REPORT OF THE GERMAN TRANSMISSION SYSTEM OPERATORS ON AVAILABLE CROSS-ZONAL CAPACITY FOR THE YEAR 2023 PURSUANT TO ARTICLE 15(4) INTERNAL MARKET FOR ELECTRICITY REGULATION (EU) 2019/943

AS OF: 15/03/2024

CREATED BY

THE GERMAN TRANSMISSION SYSTEM OPERATORS WITH CONTROL AREA RESPONSIBILITIES

50hertz | Elia Group

amprion

TenneT Taking power further

TRANSNET BW

IN COLLABORATION WITH THE TRANSMISSION SYSTEM OPERATOR WITHOUT CONTROL AREA RESPONSIBILITY

baltic cable

Table of Contents

SUMMARY

The EU Electricity Market Regulation (EU) 2019/943 of 05/06/2019, prescribes a minimum value for the capacity to be available for cross-zonal electricity trading of 70% as of 01/01/2020. With its “Bidding Zone Action Plan”[1], Germany is applying a transitional arrangement provided in Art. 15 of the EU Electricity Market Regulation and is increasing the capacity for cross-zonal electricity trading from the level of before 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 transmission system operators with control area (cTSO) 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[2], Germany – Denmark 2, and Germany – Norway 2 were fulfilled at all times during 2023 by the transmission system operators with control area 50Hertz and TenneT. At the border Germany – Sweden 4, a lower deviation of the minimum occurred in 222 hours due to unavailability of critical network elements in the TenneT control area (including the distribution network level) in accordance with Art. 16(3) of the EU Electricity Market Regulation to ensure system security.

On the network elements of the Core region, the cTSOs complied with the requirements according to Art. 16 of the EU Electricity Market Regulation in all hours, although in a few hours a lower deviation of the currently applicable minimum value of 40.8% for the year under review occurred. In these hours, the lower deviation was necessary to ensure system security or was due to the methodological discrepancy described in Chapter 3.1.2.. This took place in accordance with the requirements of Art. 16(3) of the EU Electricity Market Regulation at all times.

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 2023.

[1] https://www.bmwi.de/Redaktion/DE/Downloads/A/aktionsplan-gebotszone.pdf?__blob=publicationFile&v=10
[2] For the direction Denmark 1 to Germany, a lower deviation must be disclosed, which, however, does not represent a lower deviation if the assumptions at the time of the capacity calculation are taken into account.

1. LEGAL BACKGROUND

The EU Electricity Market Regulation (EU) 2019/943 of 05.06.2019 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 01/01/2020, at least 70% of the border transmission capacity of borders with NTC[3] 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 (cf. Art. 16(8)).

For Member States that have identified structural grid congestion, the EU Electricity Market Regulation opens the possibility of submitting an action plan to reduce this congestion (cf. Art. 15(1)). In this case, the minimum value for cross-zonal trade capacity is to be raised annually in steps during the period from 01/01/2021 through 31/12/2025 until reaching 70%, starting from the average level of the past three years or the maximum of these years (cf. 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 on 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.

The present report was produced by the TSOs control area responsibility (cTSO) 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) EU Electricity Market Regulation for the year 2023.

[3] 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, formerly known as BMWi) 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[4], the German TSOs 50Hertz, Amprion, TransnetBW and TenneT[5] have calculated and published[6] the initial values for the German bidding zone borders[7] 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 are part of the flow-based market coupling[8] in the capacity calculation region[9] Core. 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 flow-based market coupling (Core FBMC) on 08/06/2022, the minimum values determined in this way were 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 FBMC in the future.

This report examines the German borders of the CCR Core according to the flow-based market coupling method for the time after 09/06/2022.

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).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 as an EU Member State in these cases although it is not bound to the Regulation if it has not adopted it yet. These calculations result in the initial values and the corresponding linear trajectories, as shown below.

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[4]Bundesnetzagentur - Europäische Marktkopplung - Prinzipien zur Berechnung und Ausweisung der Startwerte nach Artikel 15 Absatz 2 Verordnung (EU) 2019/943
[5] The initial value for the border DE-SE4 was determined by TenneT.
[6] https://www.netztransparenz.de/EU-Network-Codes/CEP-Startwerte
[7] This refers to the Germany-Luxembourg bidding zone. To improve readability, the term “German bidding zone” is used below.
[8] Flow-based Market Coupling, FBMC
[9] Capacity Calculation Region, CCR

CCR Core

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

Table 1: *Linear trajectory curve for critical grid elements in the CWE and CEE regions (merged into the Core region as of 08/06/2022)*

The minimum remaining available margin introduced for the CWE region in April 2018 (CWE-MinRAM) of 20% will continue to apply in the CCR Core as well 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[10]	Kontek → KFCGS[11]→	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

Table 2: *Linear trajectory curve for critical network elements in the Hansa region*

TenneT‘s Commitment regarding the minimum value on the border DE-DK1 resulting from the „Commission Decision of 07/12/2018 […] Case AT.40461 – DE/DK Interconnector“ remain unaffected.

[10] 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.
[11] 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 in the following. 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 as EU Member States.[12] This ensures a consistent method for calculating the initial values for the German TSOs.

If the minimum values are not met according to the 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[13] and intraday (ID) timeframe as well as capacities reserved for cross-border balancing power, just like the consideration of other European borders in calculating the uncoordinated trade margin.[14] 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.[15] [16]

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[12] 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.
[13] Within the scope of the methodology monitoring for the Core flow-based capacity calculation region, the long-term capacity is already included in the coordinated trade margin in advance. In this case, no further consideration takes place at this point.
[14] 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
[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.
[16] In the case of HVDC interconnectors with implicit loss procurement, the relative price difference must be greater than the applied loss factor of the interconnector, as a further increase of the exchange would otherwise not be economic.

3.1 Core region

As described in Chapter 2, a common initial value and linear trajectory of the minimum value to be maintained on each critical network element (CNE), considering the respective critical outage combinations (CNEC), was calculated for all German borders that are part of the CCR Core.

Since 08/06/2022, the transmission capacities for the German borders in the Core region have been calculated using the flow-based methodology. The monitoring methodology is described below.

<u>Calculating the offered trade margin</u>

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 value 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. When applying default flow-based parameters (DFPs) or spanning[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 or spanning were applied are therefore excepted from the compliance evaluation.

<u>Determining the coordinated trade margin</u>

The reported coordinated trade margin corresponds firstly to the remaining available margin (RAM) offered for the cross-zonal trading within the day-ahead capacity calculation, which is published daily on the website of JAO[18].

For the monitoring of the capacities allocated in the CCR Core, the capacities allocated in the long-term area are also taken into account in accordance with Article 4(4)b of the DA CCM. This is made possible by the following procedure, which is explained in a simplified representation in Figure 1.

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[17] The application of DFP and spanning are fallback procedures according to Art. 22 of Core DA CCM. Capacities allocated when DFPs are applied correspond at least to the allocated cross-zonal long-term capacities. Spanning interpolates missing flow-based parameters of up to two consecutive MTUs based on the available parameters of the previous and subsequent MTU.

[18] https://publicationtool.jao.eu/core/

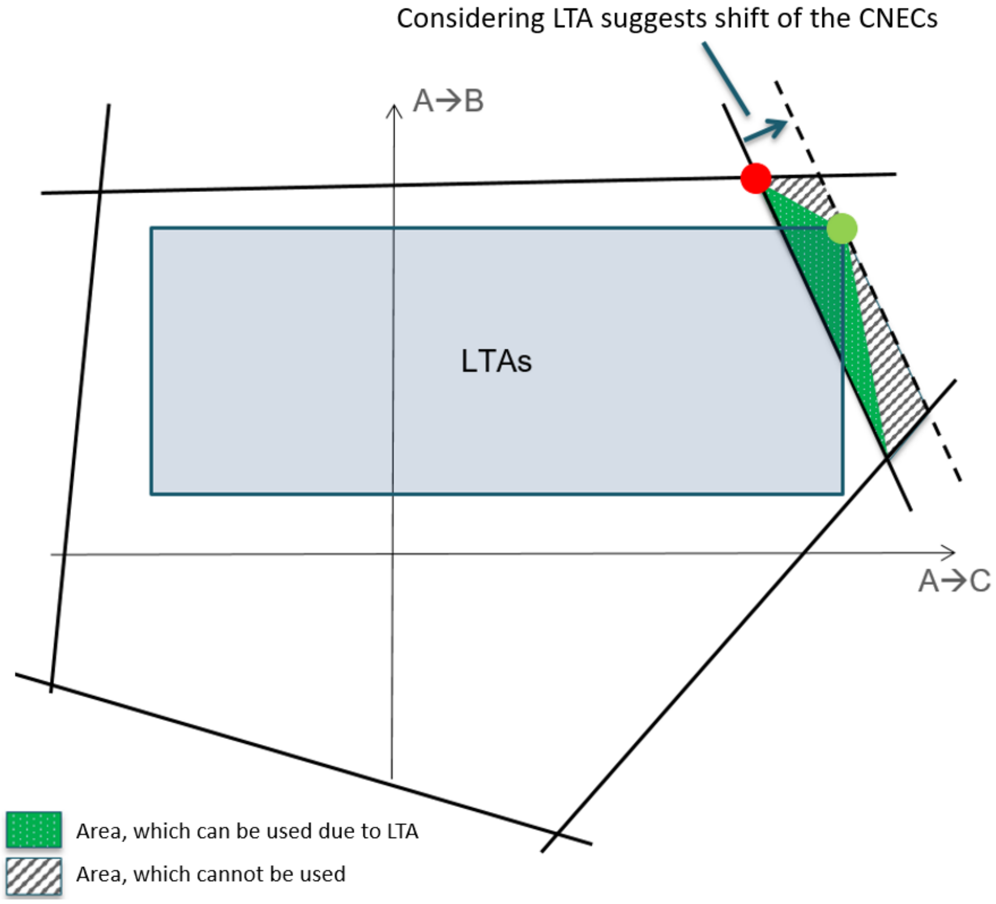


Figure 1: *Consideration of allocated long-term capacities in the coordinated trade margin (simplified representation)*

1) Determination of the offered margin per CNEC before LTA inclusion (red dot) → $RAM_{CNEC\ i,MTU\ j}$
2) Determination of the maximum LTA impact on the CNEC (green dot)

$$F\_LTA_{\max CNEC\ i,MTU\ j} = \sum LTA_{MTU\ j} \text{ x } PTDFpositive_{CNEC\ i,MTU\ j}$$

LTA is a vector containing all long-term capacities allocated within the respective capacity calculation region. $PTDFpositive$ describes a vector containing the positive (i.e., burdening) zone-to-zone PTDFs of the respective CNECs of the borders, where the long-term capacities were allocated.

