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# 2021 Assessment of available cross-zonal capacity for the Netherlands

In accordance with article 15(4) of Regulation (EU) 2019/943 of the European Parliament and the Council of 5 June 2019 on the internal market for electricity (recast)

## Executive Summary

With the establishment of the Electricity Regulation - part of the Clean Energy package - several provisions entered into force which specify the minimum levels of capacity margins that TSOs need to make available for cross-zonal trade. More specifically, article 16(8) of the Electricity Regulation requires TSOs to ensure that at least 70% of the transmission capacity is offered for cross-zonal trade, while respecting operational security limits. However, the Electricity Regulation also allows Member States to adopt transitory measures, such as action plans or derogations, to reach gradually the minimum capacity margin available for cross-zonal trade (MACZT) by the end of 2025 at the latest.

For the Netherlands, an action plan has been adopted as transitory measure to reach gradually the minimum capacity margin of 70% on the critical network elements included in CWE flow-based day-ahead capacity calculation. Next to the action plan, for the year 2021 also a derogation applies.

As a consequence of the action plan, TenneT is obliged to assess on an annual basis whether the available cross-border capacity has reached the required minimum levels. **This report provides the results for the assessment on the transmission capacity made available for cross-zonal trade in the year 2021**. Furthermore the report contains an assessment of the transmission capacity made available on the bidding zone borders with Norway and Denmark, which are not part of the action plan, on which the target capacity margin of 70% already applies.

Because of the interplay between action plan, derogation and the CWE flow-based capacity calculation methodology, it is not straightforward to assess whether the capacity made available was in accordance with all the applicable provisions. Within this report, TenneT clarifies what specific provisions related to minimum capacities apply for the Netherlands, how it implemented those specific provisions in operations and how it has monitored its compliance against those provisions.

For this assessment, TenneT has generally followed the approach and principles as set out by ACER and applied in ACER's EU MACZT monitoring report. However, in comparison this report provides more specific information for the Netherlands, as well as additional figures and results including the level of capacity made available on individual network elements. By doing so, TenneT aims to provide maximum transparency on its performance to its stakeholders.

For the **Central West Europe (CWE) region**:

- For **50%** of the time, **TenneT has provided capacity margins at or above the required minimum levels** on all its network elements
- For **50%** of the time, **TenneT has offered insufficient capacity margins**. The main underlying reason is that the local tooling that TenneT used to calculate capacity from outside the CWE area was unintentionally providing erroneous values. After an updated tool was taken in operation per Business Day 2/10/2021, the results improved significantly.
- **Fortunately**, **the insufficient capacity margins have only had a very limited impact on cross-zonal trade.** This because **only 1.0% of the time a Dutch critical network element** with insufficient margins has **limited cross-zonal exchanges** in the day-ahead market coupling. **Also, the welfare effect of these constraining network elements has been comparatively small**, when compared to the average effect of active constraints from the CWE region.

For the **HVDC bidding zone borders (NL-DK1, NL-NO2)**:

- For **100%** of the time**, TenneT has provided capacity margins at or above the required minimum level** of 70% for the NL-DK1 and NL-NO2 bidding zone border.
- For 7% of the time for the DK1→NL and 9% of the time for the NO2→NL bidding zone border, TenneT has applied a reduction of NTC capacity on these borders, but none of the reductions was below the minimum level of 70%.

TenneT expects that for 2022 a significant improvement for the capacity margins as offered within the CWE region is realistic. The results for October-December 2021 show that with the updated tooling, it has been possible to meet the minimum levels on all the network elements. Also, after the go-live of Core flow-based day-ahead capacity calculation the need for a separate local tooling for the calculation of capacity from outside the coordination area becomes obsolete, as this will be calculated as an integral part of the Core tooling. This should increase the robustness of the capacity calculation process.

Therefore, with updated local tooling for CWE and go-live of Core flow-based day-ahead capacity calculation, it should in principle be possible for TenneT to meet the minimum levels of capacity margins in 2022.

