out annual evaluations of compliance with the minimum values for cross-zonal electricity trading by the involved transmission system operators. The present report has been produced to meet this obligation by the control area-managing transmission system operators 50Hertz Transmission GmbH (50Hertz), Amprion GmbH (Amprion), TransnetBW GmbH (TransnetBW) and TenneT TSO GmbH (TenneT) as well as the transmission system operator without control area responsibility Baltic Cable AB (BCAB). In accordance with the requirements of the EU Electricity Market Regulation, the methodology and data basis of the present report had been submitted to the national regulatory authority Bundesnetzagentur (Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railways, BNetzA) for approval.

The minimum values for cross-zonal electricity trading at the borders Germany – Denmark 1, Germany – Denmark 2, Germany – Norway 2 and Germany – Poland/Czech Republic were fulfilled at all times during 2021 by the balancing responsible transmission system operators 50Hertz and TenneT. At the border Germany – Sweden 4, TenneT has always reached the minimum value in the import direction and in the export direction in 99% of all 2021 hours. In 90 hours, the minimum value in the export direction was suspended due to critical line unavailability.

On the network elements of the CWE region, the minimum value had been reached at all times by the responsible transmission system operators Amprion, TenneT and TransnetBW.

In summary, 50Hertz, Amprion, TransnetBW, TenneT and BCAB complied with the statutory requirements for cross-zonal electricity trading pursuant to Art. 15 and 16 of the EU Electricity Market Regulation at all times during the year 2021.

[1] https://www.bmwi.de/Redaktion/DE/Downloads/A/aktionsplan-gebotszone.pdf?__blob=publicationFile&v=10

1. LEGAL BACKGROUND

The EU Electricity Market Regulation (EU) 2019/943, which entered into force on 4/7/2019, stipulates that transmission system operators (TSOs) may not restrict the cross-zonal transmission capacity to eliminate congestion within a bidding zone. This requirement is considered met if a minimum value of 70% is achieved for the cross-zonal electricity trading. Specifically, this means that as of 1/1/2020, at least 70% of the border transmission capacity of borders with NTC[2] capacity calculation and at least 70% of the transmission capacity of the critical network elements of borders with flow-based capacity calculation (in consideration of system stability) must be offered for cross-zonal electricity trading (Art. 16(8)).

For Member States that have identified structural grid congestion, the EU Electricity Market Regulation opens up the possibility of submitting an action plan to reduce this congestion (Art. 15(1)). In this case, the minimum value for cross-zonal trade capacity is to be raised annually in steps from 1/1/2021 to 31/12/2025 until reaching 70%, starting from the average level of the past three years or the maximum of these years (Art. 15(2)) as a minimum value in 2020.

Against this backdrop and after consultation with stakeholders and Member States, the Federal Republic of Germany submitted the Bidding Zone Action Plan 28/12/2019 to the European Commission (EC) and the Agency for the Cooperation of Energy Regulators (ACER). The Bidding Zone Action Plan contains concrete measures by which Germany will counteract the structural congestion described above and raise the minimum capacity for cross-zonal electricity trading in stages up to 70% by 31/12/2025.

Implementation of an action plan is associated with an obligation to carry out annual evaluations of compliance with the minimum values for cross-zonal trade capacity by the involved TSOs. The data basis for these evaluations must be approved by the corresponding national regulatory authority (NRA), in this case by the BNetzA.
On this basis, the first evaluation was submitted to the relevant NRA BNetzA and to ACER (Art. 15(4)) as the 2020 Compliance Report dated 18/5/2021. This Report was approved by the BNetzA by a decision dated 1/6/2021. The legal requirements for cross-zonal trade capacity in accordance with Articles 15 and 16 of the Electricity Market Regulation therefore have been met at all times in 2020. The present report has been produced by the control area-managing TSOs 50Hertz Transmission GmbH (50Hertz), Amprion GmbH (Amprion), TransnetBW GmbH (TransnetBW) and TenneT TSO GmbH (TenneT) as well as the TSO without control area responsibility Baltic Cable AB (BCAB) to comply with the obligations under Art. 15 (4) Electricity Market Regulation for the year 2021.

[2] NTC (net transfer capacity) refers both to a capacity calculation method for determining border-specific transmission capacity and to its result.

2. LINEAR TRAJECTORY OF THE GERMAN ACTION PLAN

In accordance with the “Bidding Zone Action Plan”, the Federal Ministry for Economic Affairs and Climate Action (BMWK) has instructed the German TSOs to calculate the initial values for the linear trajectory pursuant to Art. 15(2) of the EU Electricity Market Regulation.

Based on the principles for calculating and reporting the initial values provided by the BNetzA[3], the German TSOs 50Hertz, Amprion, TransnetBW and TenneT[4] have calculated and published[5] the initial values for the German bidding zone borders[6] and critical network elements. The principles for calculating the initial values stipulate, amongst other rules, that a common average be calculated and defined as the initial value for all bidding zone borders and critical network elements that will in future be part of the flow-based market coupling in the capacity calculation region (CCR) Core (Core FB MC). Starting from this initial value, a staged linear trajectory of minimum values is to be determined for the intervening years until reaching the target level of 70% on 31/12/2025. Until the implementation of the Core FB MC in 2022, the minimum values determined in this way will be applied within the flow-based market coupling in the Central Western European region (CWE) and at the NTC borders that will be part of the Core FB MC in the future. An initial value must be determined and applied for each of the borders in the capacity calculation region Hansa Germany – Denmark 1 (DE-DK1), Germany – Denmark 2 (DE-DK2) and for the borders of Germany – Sweden 4 (DE-SE4) and Germany – Norway 2 (DE-NO2), which were previously not assigned to any region. The minimum capacities and the linear trajectory will be applied at the border DE-NO2 based on the general principle of equal treatment and on European competition law. As part of the European Economic Area, Norway is treated in this cases as an EU Member State although it is not directly subject to the Regulation (EU) 2019/943 unless it chooses to adopt this regulation. These calculations result in the initial values and the corresponding linear trajectories, as shown below.

[3]https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/HandelundVertrieb/EuropMarktkopplung/MarketCoupling_node.html

[4] The initial value for the border DE-SE4 was determined by TenneT.

[5] https://www.netztransparenz.de/EU-Network-Codes/CEP-Startwerte

[6] This refers to the Germany-Luxembourg bidding zone. To improve readability, the term “German bidding zone” is used below.

CCR Core

Border	% of capacity per critical network element (CNE)						
	2020	2021	2022	2023	2024	2025	As of 31/12/2025
Core region	11.5	21.3	31.0	40.8	50.5	60.3	70.0

The minimum remaining available margin introduced for the CWE region in April 2018 (CWE-minRAM) of 20% will continue to apply as before if this is possible without sacrificing system stability.

CCR Hansa

Border	% of capacity per border						
	2020	2021	2022	2023	2024	2025	As of 31/12/2025
DE-SE4	41.4	46.2	50.9	55.7	60.5	65.2	70.0
DE-DK1	23.9	31.6	39.4	47.0	54.6	62.3	70.0
DE-NO2	0	11.7	23.3	35.0	46.7	58.3	70.0
DE-DK2[7] Kontek → KF CGS[8] →	70.0 0.0	70.0 11.7	70.0 23.3	70.0 35.0	70.0 46.7	70.0 58.3	70.0

TenneT's Commitment regarding the minimum value on the border DE-DK1 resulting from the „Commission Decision of 7.12.2018 […] Case AT.40461 – DE/DK Interconnector" remain unaffected.

[7] For interconnectors commissioned after January 1st, 2020, the BNetzA has stipulated that these have a starting value of 0% in the year of commissioning and that this value increases to up to 70% annually. Therefore, the minimum value for the DE-DK2 border is made up of the individual values of the two interconnectors located on the border.
[8] The minimum value in percent is applied to the available transmission capacity after deducting the forecast feed-in from the offshore wind farms

3. MONITORING METHODOLOGY

The methodology for monitoring compliance with the minimum values for cross-zonal electricity trading pursuant to the EU Electricity Market Regulation and the stipulations of the BNetzA is described below. The minimum value must be respected by the offered capacity within every market time unit (MTU), in other words every hour, and in both directions. The minimum value defines the minimum capacity to be offered. The first step of evaluating compliance with the minimum values is based on the capacities offered in the day-ahead capacity calculation. The offered capacity is also referred to below as the "trade margin".

The trade margin consists of two components. The first is the coordinated trade margin, which represents the offered capacity at the border or borders in question that participate in the capacity coordination. The second is the uncoordinated trade margin. This represents the consequences of the trade capacities offered to other borders not participating in the capacity coordination, if data are available. Third countries that are not EU members are treated just the same as EU Member States.[9] This ensures a consistent method for calculating the initial values for the German TSOs.

If the minimum values are not met according to the standard method described above, further special analysis is required. Additional components of relevance to compliance are then taken into account, such as offered capacity in the long-term and intraday (ID) time-frame as well as capacities reserved for cross-border balancing power, just like the consideration of other European borders in calculating the uncoordinated trade margin.[10] Such conclusive compliance evaluations are described in the results section below.