3) Determination of the maximum of both values:

$$coordinated\ trade\ margin\ _{CNEC\ i,MTU\ j} = \max\left(RAM_{CNEC\ i,MTU\ j}\ ;\ F\_LTA_{max}\right)$$

<u>Calculating the uncoordinated trade margin</u>

The influence of the cross-zonal trade capacity offered in the CCR Core on the respective CNEC 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.[19]

The individual uncoordinated trade margins of the various NTC border directions are added up 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 takes into account borders where the PTDF values in the reference programme (RefProg) are available within the day-ahead Core FBMC capacity calculation.[20]

Parameter	Input data	Source
Uncoordinated trade margin	NTCs	day-ahead[21] Net Transfer Capacity requested from the ENTSO-E Transparency Platform
Coordinated and uncoordinated trade margin	PTDFs of Core CNECs	Core CC Tool (partly publicly available under JAO Publication Tool[22])
Coordinated trade margin	RAM	Core CC Tool (publicly available under JAO Publication Tool[23])
Coordinated trade margin	LTAs	Core CC Tool (publicly available under JAO Publication Tool[24])

Table 3: *Data sources for the CCR Core*

Impact of individual validation on the trade margin offered

The capacity available on the CNECs for cross-border trading is increased to the minimum value if the minimum value was not reached for the respective CNEC as a result of the capacity calculation. Within the framework of the individual validation of the TSOs, probable market results are therefore checked to see whether potentially occurring overloads on the network elements can be mitigated through the use of secured

[19] 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

[20] The borders of the reference programme for Core can be viewed in the JAO Publication Tool: https://publicationtool.jao.eu/core/refprog

[21] https://transparency.entsoe.eu/transmission-domain/ntcDay/show

[22] https:// publicationtool.jao.eu/core/finalComputation

[23] https:// publicationtool.jao.eu/core/finalComputation

[24] https://publicationtool.jao.eu/core/lta

available remedial actions (including redispatch, cross border redispatch, PST tapping and topological measures). If this is not the case, the capacity available for cross-border trade is reduced to avoid jeopardising operational security. The capacity reduction as a result of the validation does not necessarily lead to a lower deviation of the minimum values, as on most CNECs significantly more than the minimum trade margin is made available. Only in a few hours do the capacity reductions as a result of validation lead to values below the minimum values.

Special case of Core region internal DC interconnectors

In accordance with Article 12(1) of the Core Day-Ahead Capacity Calculation Methodology DC interconnectors at Core region internal borders are integrated into the flow-based capacity calculation via the "Evolved Flow-Based Procedure". In this process, the converter stations function as so-called 'virtual hubs' having their own net positions, i.e., they represent either a load or a generation node. These virtual hubs thus also have PTDFs to map their influence on the CNECs.

Therefore, the virtual hubs of the DC interconnector compete with the other bidding zones for free capacity on the CNECs to enable cross-zonal electricity trading via the interconnector. The maximum net position of the virtual hubs is thereby usually limited by the maximum physical transmission capacity of the DC interconnector.

In the case of a DC interconnector with a physical transmission capacity of 1,000 MW, the possible net position of the virtual hub would consequently be between -1,000 MW and +1,000 MW. The maximum possible net position thereby also reflects the coordinated trade capacity offered on the DC interconnector. There is no uncoordinated trade margin, as the entire trade capacity of the DC interconnector is made available to cross-zonal electricity trading within the flow-based capacity calculation region. In the above example, a minimum capacity of 70% would be fulfilled provided that the offered maximum net position of the virtual hub is at least +/- 700 MW. If the exchange via the DC interconnector is restricted by Core AC CNEC, this does not change the offered coordinated trade capacity for the DC interconnector.

3.1.1 Validation within the framework of the Core capacity calculation

The four German TSOs with control area responsibilities, together with the Austrian TSO APG and the Dutch TSO TTN, have developed the DAVinCy procedure to perform individual validation within the Core day-ahead capacity calculation process. This procedure consists of the following steps:

- Determination of probable market outcomes: The outcome of the Core day-ahead capacity calculation is the capacity available for cross-border trading per CNEC. How the market will use the available capacity, i.e., which combination of cross-border trades will be realized, is not known at the time of the capacity calculation and individual validation. Therefore, eight likely market outcomes are determined for further assessment.
- Determination of congestion: For each of the eight market outcomes, the network elements (CNECs and internal network elements) that are congested are identified.

- Removal of congestions: Then, considering all assured available remedial actions (redispatch, cross-border redispatch, PST tapping, and topological measures), the congestions are relieved to the extent possible. The result is the remaining congestion that cannot be removed.
- Determination of the necessary capacity reduction: For this purpose, DAVinCy analyses to what extent the offered capacities must be reduced so that neither CNECs nor internal network elements are overloaded after all remedial actions have been applied. As a result, the capacity available on the CNECs for cross-border trading is reduced by means of so-called Individual Validation Adjustments (IVA).

The complexity of the IVAs in the context of DAVinCy results from the simultaneous consideration of possible market outcomes, the resulting network conditions as well as congestion management usage and its influence on the capacities for cross-zonal exchange. A joint validation leads to advantages. Important aspects are summarized below:

- Capacity reductions as a result of the DAVinCy process results are always justified by a potential threat to operational security. The Internal EU Electricity Market Regulation explicitly provides for this case as permissible. For each IVA application, it is published for which network element congestion is imminent after considering the assured available remedial actions.[25]
- Overall, the joint validation leads to lower capacity reductions than if all six TSOs would perform the validation independently. On the one hand, this is due to the fact that the availability of remedial actions is greater in the consortium, and, on the other hand, the limitation of capacity can be designed more efficiently, in this case lower, due to the available CNECs.
- A capacity reduction or IVA application in a control area does not equate to the presence of congestion in the same control area. DAVinCy results very often show that congestion in one control area can be most efficiently addressed with an IVA application in an adjacent control area.

A capacity reduction is not the same as a lower deviation of the minimum values. As a result of the preliminary capacity calculation, capacity is often released for cross-zonal trading per CNEC that is significantly greater than the minimum value.

<u>DAVinCy fallback</u>

A so-called DAVinCy fallback is applied in the following two possible situations: 1. the results from the validation are not plausible for at least one MTU or 2. the validation calculation fails for at least one MTU. In these cases, the available coordinated trade margin for CCR Core-internal trades on DAVinCy TSOs' CNECs is reduced to 20%[26]. Long-term capacity will not be curtailed in the event of a fallback and will remain available to the market. This limitation, which can also lead to a lower deviation of the minimum values, is necessary

[25] https://publicationtool.jao.eu/core/validationReductions

[26] When the Core FBMC was put into operation, in case of DAVinCy fallback, the sum of trading from outside and inside the CCR Core was capped at 20%. On 13/09/2022, a change was made to guarantee a coordinated trade margin for CCR Core internal trades of 20%.

because without validation the TSOs have no knowledge of whether their grid elements are being overloaded, which in turn creates a high risk for operational security.

3.1.2 Discrepancy between the German requirements for monitoring and the Core capacity calculation method

The BNetzA methodology for monitoring, which is decisive for the German TSOs, differs from the CCR Core capacity calculation method regarding the determination of the uncoordinated trade margin. The German monitoring method sums up the strained flows of the offered capacities on borders outside the CCR Core when determining the uncoordinated trade margin. Under the Core capacity calculation method on the other hand, the forecast exchange is assumed for the borders outside the CCR Core. This can be both a burden and a relief. An assumed relief of CNECs through other borders reduces the uncoordinated trade margin and can even make it negative. Consequently, a correspondingly higher coordinated trade margin is required to achieve the minimum value for the trade margin than would be necessary if only the offered capacities per direction, or the burdening flows, were used.
Conversely, in rare cases, the exchange forecast in the Core capacity calculation may be higher than the capacity actually offered because short-term capacity restrictions (e.g., technical outages) could no longer be taken into account in the forecast. In these cases, the uncoordinated trade margin in the Core capacity calculation is higher than according to the German monitoring method. As a result, the minimum values according to the German monitoring method may not be met because a lower coordinated trade margin is determined in the Core capacity calculation than would be required according to the German monitoring method. As the German TSOs do not have the option of increasing the coordinated trade margin in the Core capacity calculation depending on the uncoordinated trade margin according to the German methodology, but are fixed to the Core methodology, the German TSOs are not responsible for such cases.

3.2 Hansa region

As described in chapter 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) 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, considering 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.[27] 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.

<u>Calculating the offered trade margin</u>

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.

<u>Determining the coordinated trade margin</u>

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).

<u>Calculating the uncoordinated trade margin</u>

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

[27] 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).

is calculated via PTDF).[28] 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.

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 and uncoordinated 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

Table 4: *Data sources for the CCR Hansa*

3.2.2 NTC border Germany – Denmark 2

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

<u>Calculating the offered trade margin</u>

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.

<u>Determining the coordinated trade margin</u>

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 went 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.

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

[28] 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.

Table 5: *Data sources for determining the trade margin at the DE-DK2 border*

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 considered. For monitoring of the border DE-SE4, the offered capacity (referred to as receiving side of the bidding zone border) is compared to the minimum capacity relative to the maximum capacity of the Baltic Cable (600MW on the receiving side).[29]

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 as they are also utilised by the implicitly procured power to cover losses.

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[30]	Baltic Cable AB / Operational Handbook of Baltic Cable

Table 6: *Data sources for determining the trade margin at the DE-SE border4*

[29] 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).

[30] 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 as operating hours.

4. RESULTS

4.1 Core region

The results of the offered cross-zonal trade margin on the network elements of the CCR Core are depicted for the year 2023 below. First, the methodology for evaluating the results is described.

As described in Art. 16(8)(b) of the EU Electricity Market Regulation for borders with flow-based capacity allocation[31], 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.

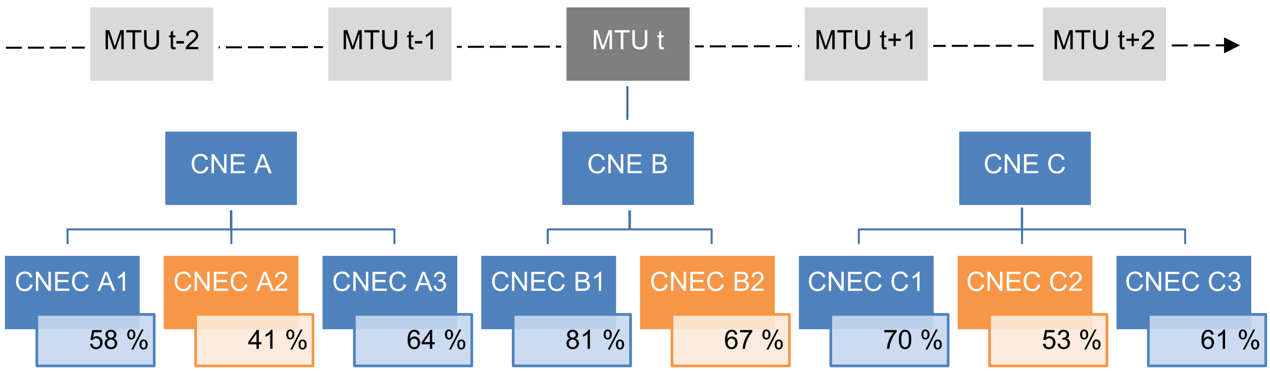


Figure 2: *Example of determining the offered trade capacity per critical network element*

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 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 operational 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.[32] One value per CNE therefore enters the evaluation for each MTU[33]. This means

[31] C.f. 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. […]*"

[32] 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.

[33] 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.

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 still further increase 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, as only one value per MTU (of the network element or CNE with the lowest trade margin) would enter 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.

4.1.1 Evaluation of process stability

In 2023 there were 4 spanning or DFP MTU applied due to technical problems in the flow-based capacity calculation. The technical problems were beyond the TSOs' control:

- 1 hour of spanning on 31/03/2023
- 1 hour spanning on 23/10/2023
- 1 hour DFP on 23/10/2023
- 1 hour spanning on 26/10/2023

Figure 3 shows the share of MTUs, in which a process failure in the Core capacity calculation occurred. Because of the missing data base for the concerned MTUs in the CCR Core, the listed hours have been excluded from the compliance assessment. For this reason, 8,756 out of 8,760 hours were considered.