# Table of contents

# 1. Introduction

In December 2019, the Ministry of Economic Affairs and Climate Policy of the Netherlands has established an action plan pursuant to Article 15 of the Electricity Regulation[1].

Article 15, paragraph 4 of the Electricity Regulation prescribes that on an annual basis, during the implementation of the action plan and within six months of its expiry, the relevant transmission system operators shall assess for the previous 12 months whether the available cross-border capacity has reached the linear trajectory.

This report provides the assessment of TenneT TSO B.V. (hereinafter "TenneT") of the cross-border capacity made available in the year 2021, and whether this was in accordance with the various provisions on minimum capacities that were applicable to TenneT in the year 2021.

It is the second report in its kind, and follows in general the structure as was applied before in the assessment of the cross-border capacity made available in the year 2020 (2020 MACZT assessment report)[2]. However, also some improvements were made and some additional elements were added to the report. The main differences compared to the previous report are:

- Further in-depth assessments of the capacity provided in the CWE region, including distributions of capacity margins provided on all critical network elements instead of the least performing network elements.
- Comparison of results considering and not considering third country flows
- High-level assessment of the market impact of insufficient capacity margins in the CWE region

The outline of the report is as follows:

- First in chapter 2, TenneT sets out the various obligations on minimum capacities that were applicable for TenneT in the year 2021
- Then in chapter 3, TenneT sets out how these various obligations have been implemented in its daily operations
- Chapter 4 describes the methodology applied behind the assessment as performed for this report
- Chapter 5 contains the results from the assessment
- Chapter 6 contains a high-level assessment of the market impact of MACZT deficits in the CWE region
- Chapter 7 provides the main conclusions resulting from the assessment

Furthermore, six annexes with relevant background information are included to this report.

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[1] Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast), available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943&from=EN

[2] 2020 Assessment of available cross-zonal capacity for the Netherlands, approved by ACM on 26 August 2021 and available at: https://www.acm.nl/sites/default/files/documents/bijlage-bij-besluit-tennet.pdf

# 2. Obligations on TenneT TSO B.V. with respect to minimum capacities to be made available for cross-zonal trade

In the year 2021, several provisions related to the minimum levels of capacity margins that TenneT needs to make available for cross-zonal trade were applicable. This chapter sets out the relevant provisions from:

- The EU Electricity Regulation and the Action Plan established for the Netherlands
- The Derogation from the minimum level of capacity
- The CWE Flow-Based Market Coupling Approval Documents

## 2.1 The EU Electricity Regulation and the Dutch Action Plan

The Electricity Regulation article 16(8) requires TSOs to ensure that at least 70% of the transmission capacity is offered for cross-zonal trade, while respecting operational security limits. According to this Regulation, Member States may also adopt transitory measures, such as action plans or derogations, to reach gradually the minimum capacity margin available for cross-zonal trade (MACZT) by the end of 2025 at the latest.

In December 2019, the Ministry of Economic Affairs and Climate Policy of the Netherlands has established an action plan[3] pursuant to Article 15 of the Electricity Regulation. The action plan has established a linear trajectory for the minimum capacity available for cross-zonal trade to be compliant with Article 16(8) of the Electricity Regulation. The action plan establishes an individual linear trajectory for every Critical Network Element (CNE) which is included in CWE Flow-Based Day-Ahead Capacity Calculation (CWE FB DA CC).

The other (HVDC-based) bidding zone borders of the Netherlands are not specifically included in the action plan and for these borders no linear trajectory is established. Therefore, for these borders the minimum value of 70% as established in article 16(8) of the electricity Regulation already applies per 1/1/2020.

Table 1 shows a full overview of the applicable target minimum capacity margins ($MACZT_{target}$) per Capacity Calculation Area (CCA). Details on how the linear trajectory values have been determined can be found in the action plan itself[3]. The applicable values per Dutch CNE are included in annex 2.