In case the minimum values are not met, an analysis of whether this caused a restriction to cross-border electricity trading is triggered. Such restrictions are considered situations in which the capacity was fully utilised and a market price difference remained such that an additional exchange would have been cost-efficient.[11]

3.1 Core region

As described above in section 2, a common initial value and linear trajectory was calculated for all German borders that will be part of the Core FB MC in the future. Since a common flow-based approach to capacity calculation will apply in the future to the CCR Core, the minimum value arising from the initial value and the linear trajectory must be complied with at every critical network element in connection with the respective critical contingency combinations (CNEC). An NTC method is currently used to calculate the capacity for the

[9] In this respect, this methodology differs from the approach taken by ACER in their Report on the Result of Monitoring the Margin Available for Cross-Zonal Electricity Trade in the EU.
[10] In this respect, this methodology differs from the approach taken by ACER in their Report on the Result of Monitoring the Margin Available for Cross-Zonal Electricity Trade in the EU
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borders of Germany – the Czech Republic (DE-CZ) and Germany – Poland (DE-PL), while a flow-based method is used for all borders in the CWE region. Therefore, different technical implementations of the monitoring are applied and separate descriptions are provided below.

3.1.1 NTC border Germany – Poland and the Czech Republic

The transmission capacity of the bidding zone borders DE-CZ and DE-PL is determined by the TSOs 50Hertz, TenneT and the Czech TSO Czech Transmission System Operator (CEPS) as a combined value DE – PL/CZ based on the NTC capacity calculation method. The TSOs carry out independent NTC capacity calculations, exclusively taking into account their CNECs. The lowest result per MTU (harmonisation) represents the NTC DE – PL/CZ. Half of this is allocated to the NTC DE-CZ, while the other half remains as the technical profile DE – PL/CZ. The technical profile capacity is allocated among the two bidding zone borders DE-CZ and DE-PL based on demand and in accordance with the goal of optimising welfare. 50Hertz treats PL and CZ as a single bidding zone in the capacity calculation for determining the technical profile. The monitoring method applied by 50Hertz and TenneT is described below.

Calculating the offered trade margin

As described previously in this section, the offered trade margin consists of two components. When applying an NTC method, only the limiting CNEC[12] is relevant for determining compliance because this determines the coordinated trade margin in connection with the capacity calculation. The same applies for the uncoordinated trade margin as well, which is also based solely on the limiting CNEC.

Determining the coordinated trade margin

The coordinated trade margin at the limiting CNEC corresponds to the share of the determined cross-zonal transmission capacity that induces a load on the limiting CNEC (share calculated via PTDF[13]). For the borders DE – PL and CZ, the TSO on the German side provides the limiting CNEC, which contributed the lower capacity to the harmonisation with CEPS. This capacity is used for calculating the coordinated trade margin.

Calculating the uncoordinated trade margin

The uncoordinated trade margin at the limiting CNEC[14] corresponds to the load-inducing impact of the capacities offered at adjacent borders that was offered for these borders at the limiting CNEC in each direction (the share is calculated via PTDF)[15]. This is accomplished by estimating the capacities offered at adjacent borders based on the information available at the time of the day-ahead (DA) capacity calculation. The result is a value for the uncoordinated trade margin per CNEC for each MTU and direction.

[12] Multiple CNECs may also simultaneously act as limits for a given MTU.
[13] PTDF (power transfer distribution factors) translate a cross-border exchange into the corresponding load flows at the CNEC.
[14] Multiple CNECs may also simultaneously act as limits for a given market time unit.
[15] In this respect, this methodology differs from the approach taken by ACER in their Report on the Result of Monitoring the Margin Available for Cross-Zonal Electricity Trade in the EU.

TenneT data sources

Parameter	Input data	Source
Relative trade margin	F_{max}	D2CF CGM
Coordinated trade margin	NTC	Internal alternating current (AC) load flow calculation based on D2CF-CGM[16]
Coordinated trade margin	PTDF	Internal calculation from D2CF CGM
Uncoordinated trade margin		
Uncoordinated trade margin	NTC	Forecasted day-ahead capacity (Art. 11.1 EU Regulation 543/2013) from ENTSO-E Transparency Platform

50Hertz data sources

Parameter	Input data	Source
Coordinated trade margin	F_{ref}, F_{max}, PTDF and phase shift distribution factor (PSDF)	Internal Direct Current (DC) load flow calculation and optimisation based on D2CF-CGM[16]
Uncoordinated trade margin	PTDF	DC load flow calculation
Uncoordinated trade margin	NTC	Forecasted long-term capacity (Art. 11.1 EU regulation 543/2013) from ENTSO-E Transparency Platform

3.1.2 CWE region

The monitoring method used by the TSOs Amprion, TenneT and TransnetBW in the CWE region is described below.

Calculating the offered trade margin

The offered trade margin is determined according to the EU Electricity Market Regulation for each CNEC. As described above, the offered trade margin is the sum of the coordinated and uncoordinated trade margins. The resulting offered trade margin is given as a percentage. This is calculated as the trade capacity offered at the CNEC (sum of the coordinated and uncoordinated shares) divided by its physical capacity (F_{max}). For all MTUs, the value for F_{max} used in the calculations for compliance monitoring is equivalent to the physical limit applied in the capacity calculation. In the special case of determining the trade margin at the bidding zone or control area border, the lower offered capacity of the two participating TSOs applies. When applying default flow-based parameters (DFPs)[17] due to technical problems in the flow-based capacity calculation, it is not possible to determine the relative offered trade margin. MTUs where DFPs were applied are therefore excepted from the compliance evaluation.

Determining the coordinated trade margin

The reported coordinated trade margin corresponds to the remaining available margin (RAM) offered for the cross-zonal trading within the day-ahead CWE capacity calculation, which is daily published on JAO.eu as

[16] D-2 congestion forecast common grid model (CGM) as per SO GL Regulation Art. 67 and Art. 70.

[17] The application of DFPs is an available fall-back option if a technical problem arises with the DA capacity calculation. The capacity calculation is then suspended and cross-zonal capacities equal to the already allocated long-term capacities are made available for trading.

the “virgin flow-based domain”. The impact of long-term capacities offered on CWE borders is currently not taken into account. Therefore, the actual capacity offered in CWE for cross-zonal electricity trading can exceed the reported values.

Calculating the uncoordinated trade margin

The influence of the cross-zonal trade capacity offered outside of the CWE region on the respective CNEC included in the CWE region is determined for calculating the uncoordinated trade margin. Specifically, the corresponding load-producing PTDFs are multiplied by the respective NTCs to determine the influence of the NTCs on the respective CNEC.[18]

The individual uncoordinated trade margins of the various NTC border directions are added together to determine the total uncoordinated trade margin of the CNEC.

$$Uncoordinated\ trade\ margin = \sum_{j,k;j\neq k} Uncoordinated\ trade\ margin_{j\rightarrow k}$$

This only takes into account borders where the PTDF values are available within the day-ahead CWE capacity calculation.

Data sources

Parameter	Input data	Source
Uncoordinated trade margin	NTCs	At the time of the respective capacity calculation of the day-ahead[19] or, alternatively, month-ahead[20] forecasted transfer capacity accessed from the ENTSO-E Transparency Platform. If one of the two values was unavailable, default values based on annual capacities were used.
Uncoordinated trade margin	PTDFs of the CWE CNECs	CWE flow-based common system (partially publicly available at JAO.eu[21])
Coordinated trade margin	RAM	CWE flow-based common system (publicly available at JAO.eu[22])

[18] In this respect, this methodology differs from the approach taken by ACER in their Report on the Result of Monitoring the Margin Available for Cross-Zonal Electricity Trade in the EU
[19] https://transparency.entsoe.eu/transmission-domain/ntcDay/show
[20] https://transparency.entsoe.eu/transmission-domain/r2/forecastedTransferCapacitiesMonthAhead/show
[21] https://www.jao.eu/marketdata/implicitallocation >> Utility Tool >> Virgin Flow-Based Domain
[22] https://www.jao.eu/marketdata/implicitallocation >> Utility Tool >> Virgin Flow-Based Domain

3.2 Hansa region

As described in section 2, individual initial values and linear trajectories were calculated per bidding zone border in the CCR Hansa. Because an NTC capacity calculation takes place at all four borders, the values apply per border.

3.2.1 NTC borders Germany – Denmark 1 and Germany – Norway 2

The transmission capacities of the bidding zone borders DE-DK1 and DE-NO2 are determined using the coordinated NTC method (cNTC).This allows the individual minimum capacities of the borders to be applied to the respective critical network elements as minimum trade margins (share of the maximum permissible power flow). This calculation is based on a common grid model (CGM) according to Art. 67 and Art. 70 of Regulation (EU) 2017/1485 establishing a transmission system operation guideline (SOGL) for each import and export direction and for all MTUs. The individual minimum values were applied to the trade margins for the first time as of 17/12/2020, however, using the minimum values applicable for the year 2021. Since different minimum values apply for the borders DE-DK1 and DE-NO2 according to the Bidding Zone Action Plan, the transmission capacities are initially determined based on the lower trade margin (DE-NO2) in order to determine the transmission capacity of the associated border. The transmission capacity of the border with the higher minimum margin (DE-DK1) is then determined, taking into account the previously determined transmission capacity of the other border (DE-NO2). The transmission capacities of the two borders can therefore be determined by different CNECs. The monitoring method applied by TenneT is described below.