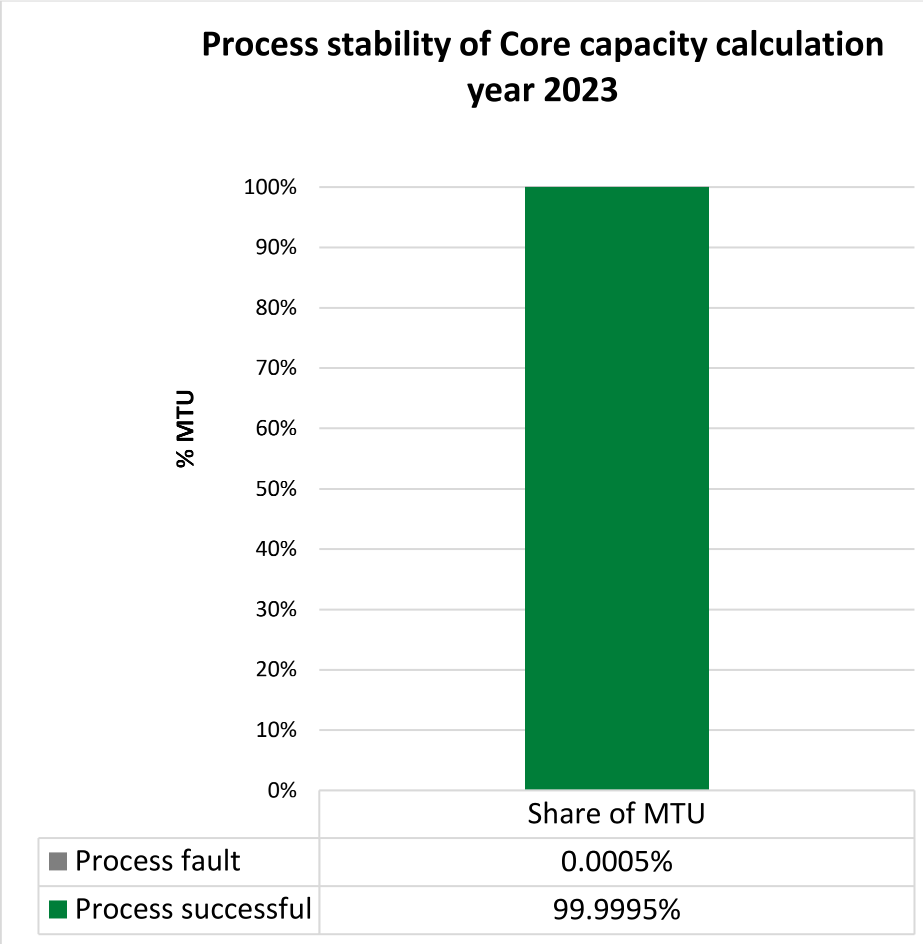


Figure 3: *Process stability in CCR Core of all TSOs during the period from 09/06/2022 through 31/12/2022*

4.1.2 Evaluation of minimum value lower deviations as a result of the validation process

In the following explanation, the results for the four German control areas are presented separately. The results are presented in a bar chart and additionally in a frequency distribution graph for each control area.

The bar charts show values below the current 40.8% minimum value. The categories "<40.8 % (overload)" and "<40.8 % (fallback)" refer to the validation process described in section 3.1.1. As a result of the validation process IVAs are applied to reduce relative trade margins to ensure operational security. When considering the cases with IVA application, cause and effect must be differentiated.
In the year 2023 IVAs were applied in 192 MTUs on German CNECs. In 141 of in total 192 MTUs the IVAs were necessary, as network elements were potentially overloaded despite considering all available remedial actions. These situations could only be remedied by the applied IVAs, which ensured operational security. In 51 of in total 192 MTUs, IVAs were required due to a DAVinCy fallback. In this situation, the validation could not be carried out in accordance with the pre-defined process and the offered trade margin was reduced as a precaution to ensure operational security. It is important to mention that not all IVA applications result in relative trade margins below the 31.0% minimum value. Only 39 out of 141 MTUs with IVA application fell below the minimum value as a result of an overload (‘IVA (overload)’ category in the following relative trade

margin figures). As a result of the DAVinCy fallback with IVA application, the 40.8% minimum value was not met in 8 out of 51 MTUs (category "IVA (fallback)" in the following figures of the relative trade margin). For the cases of a lower deviation from minimum value due to a remaining congestion, Figure 4 shows in which countries the remaining congestion would have potentially occurred geographically or how often a DAVinCy fallback was the cause.

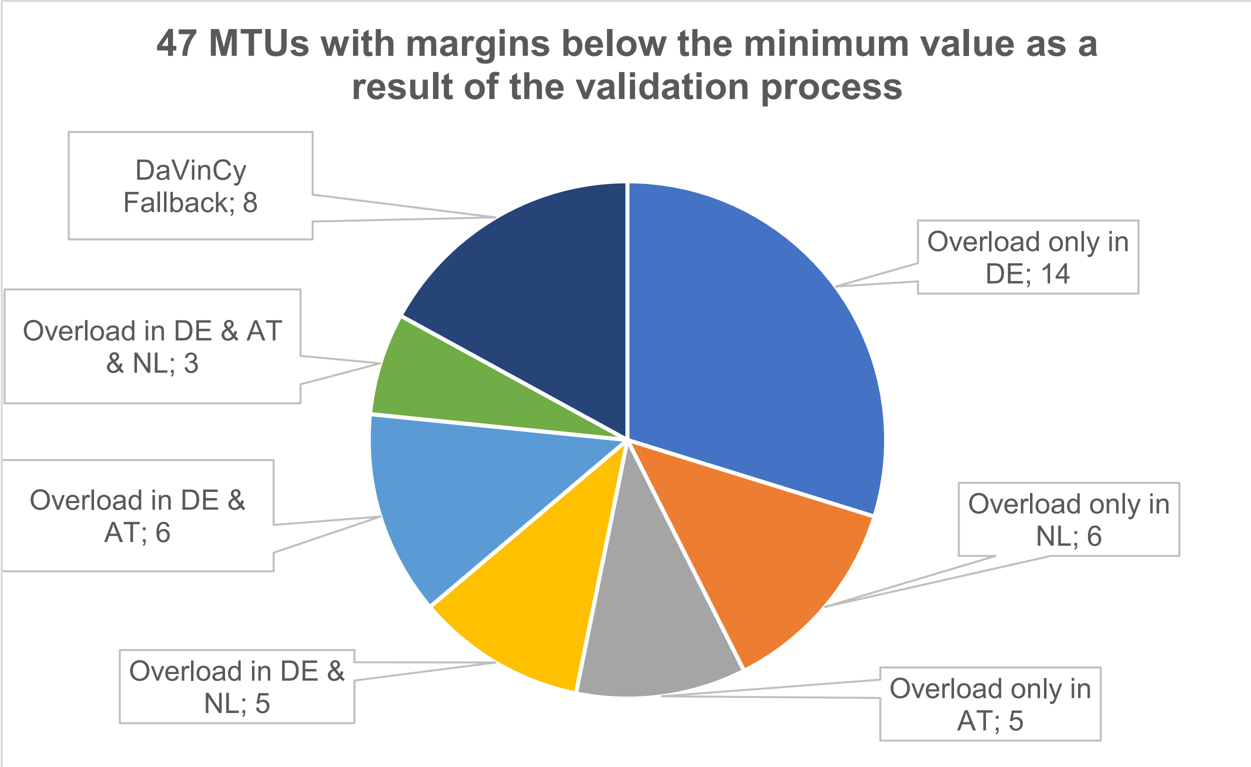


Figure 4: *Overview of causes for falling below the minimum value as a result of the validation process*

Figure 4 shows that in 28 hours an overload was expected on a German network element and network elements of other countries, which resulted in the reduction of the offered relative trade margin below the minimum value. Irrespective of the geographic location of possible overloads of network elements, the EU Electricity Market Regulation provides for the possibility of deviating below the minimum value to ensure operational security. In this respect, the hours set out above do not constitute a violation of the applicable legal requirements.

4.1.3 Evaluation of lower deviation from the minimum value due to discrepancy between German monitoring method and CCR Core capacity calculation

As described in section 3.1.2, there is a discrepancy between the German monitoring method and the Core capacity calculation, which in very rare cases can lead to a lower deviation of the minimum values according to the German monitoring method. In 2023, 6 cases occurred, which are shown in detail in the following table. This is due to the difference in the calculation of the uncoordinated margin as explained in the methodology chapter in section 3.1.2. The German TSOs are not responsible for these cases, as the Core capacity calculation method does not provide for the possibility of increasing the coordinated trade margin in accordance with the German monitoring method.

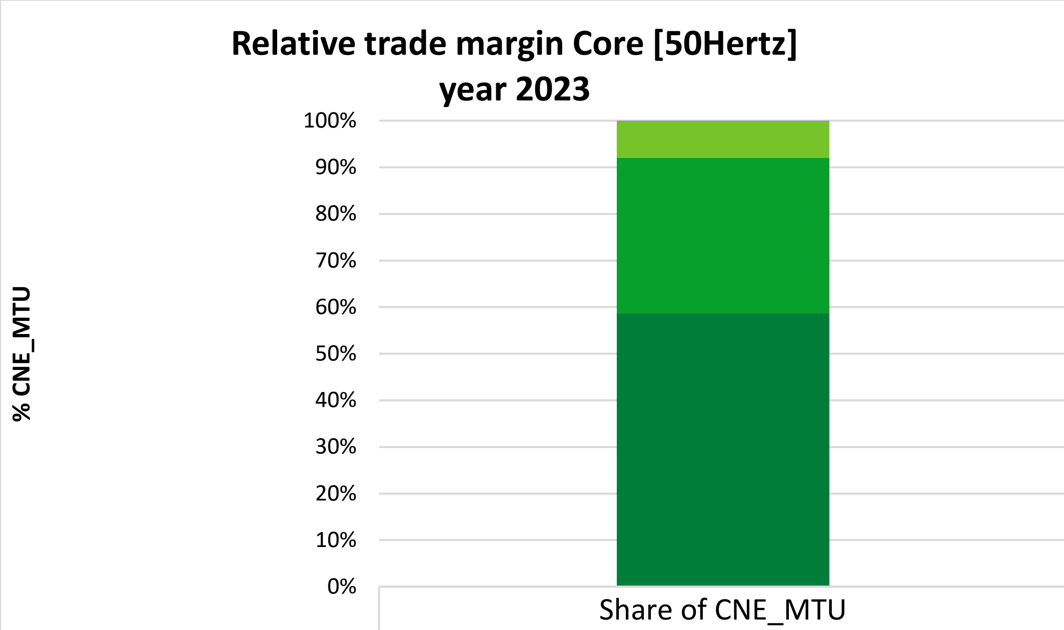
The Core capacity calculation process starts two days before delivery. One input variable is a forecast (RefProg) of trading inside and outside the CCR Core, whereby the latter is used to calculate the offered uncoordinated trade margin. The total capacity offered is made up of the coordinated trade margin within the CCR Core and the uncoordinated trade margin on borders outside the CCR Core. Under the German monitoring method, however, the NTC actually offered is used as the basis for calculating the uncoordinated trade margin. If, in the period between the forecast for the Core capacity calculation, trading on a border outside the CCR Core is limited, for example due to an outage, the uncoordinated trade margin, and thus also the sum of the coordinated and uncoordinated trade margin, can therefore be lower in the German monitoring method than in the Core capacity calculation. Table 7 shows the cases that led to a lower deviation of the minimum value in 2023 according to the German monitoring method. The column "main cause lower uncoordinated margin DE" is important here. It indicates the limit outside the CCR Core, the higher forecast from the Core capacity calculation, and the NTC actually offered. It thus provides transparency on the specific limits outside the CCR Core on which a larger trade was based in the Core capacity calculation than was later practically available as NTC.