**Table 1: Overview of the $MACZT_{target}$ values from the linear trajectory per CCA for the year 2021**

| Relevant Capacity Calculation Area | Bidding Zone Borders and/or CNECs | Point of linear trajectory for target minimum capacity ($MACZT_{target}$) in relative MACZT [%][4] |
|---|---|---|
| **CWE** | NL-BE; NL-DE; and Dutch CNECs included in CWE FB DA CC | Differs per CNEC.<br>Minimum: 28% Maximum: 70%<br>Mean: 33% Median: 28% |
| **DK-NL (NL side)** | NL-DK1 | 70% (as no linear trajectory established) |
| **NL-NO (NL side)** | NL-NO2 / NL-NO2a[5] | 70% (as no linear trajectory established) |

[3] The action plan has been published by the Ministry of Economic Affairs and Climate Policy on its website.
[4] Relative MACZT means the percentage of the MACZT relative to the maximum admissible flow (Fmax)
[5] Statnett has implemented a virtual market area 'NO2a', which has gone live per BD 10/11/21. The NorNed

In comparison to the 2020 MACZT assessment, Table 1 does no longer include the bidding zone border GB-NL as the United Kingdom has left the European Union and therefore the Electricity Regulation does no longer apply to this bidding zone border.

## 2.2 Derogation for the Netherlands

In July 2020, TenneT applied for a derogation from the minimum level of capacity to be made available for cross-zonal trade in accordance with article 16(9) of the Electricity Regulation. This request for derogation was approved by the Dutch national regulatory Authority for Consumers and Markets (hereinafter "ACM") on 16 November 2020, for the duration of 1 year from 1 January 2021 up to and including 31 December 2021.[6]

The main elements of the derogation are summarised in Table 2.

**Table 2: Summary of derogation in accordance with article 16(9) of the Electricity Regulation applicable for NL in 2021**

| Reason for derogation | Remedy | Duration |
|---|---|---|
| **Loop flows on Dutch CNECs that cannot be contained to an acceptable level** | Application of a methodology to reduce the $MACZT_{target}$ values in case loop flows exceed a certain predefined threshold. | 1 year |
| **Possible lack of redispatching potential when the grid is in an outage situation** | In principle, even when one or several CNEs are in outage, TenneT aims to provide the required level of minimum capacity by using if needed non-costly and costly remedial actions. However, in case operational security limits cannot be respected due to a lack of available remedial actions when one or more critical network elements are in outage, TenneT is allowed to reduce the available capacity for cross-zonal trade to a level that respects operational security limits. | 1 year |

In accordance with article 16(9) of the Electricity Regulation, in June 2021 TenneT sent a report on methodologies and projects that shall provide a long-term solution to the operational security risks which the derogation granted to TenneT seeks to address.[7]

In the following subsection, the methodology applied to reduce the $MACZT_{target}$ values in case loop flows exceed a certain threshold is described in more detail.

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interconnector connects to this area per that BD. For the sake of simplicity, this report refers to NO2 as the bidding zone border to which the NorNed interconnector connects.

[6] The approval of the derogation including the derogation itself is available at: https://www.acm.nl/nl/publicaties/acm-verleent-een-derogatie-voor-lusstromen-en-uitvalsituaties

[7] Available at: https://www.acm.nl/nl/publicaties/rapport-tennet-derogatie-artikel-16-negende-lid-verordening-2019-943-0

### 2.2.1 Applied methodological approach to deal with Loop Flows above an acceptable level

Article 4 of the derogation[6] contains the following formula to determine the minimum capacity margin that TenneT needs to make available for cross-zonal trade ($MACZT_{min}$) on a CNEC in CWE FB DA CC:

(1) $$MACZT_{min}^{CNEC} = MACZT_{target}^{CNEC} - max\left(0; LF_{calc}^{CNEC} - LF_{accept}^{CNEC}\right)$$

Where:

- $MACZT_{target}^{CNEC}$ is the level of minimum capacity to be made available for cross-zonal trade on the given CNEC according to the linear trajectory, given in % of the maximum flow on the CNEC ($F_{max}^{CNEC}$)
- $LF_{calc}^{CNEC}$ is the loop flow on the CNEC in % of $F_{max}^{CNEC}$
- $LF_{accept}^{CNEC}$ is the threshold value of "acceptable" loop flows in % of $F_{max}^{CNEC}$,, which differs per CNE:
  - o $LF_{accept}^{CNEC}$ is 30%-$FRM^{CNEC}$ for cross-zonal CNEs
  - o $LF_{accept}^{CNEC}$ is 0.5*(30%-$FRM^{CNEC}$) for internal CNEs