The NTC calculation for DE-NO2 and thus the monitoring of the minimum values refers to the receiving side of the bidding zone border.[23] Since the NordLink cable forming the DE-NO2 border is managed with implicit loss procurement, the transmission capacity on the sending side is not exclusively available for cross-border trading since they are also utilised by the implicitly procured power to cover losses.

Calculating the offered trade margin

As described above, the offered trade margin consists of two components, the coordinated and uncoordinated trade margin. When applying an NTC methodology, only the offered trade margins of the respective limiting CNECs are relevant for determining compliance since only these determine the respective transmission capacity. Accordingly, the uncoordinated trade margin is also only considered for the limiting CNECs. Because different minimum values apply for the borders DE-DK1 and DE-NO2 and different CNECs act as limits, the calculation and monitoring for the borders DE-DK1 and DE-NO2 take place separately.

[23] The terms "receiving side" and "delivering side" of a bidding zone boundary refer to the respective directions of the transmission capacities. Each direction always points from the energy-sending side (bidding zone) to the energy-receiving side (bidding zone).

Determining the coordinated trade margin

The coordinated trade margin at the limiting CNECs corresponds to the share of the determined transmission capacities that induces a load on the respective limiting CNEC (calculated based on NTC and PTDF values). For a cNTC methodology, no coordinated trade margin for a specific border is exclusively available. This is shared among the participating borders instead. The coordinated trade margin of the respective border is therefore the sum of the two multiplications of the respective NTC (DE-NO2 and DE-DK1) and the associated PTDF of the limiting CNEC of the border in question. This calculation is carried out once for the border DE-NO2 and once for the border DE-DK1 with the respective limiting CNEC and associated PTDF values. The coordinated trade margin of the respective CNEC therefore results from the contributions of both transmission capacities (DE-DK1 and DE-NO2).

Calculating the uncoordinated trade margin

The uncoordinated trade margin at the limiting CNECs corresponds to the load-inducing impact of the capacities offered at adjacent borders that must be offered at the limiting CNECs in each direction (the share is calculated via PTDF).[24] This is accomplished by estimating the capacities offered at adjacent borders based on the information available at the time of the DA capacity calculation. The result is a value for the uncoordinated trade margin per CNEC for each MTU and direction.

Data sources

Parameter	**Input data**	**Source**
Relative trade margin	F_{max}	Calculation based on nominal voltage and I_{max} from the D2CF CGM
Coordinated trade margin	NTC	Internal AC load flow calculation based on D2CF-CGM
Coordinated trade margin	PTDF	Internal calculation from D2CF CGM
Uncoordinated trade margin	NTC	Forecasted day-ahead capacity (Art. 11.1 EU Regulation 543/2013) from ENTSO-E Transparency Platform

[24] In this respect, this methodology differs from the approach taken by ACER in their Report on the Result of Monitoring the Margin Available for Cross-Zonal Electricity Trade in the EU

3.2.2 NTC border Germany – Denmark 2

The methodology applied by 50Hertz at the border DE-DK2 is described below.

Calculating the offered trade margin

Because only the interconnectors with direct current (DC) properties Kontek cable and, since 15/12/2020, KF CGS exist at the border DE-DK2, no unscheduled load flows occur, only the coordinated trade margin is to be determined.

Determining the coordinated trade margin

The coordinated trade margin corresponds to the transmission capacity offered at the border according to the DA capacity calculation. The transmission capacity increased overall when the hybrid interconnector KF CGS entered into operation on 15/12/2020. The KF CGS connects the grid connections of the German offshore wind farms Baltic 1 and Baltic 2 to those of the Danish offshore wind farms Kriegers Flak DK, thereby establishing an interconnector between Germany and eastern Denmark. This transmission capacity arises from the total transmission capacity minus the forecasted offshore wind power infeed.

Data sources

Parameter	Input data	Source
Coordinated trade margin	NTC for the Kontek cable and for KF CGS	System management and grid control systems

3.2.3 NTC border Germany – Sweden 4

The transmission capacity of the bidding zone border DE-SE4 is determined by the transmission system operators Baltic Cable AB (BCAB), Svenska kraftnät and TenneT. The TSOs carry out independent capacity calculations. TenneT determines the transmission capacity based on a validation of wind power infeed in the grid of Schleswig-Holstein Netz AG as well as unavailability of network elements of TenneT and Schleswig-Holstein Netz AG based on a common limit value concept. BCAB determines the availability and restrictions of the transmission cable Baltic Cable.

The minimum capacity at the border DE-SE4 refers directly to the transmission capacity of the transmission cable Baltic Cable. An uncoordinated trade margin is not taken into account. For monitoring of the border DE-SE4, the offered capacity (referred to receiving side) is compared with the minimum capacity relative to the maximum capacity of the Baltic Cable (600 MW on the receiving side).[25]

[25] The terms "receiving side" and "delivering side" of a bidding zone boundary refer to the respective directions of the transmission capacities. Each direction always points from the energy-sending side (bidding zone) to the energy-receiving side (bidding zone).

Consideration of the receiving side arises from the fact that the interconnector Baltic Cable is managed with implicit procurement of power to compensate for transmission losses. The transmission capacities on the providing side are therefore not exclusively available for cross-border trading since they are also utilised by the implicitly procured power to cover losses.

TenneT data sources

Parameter	**Input data**	**Source**
Relative trade margin	F_{max}	Operational Handbook of Baltic Cable
Coordinated trade margin	NTC	Calculation according to the limit value concept plus load and infeed forecasts
Coordinated trade margin	Cable unavailability[26]	Baltic Cable AB/ Operational Handbook of Baltic Cable

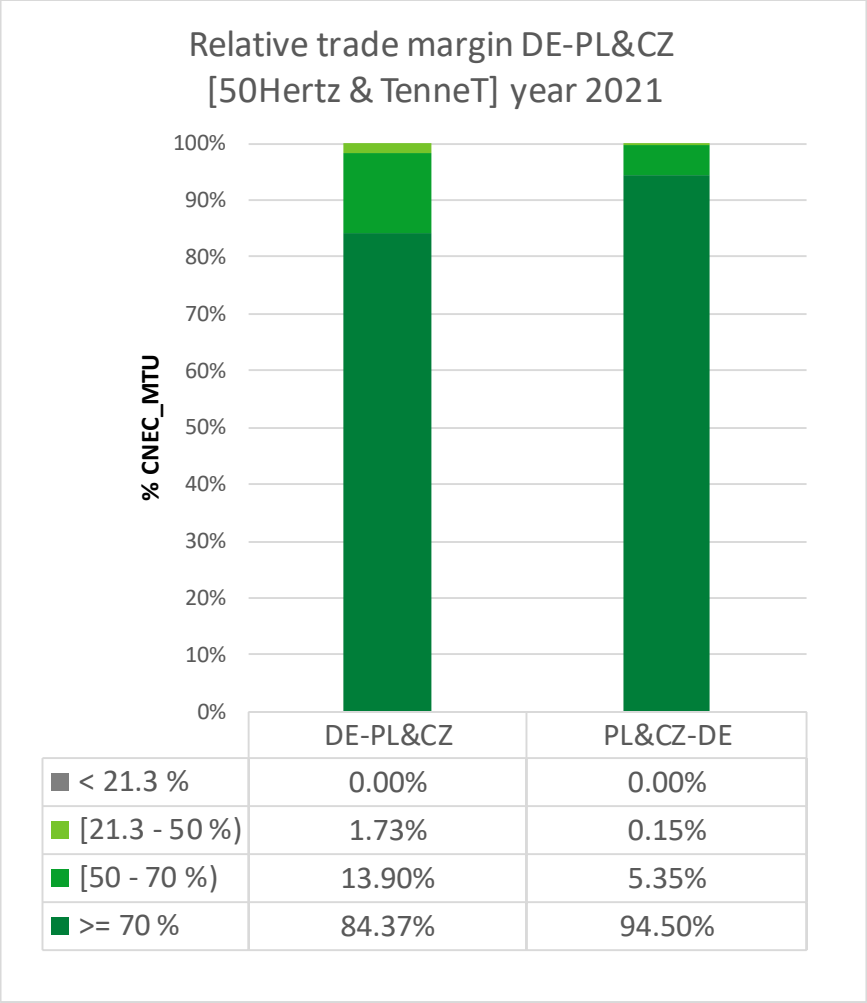
[26] The unavailability of individual items of equipment of the Baltic Cable generally leads to a transmittable capacity of 0 MW, meaning that these times are not considered operating hours. If the static VAR compensator fails, however, the Baltic Cable can still transmit 500 MW, meaning that these times are definitely considered operating hours.

4. RESULTS

4.1 Core region

4.1.1 NTC border Germany – Poland and the Czech Republic

For the borders DE-PL&CZ, the minimum of 21.3% was complied with for every MTU in 2021. The figure below shows the relative trade margin as the ratio of offered trade margin to physical transmission capacity per CNEC and for all MTUs at the borders DE-PL&CZ in the year 2021 for both trade directions.