Time (UTC)	**Network element**	**TSO**	**Uncoordinated margin**		**Main reason lower uncoordinated margin GE (Border / RefProg Core / NTC)**	**Total trade margin**
			DE Monitoring	CCR Core capacity calculation		
10/01/2023 08:00:00	Hanekenfaehr - Doerpen West [OPP]	TenneT	398.48	408.8	DK1-DE / 1.595 MW / 500 MW	40,47%
10/01/2023 08:00:00	Doerpen West - Hanekenfaehr EMSLD WB [DIR]	Amprion	398.48	408.8	DK1-DE / 1.595 MW / 500 MW	40,49%
29/01/2023 22:00:00	Lauchstaedt - Vieselbach 471 [DIR]	50Hertz	499.75	504.54	DK1-DE / 2.500 MW / 2.050 MW	40,73%
29/01/2023 22:00:00	Lauchstaedt - Vieselbach 472 [DIR]	50Hertz	499.75	504.54	DK1-DE / 2.500 MW / 2.050 MW	40,73%
28/11/2023 06:00:00	Meppen - Y Niederlangen [OPP]	TenneT	69,31	120,37	DK1-NL / 369 MW / 0 MW	39,93%
29/11/2023 02:00:00	Diele - Doerpen West [DIR]	TenneT	100,94	203,58	DK1-NL / 164 MW / 0 MW NO2-NL / 620 MW / 0 MW	37,72%

Table 7: *Main reasons for the discrepancy between the German monitoring method and the Core capacity calculation*

4.1.4 Presentation of results per control area

4.1.4.1 50Hertz control area



	Share of CNE_MTU
< 40.8 % without IVA	0.0006%
< 40.8 % IVA (fallback)	0.0120%
< 40.8 % IVA (overload)	0.0076%
[40.8 - 50 %)	7.8951%
[50 - 70 %)	33.4653%
>= 70 %	58.6194%

Figure 5: *Relative trade margin Core [50Hertz] during the year 2023 (minimum value 40.8%)*

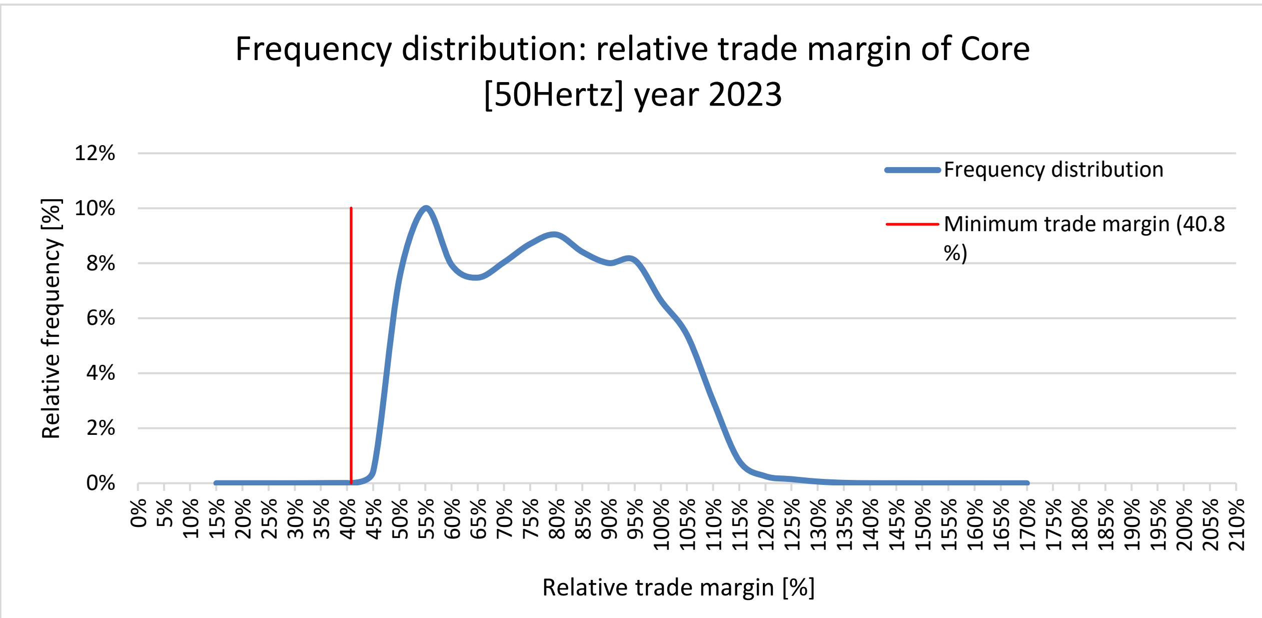
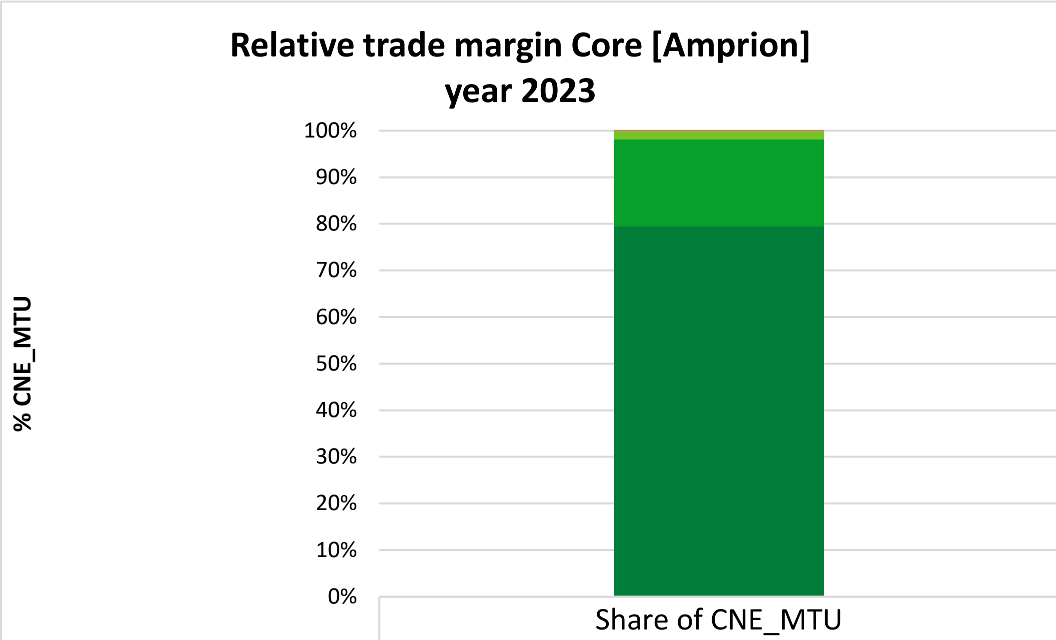


Figure 6: *Frequency distribution Core [50Hertz] during the year 2023 (minimum value 40.8%)*

Figure 5 and Figure 6 show the distribution of the offered relative trade margin on the CNEs of the 50Hertz control area for the year 2023, based on 342.199 values (one value per CNE and MTU) in a total of 8,756 MTUs. The number of 50Hertz CNEs considered in the Core capacity calculation process varies as a result of switch offs and is thus partly different per day. The small quantity of CNE_MTUs that fall below the minimum values is the result of the validation process or the discrepancy between the German monitoring method and the Core capacity calculation method. Thus, all lower deviations of the minimum capacity are justified either as a measure to ensure system security and thus meet the requirements of Art. 16(3) of the EU Electricity Market Regulation or are due to the different methodologies.

<u>4.1.4.2 Amprion control area</u>



	Share of CNE_MTU
< 40.8 % without IVA	0.00%
< 40.8 % IVA (fallback)	0.01%
< 40.8 % IVA (overload)	0.00%
[40.8 - 50 %)	1.88%
[50 - 70 %)	18.63%
>= 70 %	79.48%

Figure 7: *Relative trade margin Core [Amprion] during the year 2023 (minimum value 40.8%)*

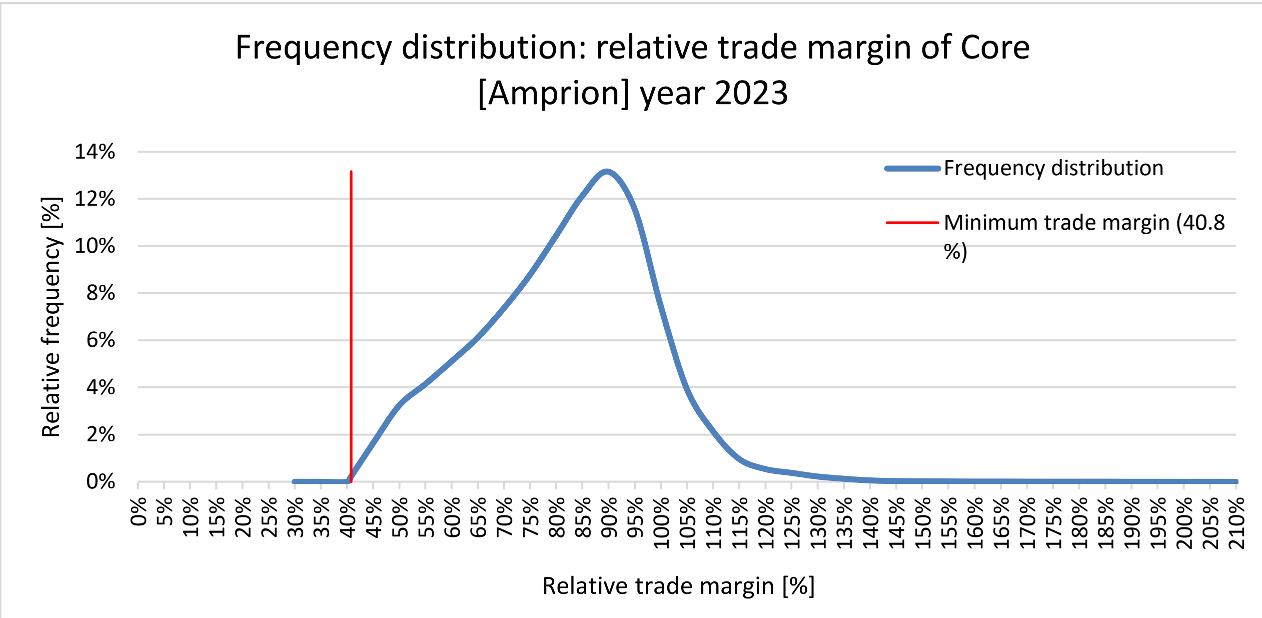
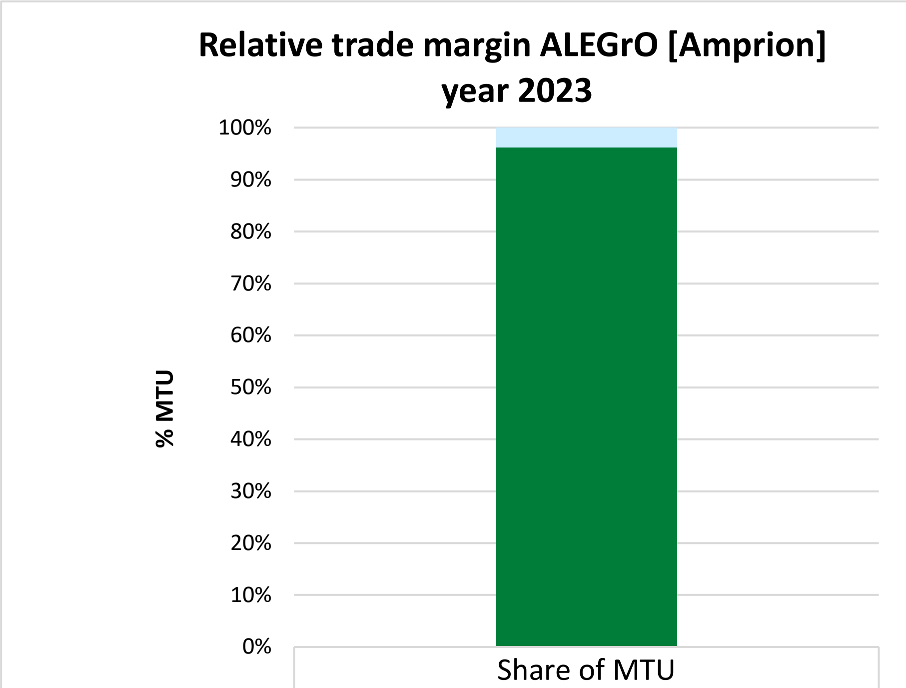


Figure 8: *Frequency distribution Core [Amprion] during the year 2023 (minimum value 40.8%)*

Figure 7 and Figure 8 show the distribution of the offered relative trade margin on the CNEs of the Amprion control area for the year 2023 based on 1.105.345 values (one value per CNE and MTU) in a total of 8,756 MTUs.