  With $FRM^{CNEC}$ being the Flow Reliability Margin of the CNEC

As result of the methodology applied in the derogation, the methodological minimum level of the MACZT ($MACZT_{min}$) can thus lead in certain hours to capacities lower than the target values as prescribed by the linear trajectory ($MACZT_{target}$).

Further details about the calculation of the loop flows and the process followed, can be found in annex 5.

## 2.3 CWE Flow-Based Day-Ahead Capacity Calculation Approval Documents

Since Business Day 26 April 2018, within CWE FB DA CC a minimum Remaining Available Margin (minRAM) of 20% has been implemented by all CWE TSOs. This means that for all CNECs included in CWE FB DA CC, the Remaining Available Margin (RAM) is at minimum 20% of the maximum admissible flow (Fmax) of this network element. In the context of the terminology, as introduced by ACER in its Recommendation 01-2019[8], the RAM made available in CWE FB DA CC is to be regarded as MCCC (Margin from Coordinated Capacity Calculation).

Originally, this 20% minRAM was a voluntary commitment from CWE TSOs, but with the approval of CWE NRAs[9] of the documentation of the CWE Flow-Based Market Coupling (CWE FB MC) version 3.0 of June 2018, this has become an obligatory provision.

Translating this obligation to a formula, this leads to an obligation for a minimum MCCC ($MCCC_{min}$) of:

(2) $$MCCC_{min} = 20\%$$

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[8] See: https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Recommendations/ACER%20Recommendation%2001-2019.pdf

[9] ACM approved the proposal on 31/08/2018, see: https://www.acm.nl/nl/publicaties/goedkeuring-voorstel-van-tennet-voor-de-wijziging-van-cwe-flow-based-da

# 3. Implementation of minimum capacity obligations by TenneT TSO B.V.

## 3.1 Implementation of minimum capacities in the CWE Capacity Calculation Area

As set out in chapter 2, TenneT simultaneously needs to comply with several provisions related to the minimum levels of capacity margins that TenneT needs to make available for cross-zonal trade (MACZT). The obligations as set out in formula (1) and (2) are the relevant formulas determining the capacity margins that TenneT needs to make at minimum available for cross zonal trade within CWE FB DA CC.

As set out in ACER recommendation No 01-2019, for AC network elements the MACZT consists of both a margin from capacity calculation *within* a capacity calculation area (MCCC), as a margin from non-coordinated capacity calculation *outside* the capacity calculation areas (MNCC):

$$MACZT = MCCC + MNCC \quad (3)$$

In this context, the Remaining Available Margin (RAM) made available within CWE FB DA CC is to be regarded as MCCC made available in the CCA of CWE. Flows on Dutch CNEs resulting from exchanges outside the CWE region or exchanges between a CWE country and a non-CWE country, such as exchanges over the Dutch HVDC interconnectors, are to be regarded as MNCC in the CCA of CWE.

Within the CWE FB DA CC process, the MCCC is an output which is calculated by the CWE TSO common system (i.e. the tooling that CWE TSOs use for performing the CWE day-ahead capacity calculations). In contrast, MNCC is calculated by each TSO individually and included as input to the CWE FB DA CC process as part of the Reference Flow[10]. As a consequence, within the CWE CCA the $MACZT_{min}$ of formula (1) can only be met by determining what minimum value needs to be provided for MCCC while taking into account the MNCC as explicit input. Also, TenneT needs to comply with both formula (1) and formula (2) at the same time, meaning that the larger of these two determines the minimum amount of capacity margin that needs to be made available by TenneT. Combining (1) and (2) in a single calculation, this leads to the following formula of the minimum MCCC ($MCCC_{min}$) that needs to be made available in CWE FB DA CC:

$$MCCC_{min}^{CNEC} = max\,\{20;\ MACZT_{target}^{CNEC} - MNCC^{CNEC} - max\left(0; LF_{calc}^{CNEC} - LF_{accept}^{CNEC}\right) \quad (4)$$