	DE-PL&CZ	PL&CZ-DE
< 21.3 %	0.00%	0.00%
[21.3 - 50 %)	1.73%	0.15%
[50 - 70 %)	13.90%	5.35%
>= 70 %	84.37%	94.50%

Figure 1: Relative trade margin DE-PL&CZ [50Hertz and TenneT] year 2021 (minimum value 21.3%)

Figure 1 shows that a trade margin of at least 21.3% with respect to the physical transmission capacity (F_{max}) per limiting CNEC was offered in all considered MTUs. Because the underlying NTC values are determined independently of each other for each direction, the directions are differentiated in the figure. All 8,760 hours of the year 2021 were taken into account for both directions. Because more than one CNEC per MTU limited

the trade margin in the export direction (DE-PL&CZ) in some cases, the depiction of the export direction is based on 14,461 data points, while the import direction (PL&CZ-DE) is based on 8,736 data points (one CNEC per MTU). As no D2CF data set was available on 11/03/2021, TenneT applied a back-up NTC of 2,000 MW for all hours. The back-up NTC is based on the ENTSO-E annual forecast scenarios using the minimum value of 21.3%.[27] The back-up NTC was only decisive in the import direction (lower than the 50Hertz NTC values). Since no relative trading margin can be determined without the D2CF data set, these MTUs were excluded from the evaluation regarding the relative trading margin for the import direction. In addition to compliance with the minimum value of 21.3% per limiting CNEC applicable in 2021, Figure 1 also shows that at least a relative trade margin of 70% (trade margin relative to the physical transmission capacity) was made available at 84.4% of the limiting CNECs in the export direction and 94.5% in the import direction. In other words, the minimum value that will apply as of 31/12/2025 was already complied with in these cases.

4.1.2 CWE region

The results of the offered cross-zonal trade margin on the network elements of the CWE region are depicted below. As described in Art. 16(8)(b) of the EU Electricity Market Regulation for borders with flow-based capacity allocation[28], the offered trade margin per critical network element (CNE) is determined in consideration of the critical contingencies. This method is depicted in Figure *2* and described in more detail below.

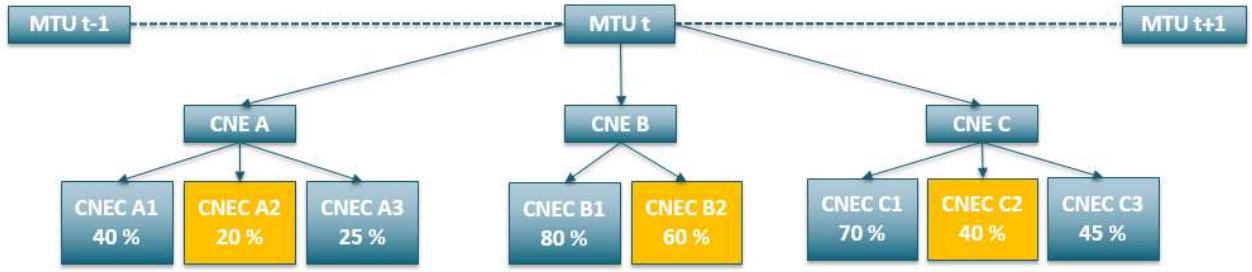


Figure 2: Example of determining the offered trade capacity per critical network element

Figure 2 shows an example of determining the offered trade capacity per critical network element in consideration of the critical contingency combinations as per Art. 16 (8) of the EU Electricity Market Regulation. The percentile values correspond to the offered cross-zonal trade margin relative to the available

[27] Year-ahead scenarios pursuant to Article 65 of Regulation (EU) 2017/1485 establishing a guideline for transmission system operation

[28] See Art. 16(8) of the EU Electricity Market Regulation: "*[…] for borders using a flow-based approach, the minimum capacity shall be a margin set in the capacity calculation process as available for flows induced by cross-zonal exchange. The margin shall be 70%* [Note: For Germany, the target values of the action plan apply here until 31/12/2025*] of the capacity respecting operational security limits of internal and cross-zonal critical network elements, taking into account contingencies, as determined in accordance with the capacity allocation and congestion management guideline adopted on the basis of Article 18(5) of Regulation (EC) No 714/2009. […]*"

physical capacity (F_{max}) per CNEC. The CNEC shown in orange defines the minimum offered trade margin of the respective CNE.

A CNE represents a real physical network element. In the operative capacity calculation process, various critical contingencies of other network elements are considered in each MTU per CNE. The combination of CNE and contingency forms a CNEC. The minimum trade margin that can be offered at one CNE is therefore determined by the CNEC that permits the lowest trade margin. Only the minimum offered trade margin per CNE is depicted below.[29] One value per CNE therefore enters into the evaluation for each MTU[30]. This means that the subsequent figures depict only a (critical) subset of the data rather than all data determined for all CNECs. In a consideration of all CNECs, the relative share would increase still further with relatively high offered trade margins. The depiction focuses on the relative trade margin, which is defined as the ratio of offered trade margin to the available physical capacity (F_{max}).

Exclusively considering the CNE with the lowest trade margin over the respective region per MTU is inappropriate because only one value per MTU (of the network element or CNE with the lowest trade margin) would enter into the depiction. This can theoretically result in the entire evaluation being determined by a single network element which exhibits continuously low offered trade margins over the time period in question. CNEs where relatively high trade margins were offered would not be represented in such an analysis. As described above, this form of representation would also be insufficient for depicting the requirements of the EU Electricity Market Regulation since the minimum margins for cross-zonal trade capacity must be complied with at *all* critical network elements. In addition, such an analysis would also fail to achieve the monitoring goal of obtaining an overview of all physical network elements and the associated offered trade margins to allow for any necessary measures to satisfy future minimum requirements at all network elements.

DFPs or Spanning were applied in 62 MTUs due to technical problems[31] in the flow-based capacity calculation.

- BD 06/02/2021: Spanning in hour 16
- BD 28/02/2021: Spanning in hour 18
- BD 11/03/2021: Application of DFP in all hours of the day
- BD 13/03/2021: Application of DFP in hours 11 to 15
- BD 27/03/2021: Spanning in hour 13
- BD 04/04/2021: Spanning in hour 10
- BD 06/04/2021: Spanning in hour 22
- BD 06/05/2021: Spanning in hour 10

[29] In this respect, this methodology differs from the approach taken by ACER in their Report on the Result of Monitoring the Margin Available for Cross-Zonal Electricity Trade in the EU.
[30] There is no differentiation here of the flow direction through the respective CNE. In other words, the minimum value is determined based on both flow directions per CNE.
[31] These technical problems were outside the TSO's sphere of influence.

- BD 28/05/2021: Spanning in hours 11 and 12
- BD 25/08/2021: Spanning in hour 13
- BD 10/11/2021: Application of DFP in all hours of the day

Figure 3 shows an overview for the full year. Due to the lack of data, the MTUs in question were excepted from the compliance evaluation with respect to the CWE region. Consequently, 8,698 hours were evaluated.

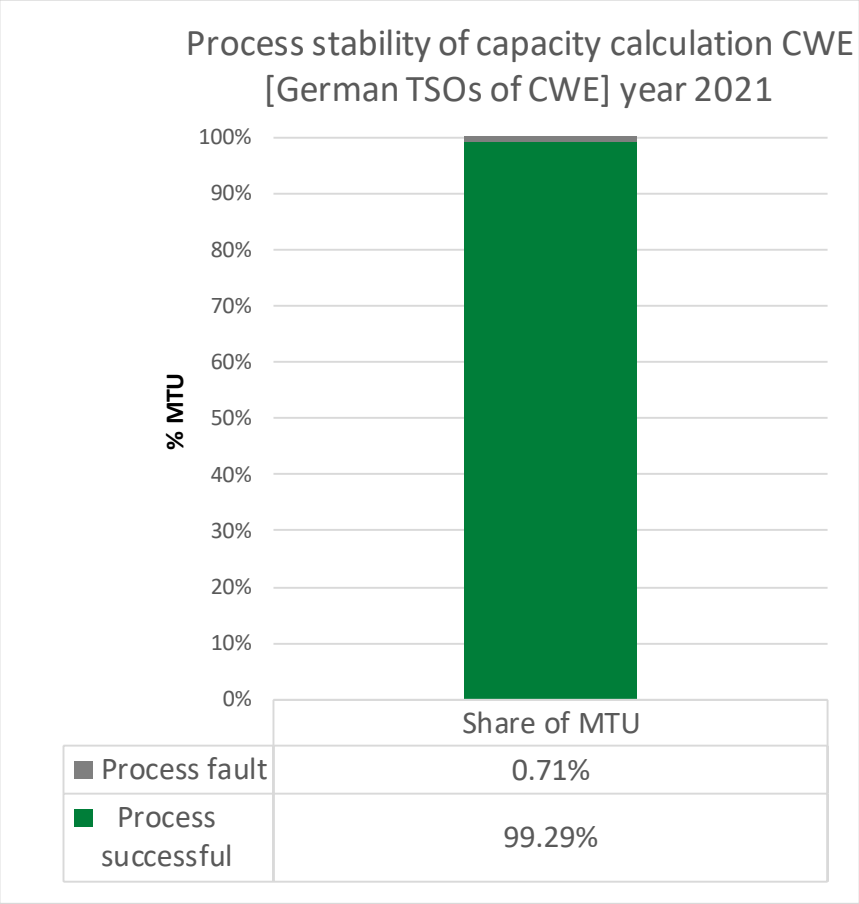


Figure 3: Stability of CWE capacity calculation process of all TSOs during the year 2021