The small quantity of CNE_MTUs that fall below the minimum values is the result of the validation process or the discrepancy between the German monitoring method and the Core capacity calculation method. Thus, all lower deviations of the minimum capacity are justified either as a measure to ensure system security and thus meet the requirements of Art. 16(3) of the EU Electricity Market Regulation or are due to the different methodologies.



	Share of MTU
Out of operation	3.78%
< 31%	0.00%
[31 - 50 %)	0.00%
[50 - 70 %)	0.00%
>= 70 %	96.22%

Figure 9: *Relative trade margin ALEGrO [Amprion] during the year 2023 (minimum value 40.8%)*

Figure 9 shows the transmission capacity provided by Amprion on ALEGrO's German hub 'AL_DE' for cross-zonal power trading in relation to ALEGrO's available thermal capacity.[34] Amprion was able to offer 100% of the available thermal transmission capacity of 1,000 MW to cross-zonal trading in all MTUs for the year 2023. As there are only two values across all (0 MW; 1000 MW), they are not presented as a frequency distribution at this point.

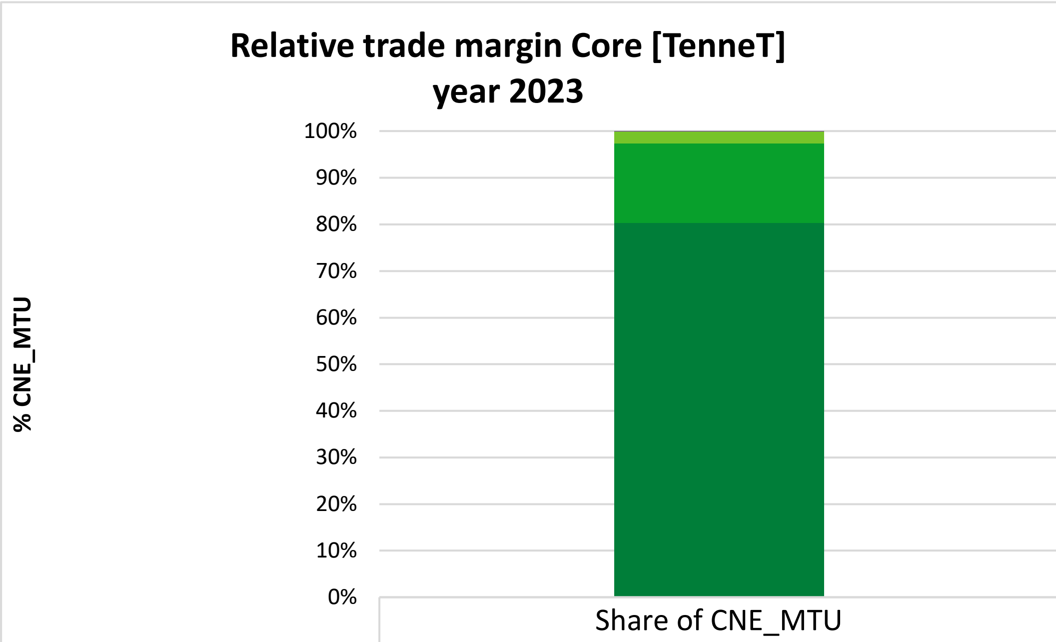
[34] A detailed description of the monitoring methodology for ALEGrO can be found in chapters 3.1.2 (special case Core-internal DC interconnectors) and 4.1.2.1 (Amprion control area).

As a DC network element, ALEGrO is not included in the Core capacity calculation as a CNEC and cannot be overloaded. Therefore, compared to the AC network elements of the CCR Core, the differentiation of the category for lower deviations of the minimum value of 40.8% is omitted.

From 08/05/2023 to 17/05/2023 and on 06/12/2023 (in the hours 7 to 15), planned activations of ALEGrO took place due to maintenance. From 06/08/2023 and 11/08/2023 there was an unplanned outage of ALEGrO due to technical defects. The capacities already offered had to be made available via the AC grid.
On 08/08/2023 no more capacity was offered on ALEGrO. In addition, between 15/08/2023 and 16/08/2023, there was another unplanned outage of ALEGrO due to an outage at the Belgian remote station during a thunderstorm. Here too, the capacity already offered had to be made available via the AC network. As this was a temporary disruption, there was no need to restrict trade capacity.

In summary, Amprion complied with the legal requirements for cross-zonal electricity trading in accordance with Articles 15 and 16 of the Internal Electricity Market Regulation in the Core region at all times in the year 2023.

<u>4.2.4.3 TenneT control area</u>



	Share of CNE_MTU
< 40.8 % without IVA	0.0009%
< 40.8 % IVA (fallback)	0.0042%
< 40.8 % IVA (overload)	0.0006%
[40.8 - 50 %)	2.5989%
[50 - 70 %)	17.1407%
>= 70 %	80.2547%

Figure 10: *Relative trade margin Core [TenneT] during the year 2023 (minimum value 40.8%)*

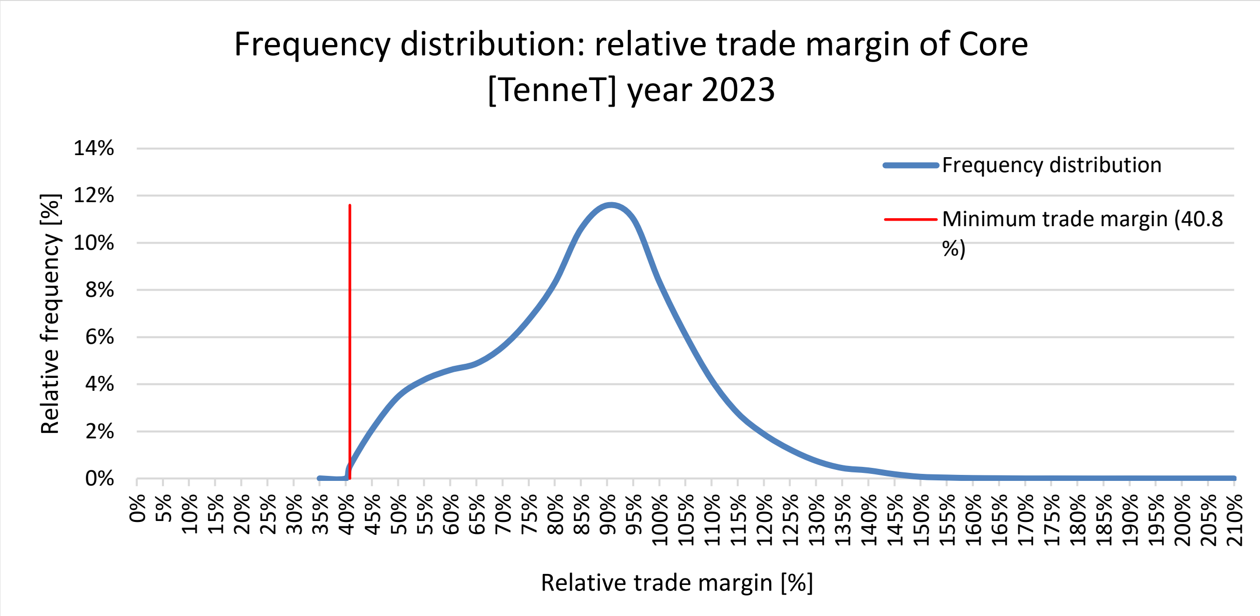


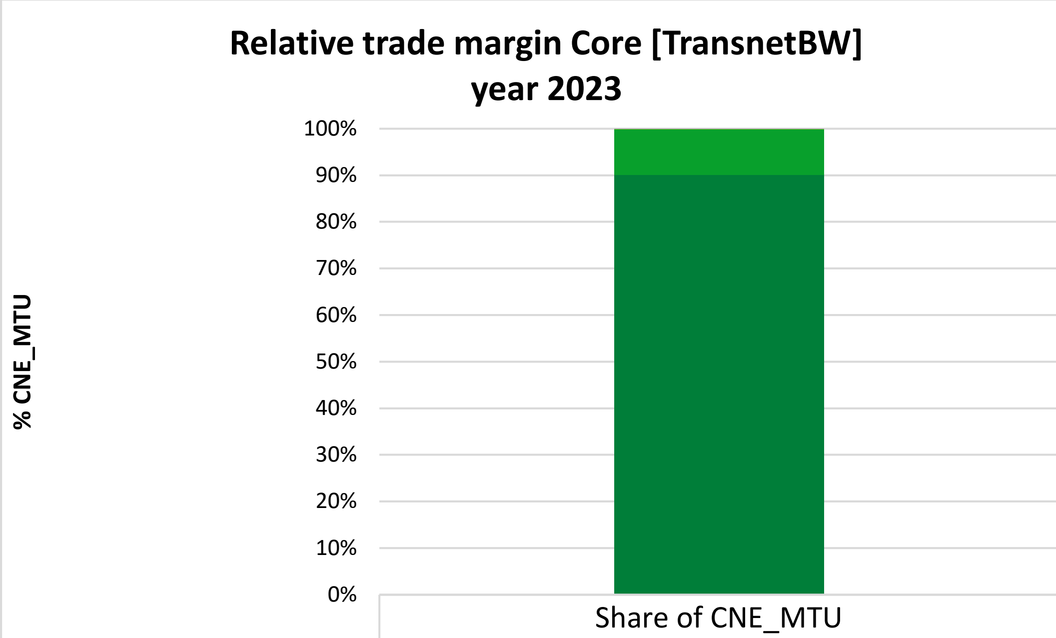
Figure 11: *Frequency distribution Core [TenneT] during the year 2023 (minimum value 40.8%)*

Figure 10 and Figure 11 show the distribution of the offered relative trade margin on the CNEs of the TenneT control area in the year 2023 based on 332.546 values (one value per CNE and MTU) in a total of 7,856 MTUs[35]. Thus, an average of 38 CNEs of the TenneT control area were taken into account per MTU in the graphs.

The small quantity of CNE MTUs falling below the minimum values is the result of the validation process or the discrepancy between the German monitoring method and the Core capacity calculation method. Therefore, all lower deviations below the minimum capacity are either justified as a measure to ensure system security and thus fulfil the requirements of Article 16(3) of the Electricity Market Regulation or are due to the different methodologies.

[35] A total of 19 CNE_MTU from 20 and 21/03/2023 with the CNE [D2-D7] Ganderkesee - St. Huelfe 2 [D2] were excluded from the presentation. Due to a data error, the Fmax value of these CNE_MTUs was only 1 MW, which led to relative MACZT values between 50,000 and 100,000 per cent.