Where:

- $MACZT_{target}^{CNEC}$ is the level of minimum capacity to be made available for cross-zonal trade on the given CNEC according to the linear trajectory, given in % of the maximum flow on the CNEC ($F_{max}^{CNEC}$)
- $MNCC^{CNEC}$ is the Non-CWE cross-zonal flow on the CNEC in % of $F_{max}^{CNEC}$
- $LF_{calc}^{CNEC}$ is the loop flow on the CNEC in % of $F_{max}^{CNEC}$
- $LF_{accept}^{CNEC}$ is the threshold value of "acceptable" loop flows on the CNEC in % of $F_{max}^{CNEC}$
- $F_{max}^{CNEC}$ is the maximum flow on the CNEC

[10] The flow per CNEC resulting from expected commercial exchanges

Since 1/4/2020, this formula is implemented in the daily operation within CWE FB MC. In case the RAM (MCCC) as calculated within CWE FB DA CC is lower than the $MCCC_{min}^{CNEC}$, an Adjustment for Minimum RAM (AMR) is calculated in the minRAM process. This adjustment is then applied to the CNEC to set the RAM (MCCC) of the CNEC to $MCCC_{min}^{CNEC}$.

Further details about the calculation of MNCC and loop flows, can be found in annex 5.

## 3.2 Implementation of minimum capacities on HVDC bidding zone borders

In line with ACER recommendation 01-2019[8], the (oriented) Net Transfer Capacity (NTC) that is made available for the HVDC bidding zone borders is to be considered fully as the MACZT made available on these bidding zone borders. Therefore, no additional tooling/calculations had to be implemented to be able to determine the level of MACZT on these interconnectors.

In a planned or unplanned outage situation, the grid capacity is reduced and flows on the remaining critical network elements increase compared to the grid situation where the outage is not present. It can occur, that in such situations some internal network elements do not have sufficient capacity to facilitate an expected level of internal flows, loop flows, cross-zonal flows via AC interconnectors as well as the maximum level of cross-zonal flows over the HVDC interconnectors.

When one or more critical network elements are in outage, TenneT aims to still respect the minimum capacity to be made available for cross-zonal trade as defined by the relevant obligations as set out in chapter 2, by using if needed non-costly and costly remedial actions. However, in case operational security limits cannot be respected due to a lack of available effective remedial actions when one or more critical network elements are in outage, TenneT is allowed to reduce capacity available for cross-zonal trade to a level that respects operational security limits. This is also confirmed by article 5 of the derogation applicable for 2021.

In practice, TenneT has implemented the following process to make this evaluation:

1. If during the week-ahead grid security assessment,
    a. it becomes apparent that operational security limits are expected to be violated due to planned outages for required maintenance or grid enforcements, or due to longer duration unexpected outages; and/or
    b. the application of redispatching during the day-ahead and intraday timeframe as remedial actions is not expected to be sufficient or appropriate to resolve the expected violations of security limits, because amongst others:
        i. The application of redispatching before D-1 as only remedial action would exhaust redispatch potential in the day-ahead and intraday timeframe, such that insufficient remedial actions would remain available to solve potential later violations of security limits; or
        ii. There is expected to be insufficient upward redispatching potential for the required redispatching volume in the day-ahead or intraday timeframe; or

iii. Restrictions on generation due to other operational security aspects, such as dynamic stability of the system, voltage control or obligations on generators to generate a certain amount of short circuit power for adequate detection of short circuits;

and

c. a reduction of capacity made available for cross-zonal trade is deemed an effective measure to reduce or resolve the violation of the operational security limits;

then a set of remedial actions including a reduction of available capacity for cross-zonal trade on some critical network elements (incl. HVDC interconnectors) is prepared. The set will then consist of a combination of the application of one-sided redispatch prior to the DA market coupling for the respective region (via negotiated restriction agreements with some generators[11]) and reductions of available cross-zonal capacity proportionate to the impact of prepared (costly) remedial actions but limited to the extent needed to safeguard grid security.