Amprion control area

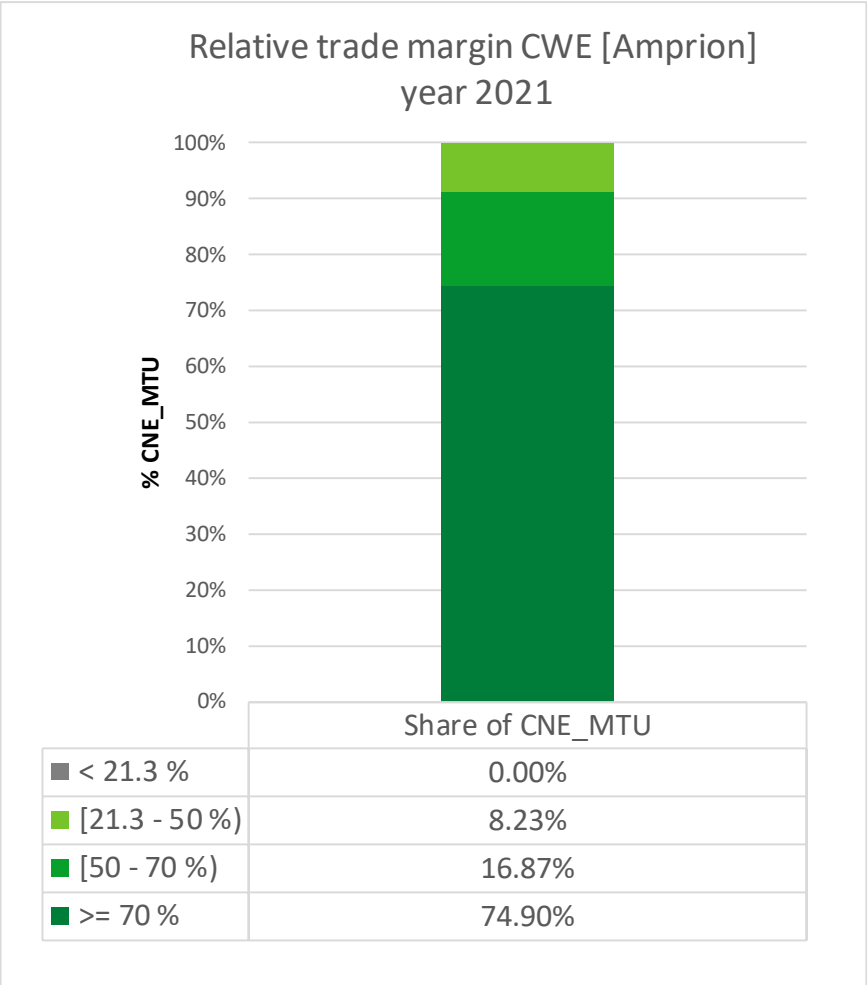


Figure 4: Relative trade margin CWE [Amprion] year 2021 (minimum value 21.3%)

Figure 4 shows the distribution of the offered trade margin on the CNEs of the Amprion control area in 2021. On average, 57 CNEs of the Amprion control area per MTU were included in the CWE capacity calculation process in the year 2020. This means that 496,618 input data points were used to create the bar chart of Figure 4. The analysis shows that the minimum value according to the linear trajectory of the Bidding Zone Action Plan for 2021 (21.3%) was complied with at all times on all CNEs within the Amprion control area.

Further analysis shows that cases in which a relatively low trade margin was offered are locally concentrated among a relatively small number of network elements. These are primarily transmission lines in the north-western region of the Amprion control area, which have to bear a high loading during times of high wind power infeed which needs to be transmitted to the southern European load centres. Providing additional capacity on these network elements for cross-zonal electricity trading then poses a great challenge. The currently reduced trade requirements of the linear trajectory defined by the Bidding Zone Action Plan are required for these particularly impacted network elements.

In November 2020, Amprion and the Belgian TSO Elia put into operation the first direct electricity interconnection between Germany and Belgium, called “ALEGrO”. Against this background, the present report provides for the first time an assessment for a complete year. ALEGrO is integrated as a DC interconnection into the CWE capacity calculation and allocation via the "Evolved Flow-Based Methodology" and is thus subject to a special monitoring methodology. The relevant metric for monitoring the compliance is the maximum transmission capacity provided in the Flow-Based Market Coupling process on ALEGrO.[32] This metric must be at least equal to the minimum percentage value according to the Action Plan multiplied by the available thermal capacity of ALEGrO. In the event of an outage or reduced thermal capacity of ALEGrO, the minimum value for cross-zonal trading capacity of ALEGrO will be reduced as well. Since congestions may occur in the AC grid, the actual trading capacity via ALEGrO may differ from the capacity offered directly on ALEGrO. However, this does not affect the monitoring results of ALEGrO.

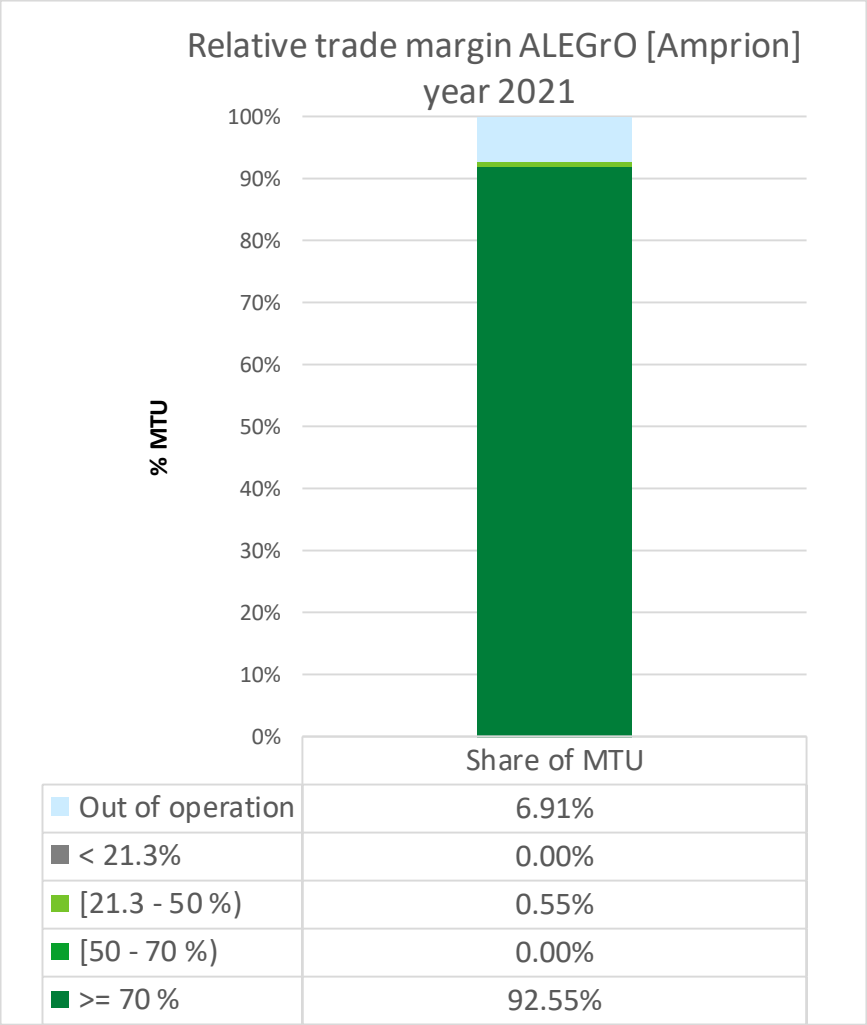


Figure 5: Relative trade margin ALEGrO [Amprion] year 2021 (minimum value 21.3%)

[32] This is modeled within the framework of "Evolved Flow-Based" via so-called "virtual hubs" of the converter stations Lixhe and Oberzier. These form their own hubs with their own PTDFs in the capacity calculation and allocation. The maximum or minimum net positions of the virtual hubs are generally limited to the available thermal capacity of ALEGrO and thus also form the basis for the assessment for the present compliance monitoring.

Figure 5 shows the transmission capacity offered on ALEGrO for cross-zonal electricity trading relative to ALEGrO's available thermal capacity. The graph was generated based on one value per hour (MTU). Amprion was able to offer 100% of the available thermal transmission capacity of 1,000 MW for cross-zonal electricity trading in 92.55% of the hours in 2021.
During the following periods, ALEGrO was not available due to maintenance work:

- 11/03/2021 7:00 am to 12/03/2021 3:00 pm: Planned outage (maintenance of critical functions: Measurement of electromagnetic coupling, replacement of defective components in the converter).
- 16/05/2021 00:00 am to 22/05/2021 10:00 pm as well as 25/05/2021 05:00 am until 26/05/2021 3:00 pm: Planned outage (annual maintenance of ALEGrO)
- 19/08/2021 06:00 am until 03/09/2021 10:00 pm: Planned outage (repair of the roof of the converter station in Lixhe on the Belgian side)

During these periods, the available thermal capacity dropped to 0 MW, so that no capacity had to be offered for cross-zonal electricity trading on ALEGrO.