4.1.4.4 TransnetBW control area



	Share of CNE_MTU
< 40.8 % without IVA	0.00%
< 40.8 % IVA (fallback)	0.00%
< 40.8 % IVA (overload)	0.00%
[40.8 - 50 %)	0.13%
[50 - 70 %)	9.77%
>= 70 %	90.10%

Figure 12: *Relative trade margin Core [TransnetBW] during the year 2023 (minimum value 40.8%)*

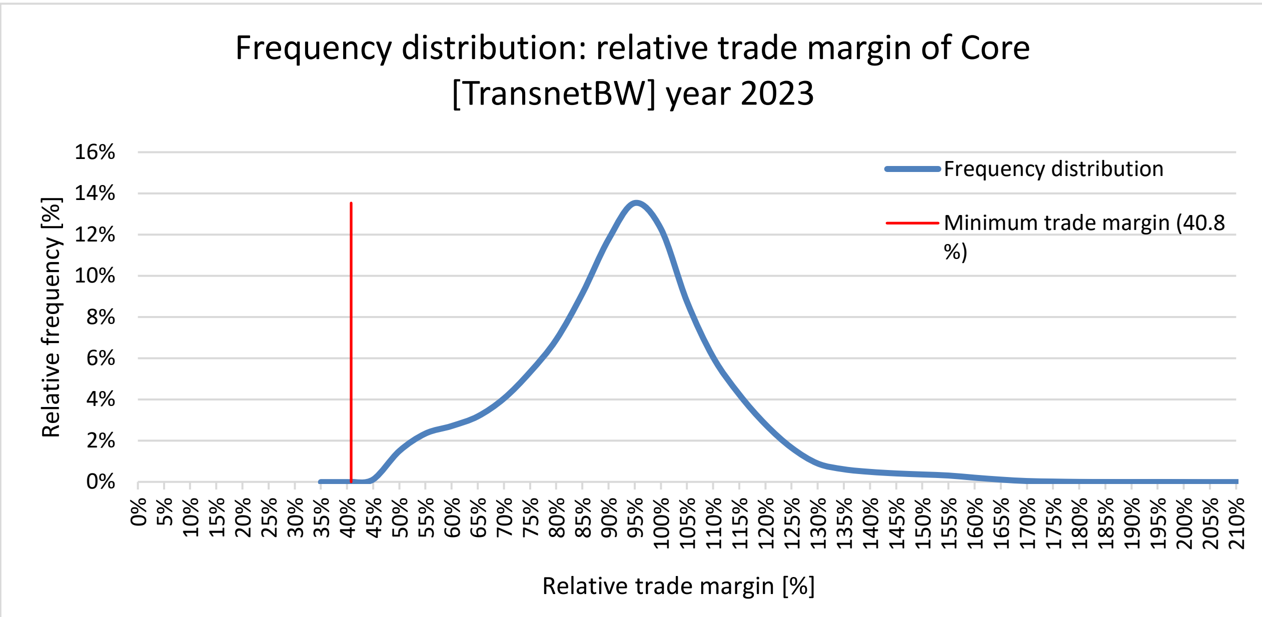


Figure 13: *Relative trade margin Core [TransnetBW] during the year 2023 (minimum value 40.8%)*

Figure 12 and Figure 13 show the distribution of the offered relative trade margin on the CNEs of the TransnetBW control area for the year 2023, based on 249.025 values (one value per CNE and MTU) in a total of 8,756 MTUs. Thus, an average of approx. 28 CNEs of the TransnetBW control area were considered per MTU.

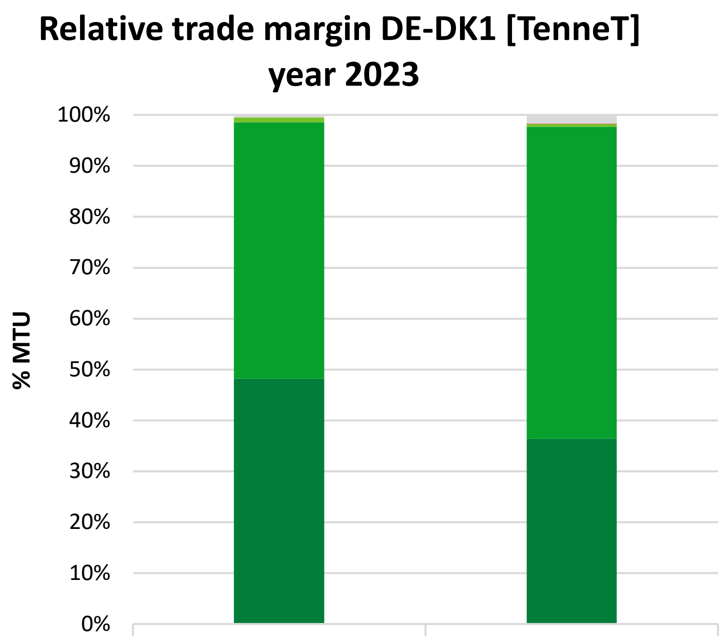
The small quantity of CNE_MTUs that fall below the minimum values is the result of the validation process. These deviations below the minimum capacity are to be regarded as justified measures to ensure system security and therefore fulfil the requirements of Article 16(3) of the Electricity Market Regulation.

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 in the year 2023, meaning that the minimum capacity of the Bidding Zone Action Plan of 40.8% was fulfilled in every hour.

4.2 Hansa Region

4.2.1 NTC border Germany – Denmark 1

Figure 14 shows the distribution of the relative trade margin offered on the CNEs of the TenneT control area, which determined the hourly NTC values of the respective directions in 2023. Both directions comprise 8,760 values (one value per MTU). The capacity calculation did not produce any results for 45 MTUs in the DE-DK1 direction and 149 MTUs in the DK1-DE direction due to process disruptions. In these hours, a backup NTC of 1,588 MW was used for both directions, which was collateralised 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. In another MTU, a process error occurred during the capacity calculation for the DE-DK1 direction, which led to the calculation being cancelled. No backup NTC was used by mistake; instead, the intermediate result at the time of cancellation was used as the NTC value. Apart from the MTUs with a process error, the minimum value in the direction from Germany to Denmark 1 was complied with in all MTUs and in the direction from Denmark 1 to Germany in all but one MTU. The one MTU with a lower deviation is due to the fact that the coordinated trade margin assumed in the capacity calculation for the Germany - Norway 2 border could not ultimately be offered due to a fault in the NordLink cable. The trade margin of DE-DK1 should actually be calculated with the capacity of DE-NO2 assumed at the time of the capacity calculation, so that no lower deviations would have to be recognised. However, this case was not foreseen and is therefore not implemented in the monitoring software. Figure 15 shows the frequency distribution of the relative trade margins of the CNE_MTU as a kind of density function.



	DE-DK1	DK1-DE
Process fault	0.51%	1.71%
< 47 %	0.00%	0.01%
[47 - 50 %)	0.91%	0.57%
[50 - 70 %)	50.33%	61.30%
>= 70 %	48.24%	36.40%

Figure 14: *Relative trade margin DE-DK1 [TenneT] year 2023 (minimum value 47%)*

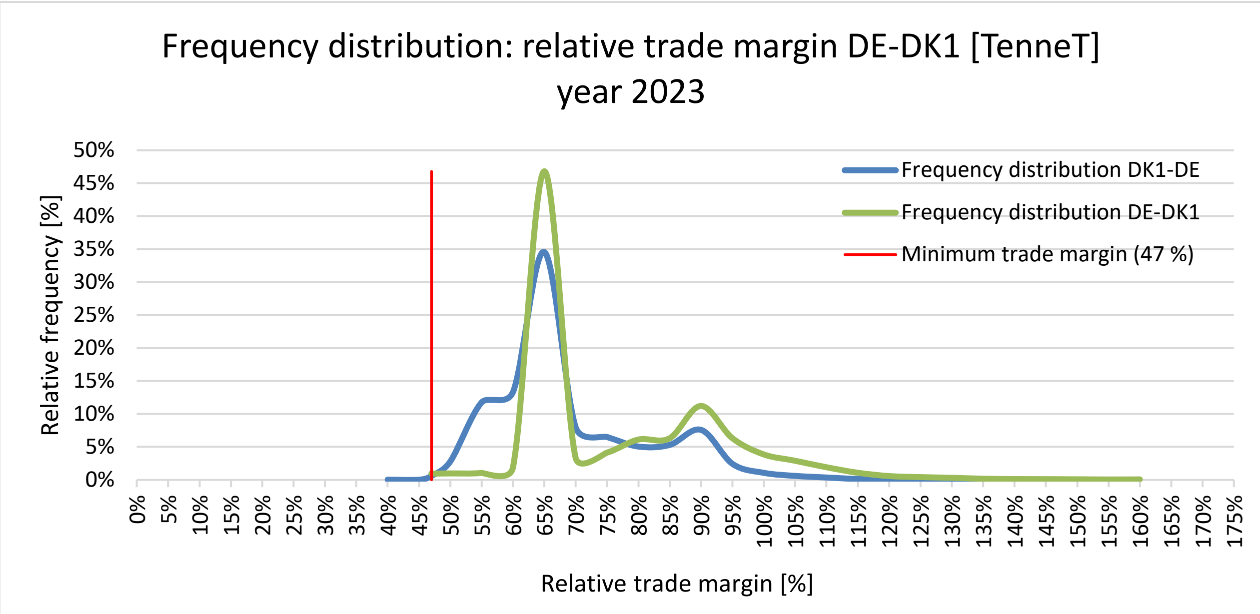
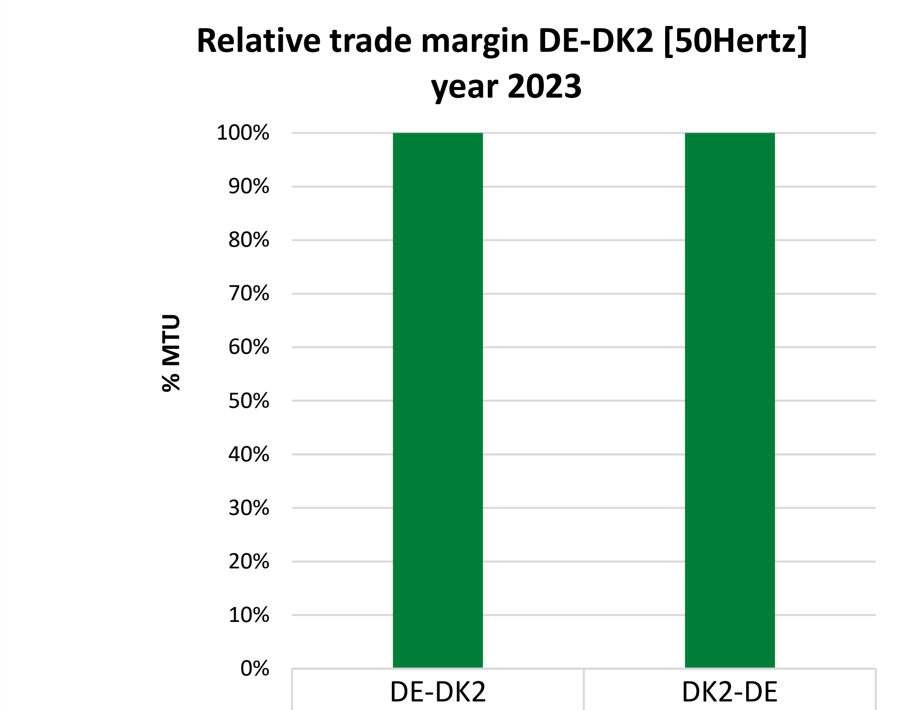


Figure 15: *Frequency distribution: relative trade margin DE-DK1 [TenneT] year 2023 (minimum value 47%)*

4.2.2 NTC border Germany – Denmark 2

For the border DE-DK2, the respectively applicable minimum value was complied with during every MTU of 2023. The minimum value per border and hour was 70.0% of the F_{max} of the Kontek cable plus 35.0 % of the F_{max} of the Kriegers Flak CGS (after deducting the forecasted DA offshore wind power infeed)[36]. After the KF CGS went 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 2023[37].