2. During the operational security assessments performed day-ahead and intraday after the DA market coupling, the applied remedial actions from the week-ahead grid security assessment are taken into account on the basis of updated forecasts integrated in the day-ahead resp. intraday congestion forecasts.[12] If this assessment indicates that operational security limits are still expected to be violated, more RAs (for example redispatching) will be applied. If the application of RAs is not possible or sufficient, additional reductions of available capacity for cross-zonal trade on some critical network elements is applied to the extent needed to safeguard grid security.

## 3.3 Consideration of flows with third countries

On European level, there is not yet consensus whether or not third country flows are to be included within MNCC and MACZT. For the assessment in this report, TenneT has included flows with third countries in its calculation of MNCC and loop flows. TenneT has done this because exchanges of electricity with third countries are today's reality and TSOs must include them in day-to-day operations. Electricity exchanges with third countries will therefore contribute to overall capacity margins made available for cross-zonal trade.

However, for the sake of completeness and transparency, in subsection 5.2.5 also some figures of results for MACZT have been included where third country flows have been excluded. In annex 5 it is specified which countries are regarded as third countries. Flows with Norway are not considered as third country flows, because TenneT and Statnett have agreed on a coordinated capacity calculation process for the NL-NO2 bidding zone border. The existence of this process has also been acknowledged by Core NRAs.

[11] Besides the application of redispatch, TenneT also resolves congestion problems through restriction agreements with market participants in the case of insufficient bids or frequent congestion problems in a specific area. The involved market participants limit their electricity generation or offtake in a specific region when called upon by TenneT, in return for a negotiated compensation.

[12] This step is part of the regular operational security assessments, taking place on the basis of the day-ahead Congestion Forecast (DACF) and IntraDay Congestion Forecast (IDCF) network models.

# 4. Methodology of the assessment

## 4.1 Introduction of parameter $MACZT_{margin}$

As set out in chapter 2, the minimum MACZT that TenneT needs to make available on a CNEC differs per CNEC and per MTU, depending on the individual $MACZT_{target}$ values of the CNECs and the level of loop flows (see also formula (1)). Therefore, the absolute levels of MACZT made available on CNECs cannot be used to assess whether the minimum capacity margins have been met.

In order to allow for an easy and intuitive way to assess whether sufficient MACZT was made available on an individual CNEC, TenneT introduced the parameter $MACZT_{margin}$:

$$(5)\quad MACZT_{Margin}^{CNEC} = MACZT^{CNEC} - MACZT_{min}^{CNEC}$$

where $MACZT_{Margin}^{CNEC}$ is the amount of MACZT made available above or below the minimum level, given in % of $F_{max}^{CNEC}$.

$MACZT_{margin}$ serves as indicator whether sufficient MACZT was made available for a CNEC for a specific MTU:

- If $MACZT_{margin} > 0\%$, more than the minimum required amount of cross zonal capacity was made available;
- If $MACZT_{margin} = 0\%$, exactly the minimum required amount of capacity was made available; and
- If $MACZT_{margin} < 0\%$, less capacity was made available than is at minimum required. However, if the cause was due to external factors or in line with the ground for derogation because of a lack of remedial actions, TenneT might still have met the applicable obligations and regulations. Therefore, these CNECs and MTUs with a negative $MACZT_{margin}$ require additional investigation.

## 4.2 Assessment of compliance in the CWE Capacity Calculation Area

### 4.2.1 Compliance with action plan and derogation

In order to assess whether TenneT complied with the applicable provisions related to the minimum levels of capacity margins that TenneT needs to make available for cross-zonal trade (MACZT) within the CWE CCA, following from the action plan and derogation, TenneT performed the following steps.