On 18 and 19 January 2021, Elia and Amprion had to lower the capacity offered on ALEGrO to 250 MW for 48 hours, which corresponds to 0.55% of the hours in 2021. The cause was a technical error in the allocation algorithm of the CWE Flow-Based Market Coupling[33] and thus outside Amprion's sphere of influence. With the reduction to 250 MW, Elia and Amprion helped to prevent a decoupling, which would have resulted in much higher economic losses than a capacity reduction on ALEGrO. Nevertheless, 25% of the available thermal capacity of ALEGrO could be offered during these hours, so that the minimum value of 21.3% could also be reached during these hours.
In summary, Amprion complied with the statutory requirements for cross-zonal electricity trading pursuant to Art. 15 and 16 of the EU Electricity Market Regulation at all times during 2021.

[33] The clearing point was outside the Flow-Based Domain. The issue has been resolved afterwards.

TenneT control area

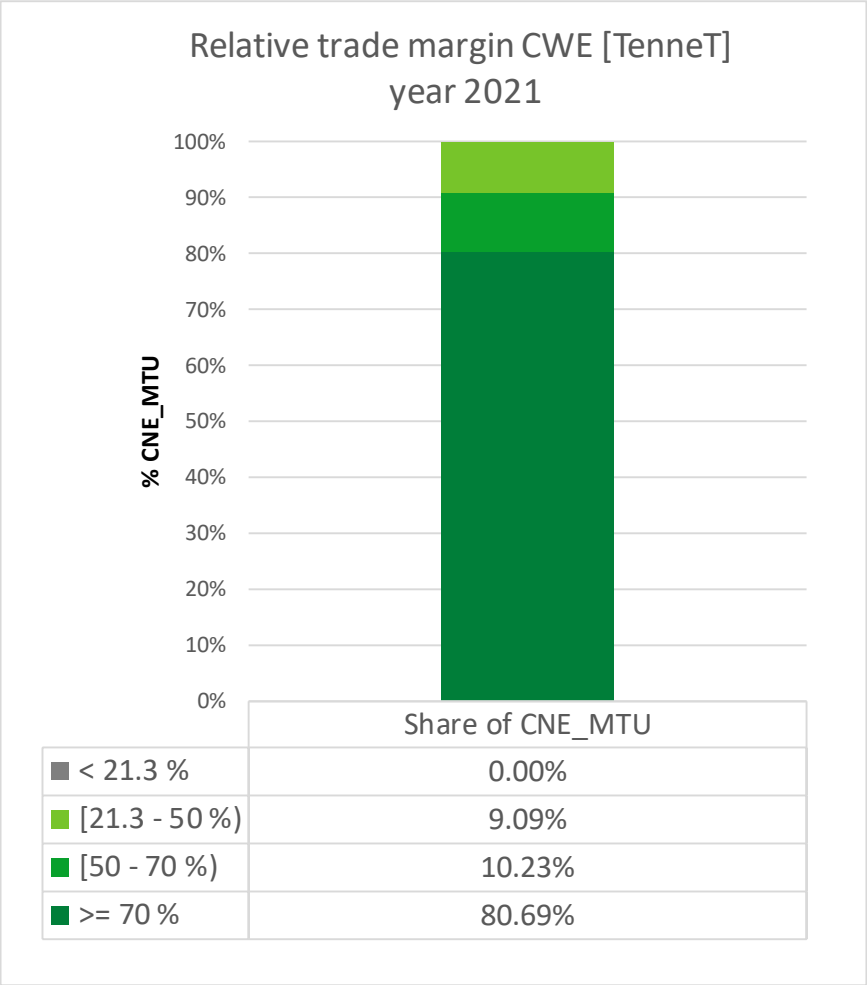


Figure 6: Relative trade margin CWE [TenneT] year 2021 (minimum value 21.3%)

Figure 6 shows the distribution of the offered relative trade margin at the CNEs of the TenneT control area in 2021 based on 277,053 values (one value per CNE and MTU). This means that, on average, about 32 CNEs of the TenneT control area were taken into account per MTU in the CWE capacity calculation process in the year 2021. The minimum value for 2021 (21.3%) according to the linear trajectory of the Bidding Zone Action Plan was complied with at all critical network elements within the TenneT control area.

TransnetBW control area

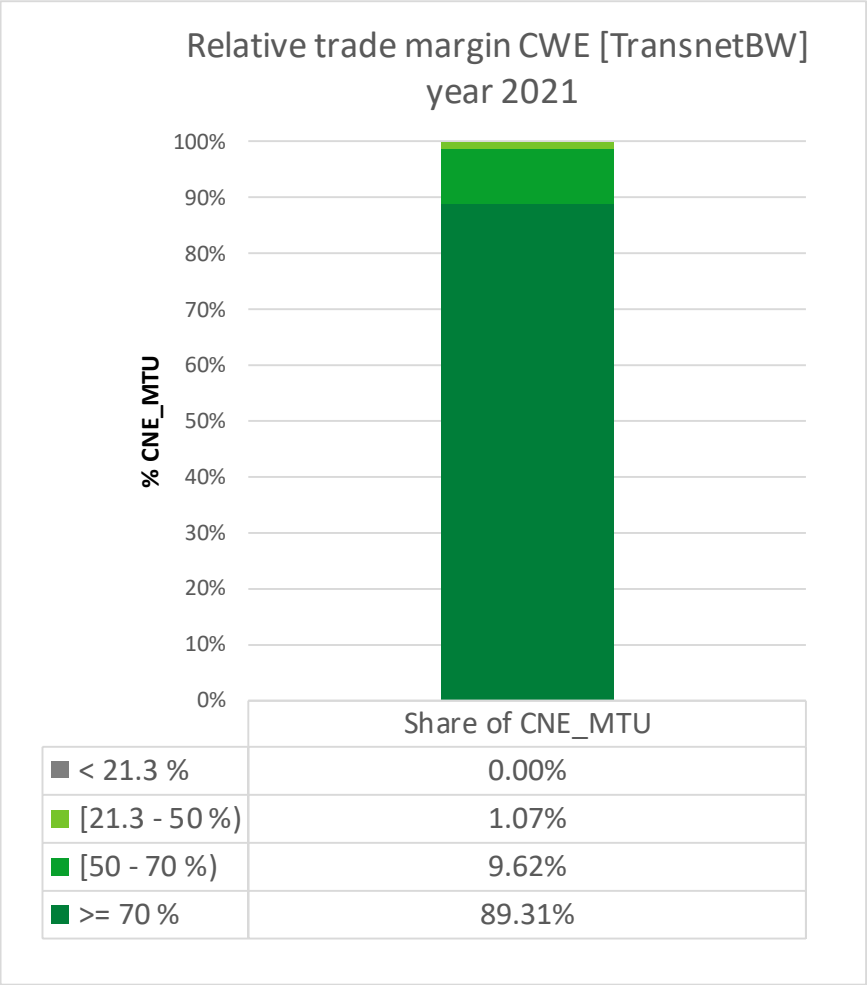


Figure 7: Relative trade margin CWE [TransnetBW] year 2021 (minimum value 21.3%)

Figure 7 shows the distribution of offered relative trade margin in 2021 at the CNEs of the TransnetBW control area. In the year 2021, the CWE capacity calculation process included 33 CNEs of the TransnetBW control area. This means that 205.680 values entered into the bar chart of Figure 7[34]. The analysis shows that the minimum value according to the linear trajectory of the action plan for 2021 (21.3%) was complied with at all times at all critical network elements within the TransnetBW control area.

The lowest trade margin offered at a TransnetBW CNE during 2021 was 28.16%, meaning that minimum capacity of the Bidding Zone Action Plan of 21.3% was significantly exceeded during every hour.
Many CNECs exhibit a high trade margin. In a given hour, a single CNEC with a lower trade margin can be sufficient to limit the market result. Providing additional capacity at these network elements for cross-zonal electricity trading then poses a great challenge. The currently reduced trade requirements of the linear

[34] 33 CNEs considered multiplied by 8,760 hours of 2021 minus CNEs removed from the capacity calculation due to insufficient sensitivity to cross-zonal trade (PTDF < 5%)