	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 16: *Relative trade margin DE-DK2 [50Hertz] year 2023 (minimum value <70%)*[38]

Figure 16 shows that the trade margin amounted to at least 70% of the transmission capacity during all hours considered. Included are 8,760 hours in the export direction and in the import direction.

[36] See also section 3.2.2 NTC border DE-DK2 in the monitoring methodology section.
[37] For the sake of simplicity, Figure 16 shows a comparison with 70% and not with the sometimes-lower minimum value.
[38] The "process fault" category refers to hours in which the capacity calculation process could not be carried out in accordance with the process; the "out of service" category refers to hours in which neither of the two interconnectors on the border was in operation.

The table below shows the number of hours in which the availability of the two interconnectors on the DE-DK2 border was restricted in 2023.[39]

Interconnector	maintenance	Partial disturbance / disturbance
Kontek cable	1,227	2,072 / 1,702
KFCGS[40]	690	948 / 122

Table 8: *Availability of interconnectors on the DE-DK2 border*

The partial restriction on the border is essentially due to:

- Maintenance: Regular maintenance work is carried out annually on both interconnectors, for which they are partially or completely taken out of operation. Furthermore, for the Kontek interconnector, shutdowns for the replacement of the land cable and the installation of a pilot DC-GIS as a bypass for the existing outdoor switchgear of the converter in Bentwisch and for the KFCGS shutdowns for preventive repairs to cable joints have been taken into account in the maintenance category.
- Partial fault / disturbance: The Kontek interconnector was faulty due to various causes (fault in the cable termination, defective circuit breaker, joint fault, fault in the filter) and was therefore completely or partially out of operation. As a result of a temperature anomaly on a cable belonging to the KFCGS, the transmission capacity on the system was reduced by a total of 25 MW throughout 2023.

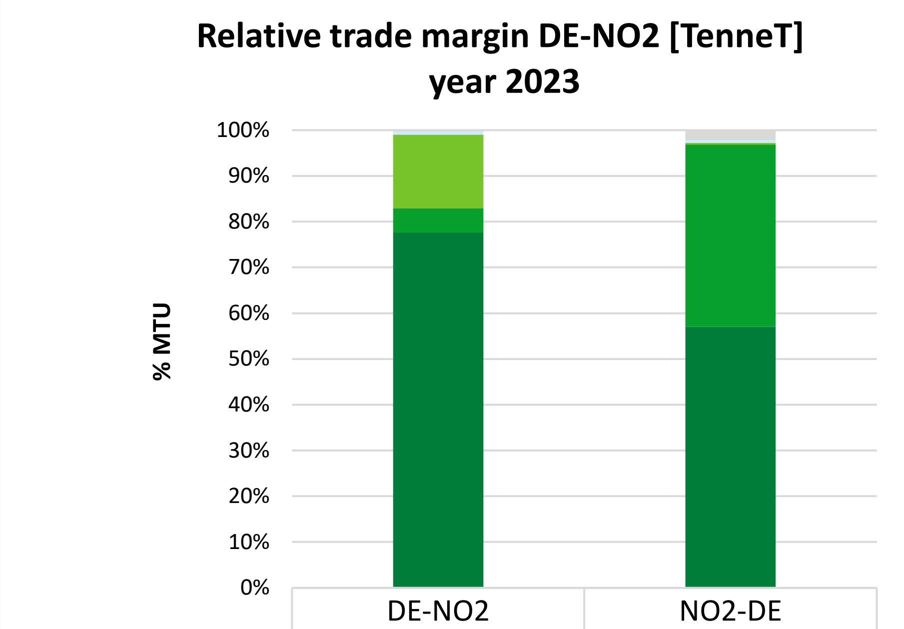
4.2.3 NTC border Germany – Norway 2

Figure 17 shows the distribution of the offered relative trade margin on the AC and DC CNECs of the TenneT control area that determined the 2023 hourly NTC values of the respective direction. Both directions include 8,760 values (one value per MTU). The minimum value for 2023 of 35.0 % according to the linear trajectory of the action plan was met on all critical network elements within the TenneT control area at all MTU. The NTC of the direction DE to NO2 was determined in 4,271 hours by the NordLink cable (DC-CNEC). The NTC of the direction NO2 to DE was determined in 3,334 hours by the NordLink cable (DC-CNEC). If the NTC is determined by the DC-CNEC, NTC equals F_{max}. Therefore, the offered relative trade margin of DC-CNECs is always 100%.

[39] In 5 hours and 28 hours respectively, no cross-border capacity was made available in the export and import direction. Cross-border capacity was available in the opposite direction in each case. During these hours, the Kontek cable was not available and the reduced transmission capacity on the KFCGS due to a partial fault was fully utilised for the transmission of the feed-in from the offshore wind farm. The monitoring requirements as described in section 3.2.2 were therefore met and these hours were therefore assigned to the >=70% class.

[40] In hours with several occurrences, a fault has overwritten the partial fault or maintenance. A partial fault has overwritten maintenance except in the case of the partial fault on KFCGS that lasted the whole year.

The capacity calculation did not produce any results for 24 MTU in the DE-NO2 direction and 187 MTU in the NO2-DE direction due to process faults. A backup NTC of 490 MW was used during these hours.



	DE-NO2	NO2-DE
Process fault	0.27%	2.13%
Out of operation	0.68%	0.68%
< 35 %	0.00%	0.00%
[35 % - 50%)	16.08%	0.31%
[50%-70%)	5.33%	39.85%
>=70%	77.63%	57.02%

Figure 17: *Relative trade margin DE-NO2 [TenneT] year 2023 (minimum value 35%)*

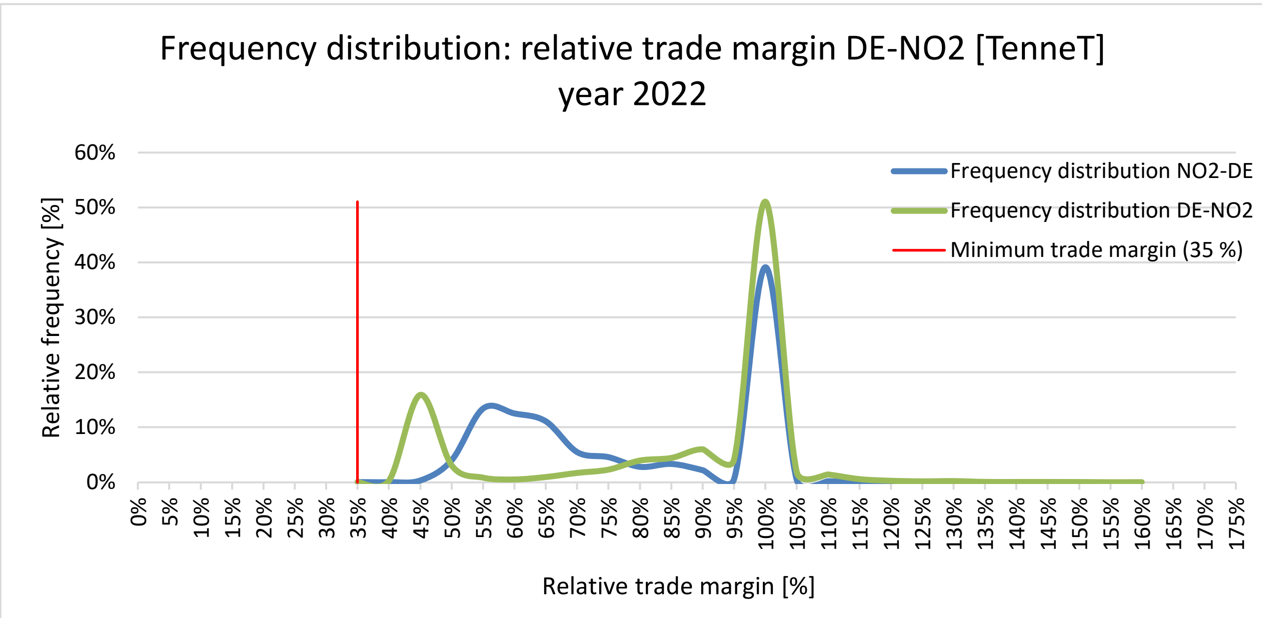


Figure 18: *Frequency distribution: relative trade margin DE-NO2 [TenneT] year 2023 (minimum value 35%)*

The NordLink cable was out of operation for 60 hours in 2023 due to maintenance or disturbances. In normal operation, the F_{max} value is 1,400 MW. For 460 hours, the cable was in monopole operation with a limitation of the F_{max} value (DC CNEC) to 685 MW.[41] In 168 hours, the F_{max} value was limited to 700 MW due to a disturbance. The hours with limited F_{max} value are included in the shown distribution for the relative MACZT data. The following table shows the number of hours with F_{max} restrictions by cause.[42]

Operating state (number of hours)	F_{max} [MW]	planned maintenance	planned repairs	forced outage	Total
Out of operation	0	49	11	0	**60**
Monopole operation	685	23	24	206	**460**
Limitation operation	700	0	0	168	**168**
				Grand total	**688**

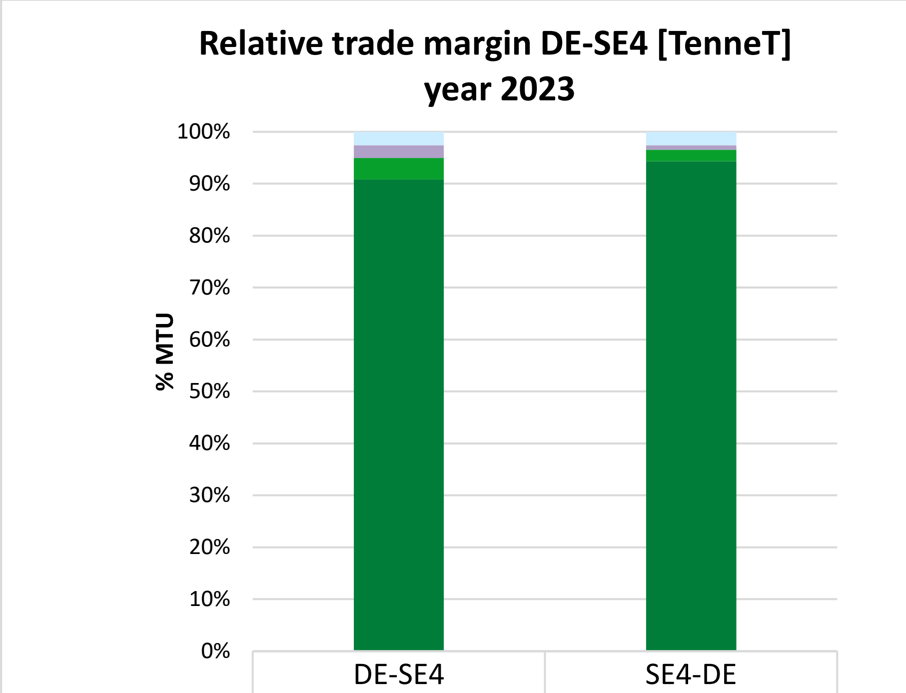
Table 9: *Availability of the NordLink cable at the DE-NO2 border*

4.2.4 NTC border Germany – Sweden 4

The Baltic Cable, which forms the border DE-SE4, was in operation during 8,529 hours in the year 2023. In the remaining 231 hours, the cable was planned out of operation due to revision, meaning that no cross-border transmission capacity was available. Figure 19 and Figure 20 show the distribution of the offered trade margin of the DE-SE4 border in the year 2023.

[41] 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.

[42] Source of the restriction on request of the Statnett: https://umm.nordpoolgroup.com/#/messages/b36d8bd8-8dca-478b-98ea-a12952411567/4.