For each MTU:

1) Calculate $MACZT_{min}^{CNEC}$ for each CNEC per direction, based on formula (1)
2) Calculate $MACZT^{CNEC}$ for each CNEC per direction, based on formula (3)
3) Calculate $MACZT_{margin}^{CNEC}$ for each CNEC per direction, based on formula (5)
4) Evaluate the $MACZT_{margin}^{CNEC}$ for each CNEC
    a. In case $MACZT_{margin}^{CNEC} \geq 0$ for all CNECs for both directions, the minimum capacity margins have been met for that MTU[13].
    b. In case $MACZT_{margin}^{CNEC} < 0$ for one or more CNECs in that MTU, TenneT potentially did not meet the minimum capacity margin obligations and a more detailed analysis needs to be performed. E.g. if there was a reduction of capacity on these CNECs due to a lack of remedial actions when the grid is in an outage situation (= ground of the derogation), the minimum capacity margins could still have been met for that MTU. However, because of the issues experienced with calculating MNCC in Q1-Q3 2021 (see annex 6), TenneT did not carry out such an evaluation for this year's report.

### 4.2.2 Compliance with 20% minRAM

In order to assess whether TenneT complied with the applicable provision to make a minimum level of MCCC ($MCCC_{min}$) available of 20% in the CWE CCA, TenneT performed the following steps.

For each MTU:

1. Select the CNEC which has the lowest $MCCC^{CNEC}$
2. Compare this lowest $MCCC^{CNEC}$ to the $MCCC_{min}$ target value of 20%
    - In case the lowest $MCCC^{CNEC} \geq 20\%$, TenneT has been compliant for that MTU;
    - In case the lowest $MCCC^{CNEC} < 20\%$, one needs to evaluate whether the reduction was appropriate for reasons of operational security. This is done on the basis on whether minRAM exclusion was justified. If that was the case, TenneT was compliant for that MTU;
    - In case the lowest $MCCC^{CNEC} < 20\%$, and the reduction was not appropriate for reasons of operational security, TenneT was not compliant for that MTU

[13] In line with the approach as applied by ACER, the compliance assessment is based on whole percentages and TenneT rounds all results to two decimals in order to get whole percentages. As result, a CNEC with a $MACZT_{margin}$ between -0.49% and 0% qualifies as $MACZT_{margin} \geq 0\%$

## 4.3 Assessment of compliance of HVDC bidding zone borders

In order to assess whether TenneT complied with the applicable provisions related to the minimum levels of capacity margins that TenneT needs to make available for cross-zonal trade (MACZT) on the HVDC bidding zone borders, TenneT performed the following steps.

For each MTU:

1) Calculate $MACZT^{BZB}$ for each bidding zone border for both directions, by dividing the Net Transfer Capacity (NTC) of the bidding zone border per direction as offered by TenneT by the available physical capacity (Fmax) of the interconnector forming the bidding zone border:

$$MACZT^{BZB} = \frac{NTC^{BZB}_{TenneT}}{Fmax^{BZB}}$$

2) Compare $MACZT^{BZB}$ with $MACZT^{BZB}_{min}$ for both directions[14]
   a. In case $MACZT^{BZB} \geq MACZT^{BZB}_{min}$ for both directions TenneT has been compliant for that bidding zone border for that MTU.
   b. In case $MACZT^{BZB} < MACZT^{BZB}_{min}$ for one or both of the directions, then go to step 3
3) In case the MACZT is below the target level for one of both of the direction, the cause for that needs to be assessed:
   a. In case the reduction was not triggered by TenneT, but by 'the other' TSO (i.e. Statnett for NL-NO2 or Energinet for NL-DK1), TenneT was considered compliant for this MTU.
   b. In case the reduction is triggered by TenneT due to a lack of remedial actions when the grid is in an outage situation, TenneT was compliant for that MTU.
   c. In case the reduction is triggered by TenneT because of a disturbance in the NL grid, maintenance in the NL grid and/or another reason while other remedial actions could have been taken, TenneT was not compliant for that MTU.

## 4.4 Differences in methodology compared to the ACER MACZT monitoring

Within this report, TenneT has generally followed the approach and principles as ACER has set out in its Recommendation No 01-2019 and which have also been used in ACER's MACZT monitoring reports.