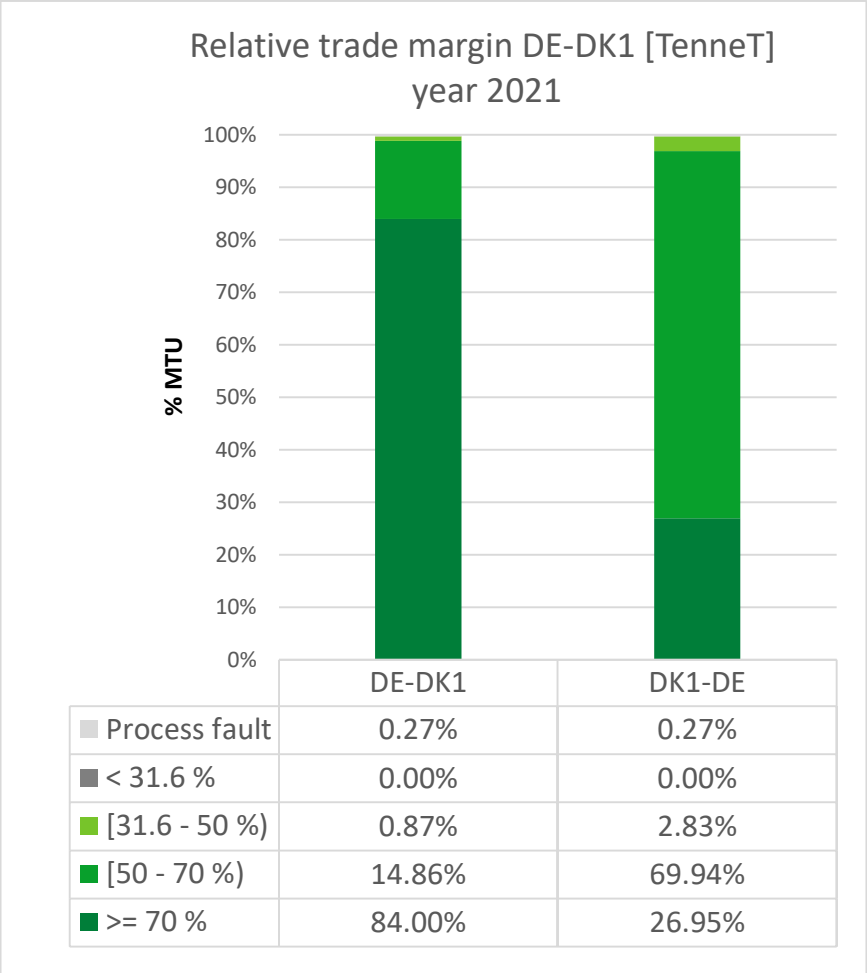
trajectory defined by the Bidding Zone Action Plan are necessary for these particularly impacted network elements.

In summary, TransnetBW complied with the statutory requirements for cross-zonal electricity trading pursuant to Art. 15 and 16 of the EU Electricity Market Regulation at all times during 2021.

4.2 Hansa borders

4.2.1 NTC border Germany – Denmark 1

Figure 8 shows the distribution of the offered relative trading margin on the CNEs of the TenneT control area that determined the hourly NTC values of 2021 of the respective direction. Both directions include 8,760 values (one value per MTU). The minimum value for 2021 of 31.6% according to the linear trajectory of the action plan was met on all CNEs within the TenneT control zone. No D2CF data set was available for the 24 hours of 11/03/2021. Without a network model, it was not possible to determine a trading margin. In these hours, a backup NTC of 1,396 MW was applied for both directions, which was secured by countertrading measures. The backup NTC corresponds to the minimum capacity according to TenneT's Commitment and cannot be converted to the CNEC-based minimum capacity considered here.

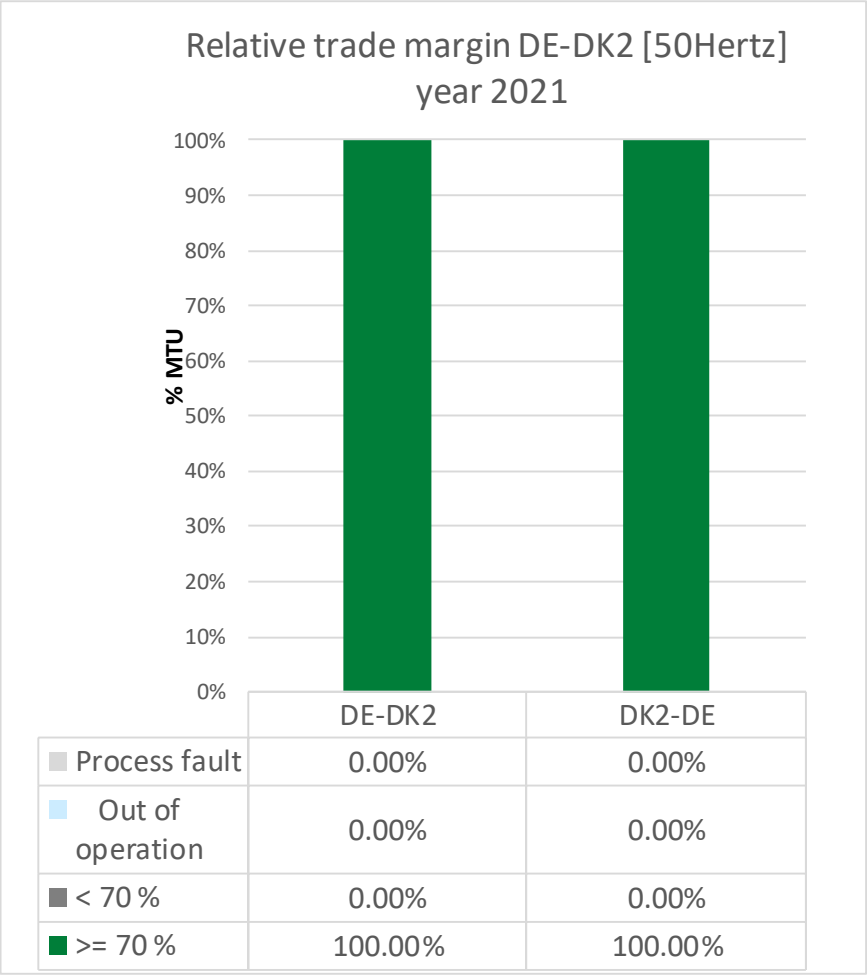


	DE-DK1	DK1-DE
Process fault	0.27%	0.27%
< 31.6 %	0.00%	0.00%
[31.6 - 50 %)	0.87%	2.83%
[50 - 70 %)	14.86%	69.94%
>= 70 %	84.00%	26.95%

Figure 8: Relative trade margin DE-DK1 [TenneT] year 2021 (minimum value 31.6%)

4.2.2 NTC border German – Denmark 2

For the border DE-DK2, the respectively applicable minimum value was complied with during every MTU of 2021. The minimum value per border and hour was 70.0% of the F_{max} of the Kontek cable plus 11.7% of the F_{max} of the Kriegers Flak CGS (after deducting the forecasted DA offshore wind power infeed)[35]. After the KF CGS entered into operation, this results in a minimum value of below 70% in total for the border DE-DK2, which has to be determined on hourly basis. The following figure shows the actually offered trade margin relative to the transmission capacity at the border DE-DK2 in the year 2021[36].



	DE-DK2	DK2-DE
Process fault	0.00%	0.00%
Out of operation	0.00%	0.00%
< 70 %	0.00%	0.00%
>= 70 %	100.00%	100.00%

Figure 9: Relative trade margin DE-DK2 [50Hertz] year 2021 (minimum value 70%)

Figure 9 shows that the trade margin amounted to at least 70% of the transmission capacity during all hours taken into account. Included are 8,760 hours in the export direction and in the import direction.

[35] See also section 3.2.2 NTC border DE-DK2 in the monitoring methodology section.
[36] For the sake of simplicity, figure 9 shows a comparison with 70% and not with the sometimes lower minimum value.

The table below shows the number of hours in which the availability of the two interconnectors on the DE-DK2 border was restricted in 2021.

Interconnector	Partial disturbance / disturbance	maintenance
Kontek	231	308
KF CGS[37]	4.870	672

The partial restriction on the border is essentially due to:

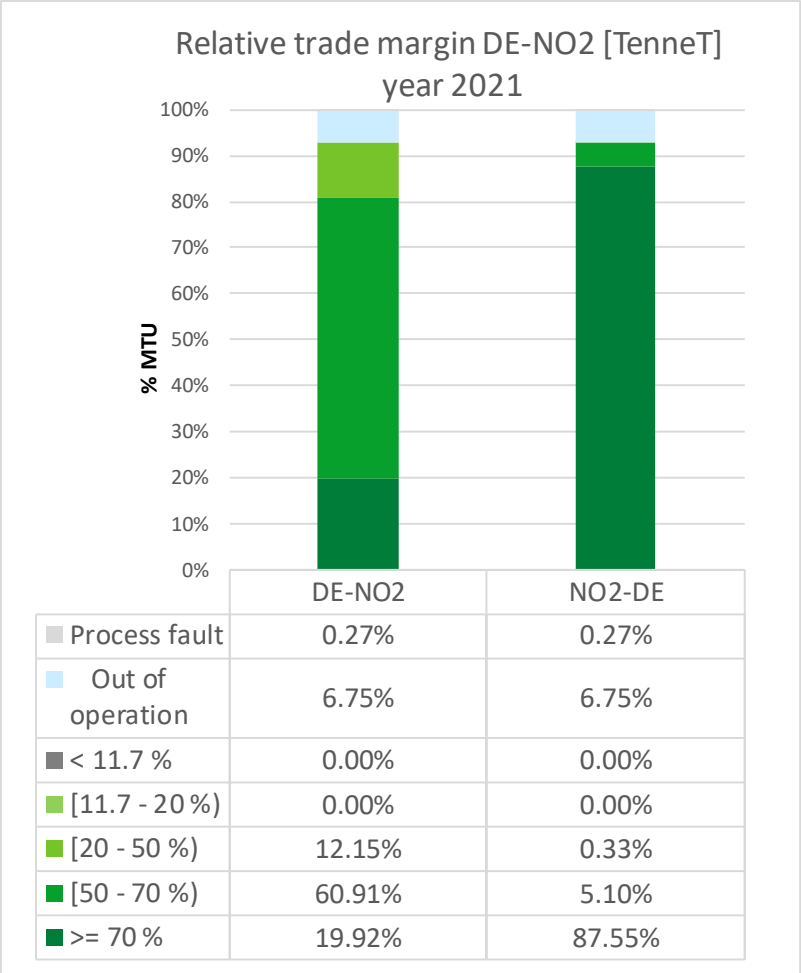
- The maintenance of the interconnectors (the interconnector must be taken entirely out of operation for maintenance)
- Limited availability of the KF CGS predominantly due to faults in the cable systems 154 and 151 (belonging to the OWF grid connections)