	DE-SE4	SE4-DE
Out of operation	2.64%	2.64%
< 55.7 %	2.44%	0.86%
[55.7 - 70 %)	4.11%	2.19%
>= 70 %	90.81%	94.32%

Figure 19: *Relative trade margin DE-SE4 [TenneT] 2023 (minimum value 55.7%)*

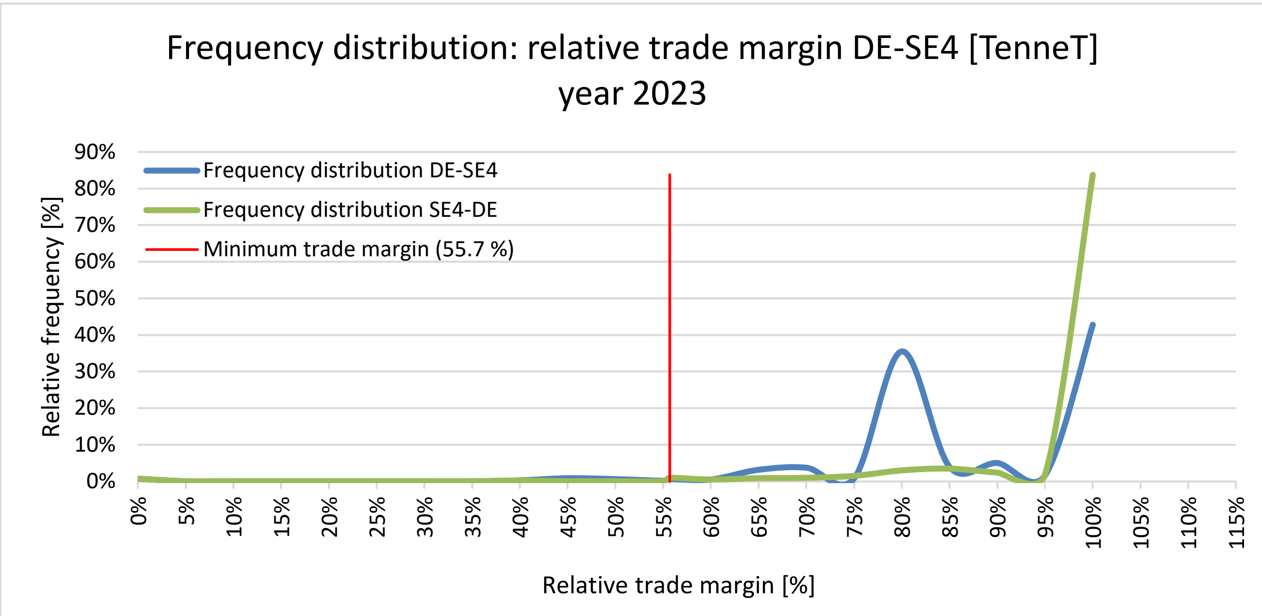


Figure 20: *Frequency distribution: relative trade margin DE-SE4 [TenneT] year 2023 (minimum value 55.7%)*

The minimum capacity of the border DE-SE4 of 334 MW according to the linear trajectory of the action plan, which corresponds to 55.7% of the maximum capacity of the Baltic Cable, was complied with in the south direction (SE4 to DE) for 8,454 hours (99.1% of the operating hours). In the north direction (DE to SE4), the minimum capacity was complied with for 8,315 hours (97,5% of the operating hours).

The minimum capacity was consistently met in the normal switching state (availability of all relevant network elements) during the year 2023 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.

Due to planned and unplanned unavailability of critical grid elements in the TenneT control area (including the distribution grid level), it was necessary to deviate below the minimum capacity in 222 MTU in accordance with Article 16(3) of the Electricity Market Regulation in order to ensure system security. These lower deviations affected the northbound direction in 214 MTU and the southbound direction in 75 MTU. The BNetzA was immediately notified of all lower deviations. In 59 MTUs, the transmission capacity across bidding zones was 0 MW in both directions. The market was restricted in 86 MTUs with a lower deviation.

The lower deviations from the minimum capacity are due to the special connection situation of the Baltic Cable. The transmission capacity across bidding zones is heavily dependent on the availability of the connections between the TenneT transmission network and the subordinate distribution network of Schleswig-Holstein Netz AG (SHN). The following figure shows the network topology of the high-voltage and extra-high voltage network at the German grid connection of the Baltic Cable.

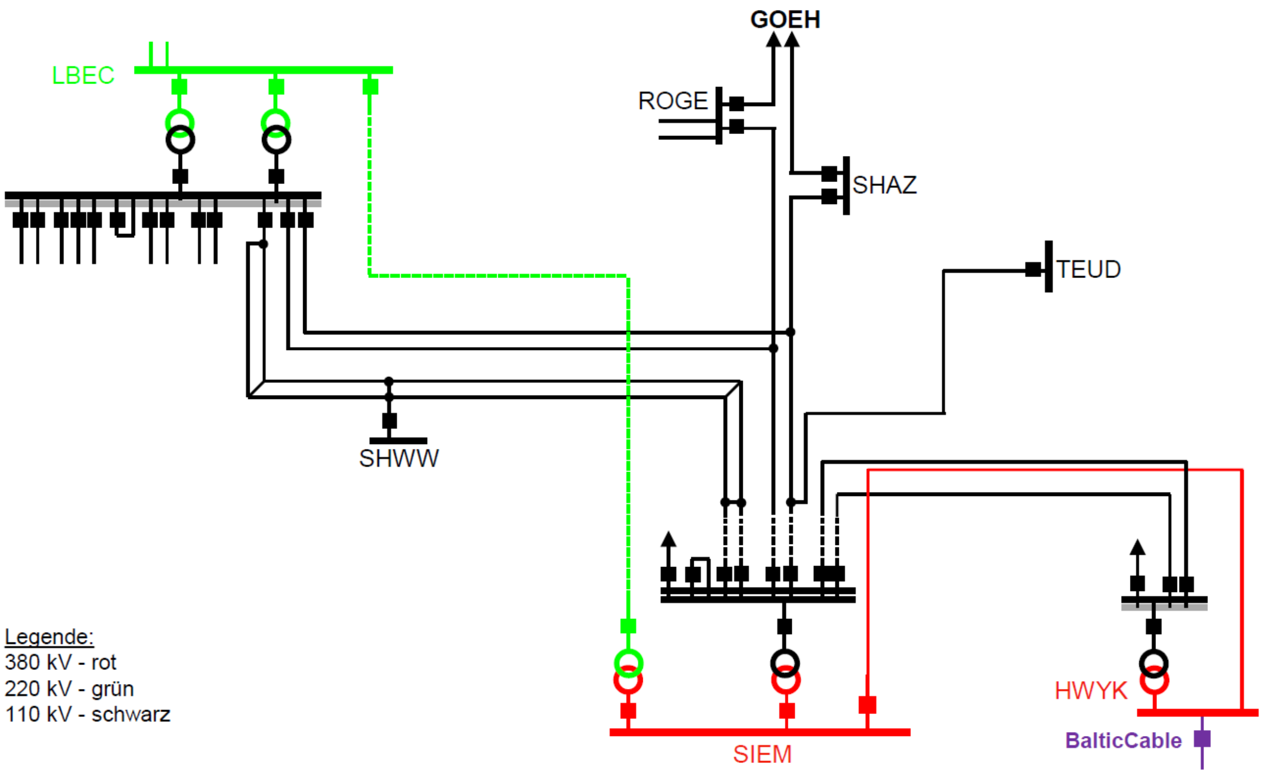


Figure 21: *Network topology of the high-voltage and extra-high voltage network at the German Baltic Cable grid connection (source: SHN)*

On the German side, the Baltic Cable is connected to the TenneT transmission grid at the grid connection point Lübeck-Herrenwyk (HWYK). From there, a 380 kV overhead line of TenneT leads to the Lübeck-Siems substation (SIEM). The Lübeck-Siems substation is connected to the Lübeck substation (LBEC) via a 220 kV underground cable of TenneT with a capacity of about 350 MW. The underground cable itself is not sufficient to transport the power of the Baltic Cable (600 MW on the receiving side). For the transmission of the Baltic Cable's power, the SHN distribution network must be utilised, which additionally connects the Lübeck-Herrenwyk and Lübeck-Siems substations with the Lübeck substation. At the DE-SE4 border, there is an unusual connection constellation for the Baltic Cable in that its power can only be transmitted cumulatively with the help of the transmission grid and the distribution grid.

In addition, the Lübeck substation is only connected to the rest of the TenneT transmission grid via two parallel 220 kV overhead lines to the Hamburg-Nord substation (not shown in the figure), which are also necessary for the Baltic Cable transmission. Each line has a capacity of approximately 460 MW. Only both lines together can guarantee the transport of the Baltic Cable. In the event of unavailability of relevant network elements of the transmission network or the subordinate distribution network due to necessary disconnection or outage, there may therefore be restrictions on the available transmission capacity, which may require a limitation of the cross-border capacity below the minimum capacity. This is particularly the case in the event of non-availability of the 220-KV underground cable between Siems and Lübeck, as well as non-availability of at least one of the two 220-KV lines from Lübeck to Hamburg-Nord.
Against this backdrop, TenneT has developed a corresponding capacity calculation process with SHN, which is available to the Bundesnetzagentur. This provides for a reduction in cross-border capacity per direction

depending on the forecasted wind feed-in in the event of the (combined) unavailability of individual lines. The limit values for the respective shutdown scenarios are laid down in the Operational Instruction Manual of Baltic Cable.

At the times of the lower deviations, network elements of TenneT or SHN that are essential for the provision of the minimum capacity were not available due to faults or work on the network. The lower deviation of the minimum capacity at the DE-SE4 border was based on the following scenarios: The technical unavailability or disconnection to carry out work on one of the two 220 kV Hamburg-Nord - Lübeck lines, one of the two 110 kV lines between the Lübeck and Siems substations, or a transformer in Lübeck or Siems.

The reason for the lower deviations is that they were necessary to ensure system security in the TenneT control area and the SHN distribution grid level. A lower deviation from the minimum capacity at the border DE-SE4 is justified for reasons of system security in accordance with Art. 16(3) of the EU Electricity Market Regulation. TenneT assumes that the connection situation of the Baltic Cable will improve significantly when the so-called East Coast line goes into operation.[43]

[43] https://www.tennet.eu/de/projekte/ostkuestenleitung

LIST OF ABBREVIATIONS

AC	Alternating current
ACER	European Union Agency for the Cooperation of Energy Regulators
APG	Austrian Power Grid
BCAB	Baltic Cable AB (German TSO without control area responsibility)
BMWK	Federal Ministry for Economic Affairs and Climate Action
BNetzA	Federal Network Agency
CCR	Capacity Calculation Region
CEPS	Czech TSO
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 FBMC	Flow-based market coupling in the Capacity Calculation Region Core
CWE	Central Western European region
CZ	Czechia
DA	Day-ahead
DA CCM	Day-Ahead Capacity Calculation Methodology
DAVinCy	Day-ahead Validation of Capacity
DC	Direct current
DE	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
D2CF CGM	Two Day-ahead Congestion Forecast Common Grid Model
EEA	European Economic Area
EU	European Union
F_{max}	Physical capacity
F_{ref}	Reference flow
KFCGS	Kriegers Flak Combined Grid Solution
HVDC	High Voltage Direct Current
ID	Intraday
IVA	Individual Validation Adjustment
JAO	Joint Allocation Office
LTA	Long Term Allocation
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
RefProg	Reference programme for day-ahead capacity calculation
SE	Sweden
SHN	Schleswig-Holstein Netz AG (DSO in Schleswig-Holstein)
SOGL	System Operation Guideline
TSO	Transmission system operator
cTSO	Transmission system operator with control area responsibility
TTN	TenneT TSO B.V. (Dutch TSO)

LIST OF FIGURES

LIST OF TABLES