4.2.3 NTC border Germany – Norway 2

Figure 10 shows the distribution of the offered relative trading margin on the AC and DC CNECs of the TenneT control area that determined the 2021 hourly NTC values of the respective direction. Both directions include 8,145 values (one value per MTU). The minimum value for 2021 of 11.7% according to the linear trajectory of the action plan was met on all critical network elements within the TenneT control area. The NTC of the direction DE to NO2 was determined in 6,033 hours by the NordLink cable (DC-CNEC). The NTC of the direction NO2 to DE was determined in 966 hours by the NordLink cable (DC-CNEC). If the NTC is determined by the DC-CNEC, NTC equals Fmax. Therefore, the offered relative trading margin of DC-CNECs is always 100%.

No D2CF dataset was available for the 24 hours of 11/03/2021. These hours are not included in the distribution because no relative trading margin can be determined without a network model. During these hours, backup NTC of 170 MW for the NO2 to DE direction and 1,400 MW for the DE to NO2 direction were applied.

[37] The classification of restrictions has not been applied consistently. In the first half of the year there was no classification as maintenance.



	DE-NO2	NO2-DE
Process fault	0.27%	0.27%
Out of operation	6.75%	6.75%
< 11.7 %	0.00%	0.00%
[11.7 - 20 %)	0.00%	0.00%
[20 - 50 %)	12.15%	0.33%
[50 - 70 %)	60.91%	5.10%
>= 70 %	19.92%	87.55%

Figure 10: Relative trade margin DE-NO2 [TenneT] year 2021 (minimum value 11.7%)

The NordLink cable was out of operation for 591 hours in 2021 due to maintenance or malfunctions. During 472 hours, the cable was in monopole operation with a limitation of the Fmax value (DC CNEC) to 685 MW.[38] The hours with monopole operation are included in the distribution. Up to and including 05.01.2021, the cable was in test operation with an Fmax value of 700 MW as part of the initial commissioning. The following table shows the number of hours with Fmax restrictions by cause.

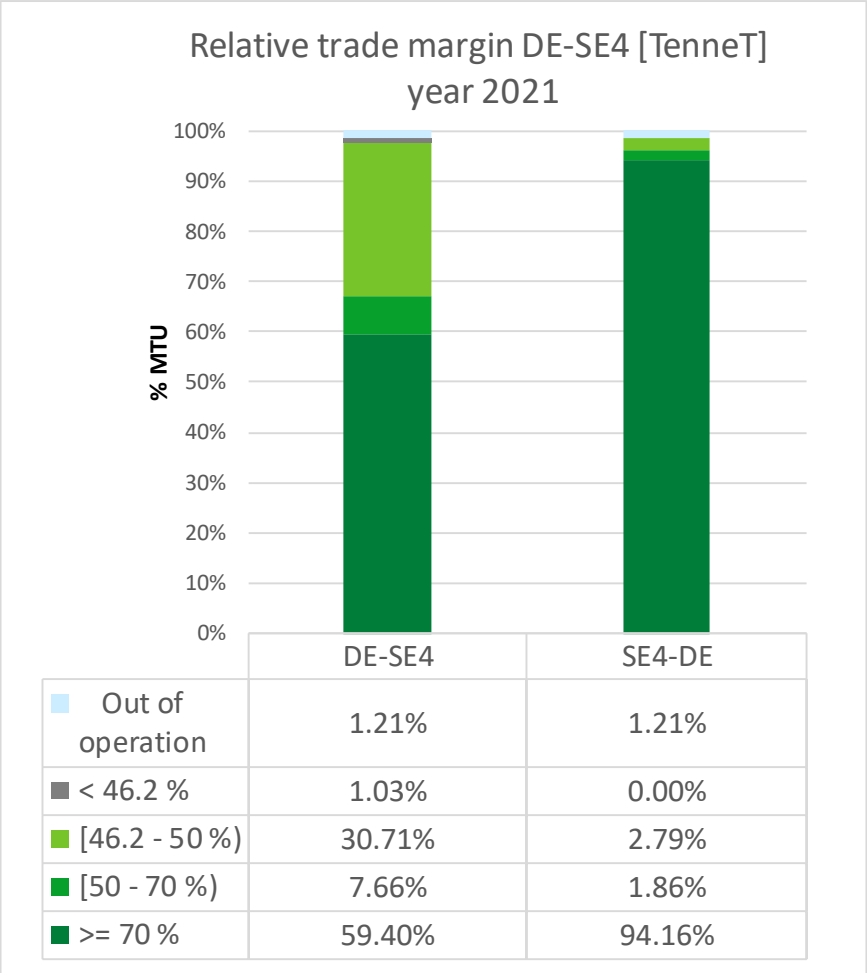
F_{max} [MW] /Cause	Test operation	Maintenance	Malfunction	Sum
0	0	328	263	**591**
685	0	34	366	**400**
700	120	0	72[39]	**192**
Summe	**120**	**362**	**701**	**1.183**

[38] The NordLink cable is a bipolar high voltage DC transmission system consisting of two high voltage cables. If only one converter is available (monopole operation), only half of the transmission power minus the full transmission losses is available.

[39] In the case of first-time monopoly operation, an F_{max} limitation of 700 instead of 685 MW is incorrectly applied.

4.2.4 NTC border Germany – Sweden 4

The Baltic Cable, which forms the border DE-SE4, was in operation during 8,654 hours in the year 2021. In the remaining hours, the Baltic Cable was out of operation, meaning that no cross-border transmission capacity was available. Figure 11 shows the distribution of the offered trading margin of the DE-SE4 border in the year 2021.



	DE-SE4	SE4-DE
Out of operation	1.21%	1.21%
< 46.2 %	1.03%	0.00%
[46.2 - 50 %)	30.71%	2.79%
[50 - 70 %)	7.66%	1.86%
>= 70 %	59.40%	94.16%

Figure 11: Relative trade margin DE-SE4 [TenneT] 2021 (minimum value 46.2%)

The minimum capacity of the border DE-SE4 of 277 MW according to the linear trajectory of the action plan, which corresponds to 46.2% of the maximum capacity of the Baltic Cable, was complied with in the south direction (SE4 to DE) during all 8,654 operating hours. In the north direction (DE to SE4), the minimum capacity was complied with during 8,564 hours (99% of the operating hours).

In a total of 90 hours, the NTC fell short of the minimum capacity required by Article 16(3) of the EU Electricity Market Regulation for reasons of system security.

The lowest NTC value in 2021 was 246 MW. All shortfalls are due to critical line unavailabilities in the TenneT control area (incl. distribution grid level) and were communicated to the market participants by means of ad-hoc messages to the BNetzA and by means of Urgent Market Messages (umm.nordpoolgroup.com).

The minimum capacity was consistently met in the normal connection state (availability of all relevant network elements) during the year 2021 because wind turbines could be curtailed as a corrective measure to prevent the overloading of critical network elements in the connection area of the Baltic Cable.

LIST OF ABBREVIATIONS

AC	Alternating current
ACER	European Union Agency for the Cooperation of Energy Regulators
BMWK	Federal Ministry for Economic Affairs and Climate Action
BNetzA	Federal Network Agency
CCR	Capacity calculation region
CGM	Common grid model
CNE	Critical network element
CNEC	Critical network element in combination with the respective critical contingency combination
cNTC	Coordinated NTC method
Core FB MC	Flow-based market coupling in the capacity calculation region Core
CWE	Central Western European region
CZ	Czechia
DA	Day-ahead
DC	Direct current
EN	Germany
DE-DK1	Border Germany – Denmark 1
DE-DK2	Border Germany – Denmark 2
DE-NO2	Border Germany – Norway 2
DE-SE4	Border Germany – Sweden 4
DFP	Default flow-based parameter
DK	Denmark
EEA	European Economic Area
F_{max}	Physical capacity
F_{ref}	Reference flow
KF CGS	Kriegers Flak Combined Grid Solution
minRAM	Minimum remaining available margin
MTU	Market time unit
NO	Norway
NTC	Net transfer capacity
PL	Poland
PSDF	Phase shift distribution factor
PTDF	Power transfer distribution factors
RAM	Remaining available margin
SE	Sweden
SOGL	System Operation Guideline
TSO	Transmission system operator

LIST OF FIGURES/ILLUSTRATIONS