A notable distinction is that TenneT makes use of the parameter $MACZT_{margin}$ as defined in formula (5) to evaluate whether the MACZT made available met the minimum requirements. TenneT considers this a helpful parameter because for Dutch CNECs the $MACZT_{min}$ varies per CNEC per MTU.

[14] In case the interconnector itself was not available because of an outage or maintenance, the Fmax of that interconnector is put to 0. In such a situation, providing 0 NTC capacity is regarded as being compliant for that interconnector for that MTU.

# 5. Results

In this chapter, the results of the MACZT assessment will be described. The chapter is divided into three sections:

- Results of the MACZT compliance assessment for the CWE CCA
- Additional assessments of the MACZT offered in the CWE CCA
- Results of the MACZT compliance assessment for the HVDC bidding zone borders

A further assessment of the impact on the market of MACZT deficits, can be found in chapter 6.

## 5.1 CWE – Results of the MACZT compliance assessment for the CWE CCA

For CWE, the process for evaluation as set out in subsection 4.2.1 has been carried out. The results of that evaluation are included in this section.

### 5.1.1 Assessment of the MACZTmargin

In Figure 1, the overall percentage of time when the minimum capacity margins have been met is given for the year 2021. The figure shows that:

- for 50% of the time, the minimum capacity margins have been met (green categories) for all CNECs in those MTUs.
- For 7% of the time (yellow category) the minimum capacity margins have almost been met as the deficit was only 1% on the least performing CNEC. This error of 1% is mostly caused by some numerical rounding applied by TenneT in the local tooling for CWE FB DA CC.
- For 43% of the time (red categories), insufficient capacity margins were offered on at least on CNEC in those MTUs.

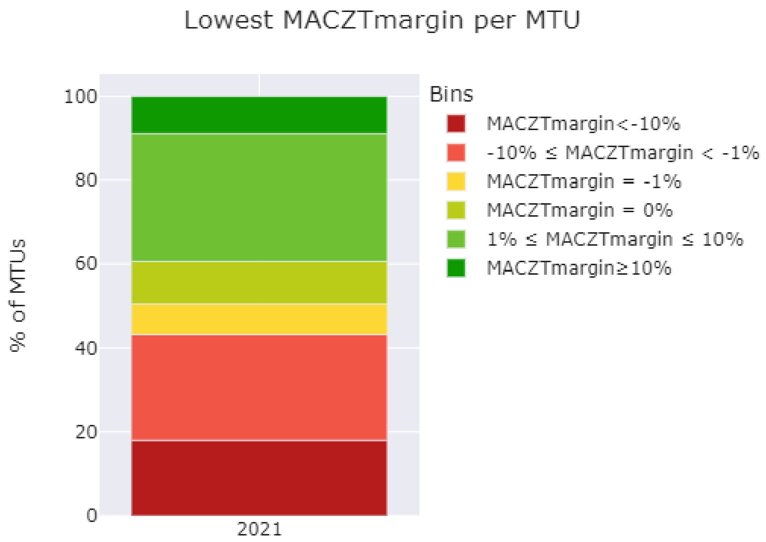



**Figure 1: Percentage of time when the minimum capacity margins have been met (green), and how much capacity was provided above or below the minimum margin. For each MTU, the CNEC with the lowest $MACZT_{margin}$ was selected and categorised to one of the ranges. CWE CCA, considering third countries. Period Jan-Dec 2021**

The underlying reason why the results have deteriorated compared to 2020, despite using the same methodological approach, is that the local tooling that TenneT used to calculate MNCC was providing erroneous MNCC values. A further explanation about this issue, is given in annex 6.

After discovering the malfunctioning of the local tooling, an updated tool was taken in operation per Business Day 2/10/2021. The breakdown per month in Figure 2 shows indeed after the updated tool was taken in operation, the results improved significantly. Later during November, the main cause behind the rounding error was identified in the tool and was corrected, leading also to the disappearing of the yellow category for December. This supports that the undershoot of the $MACZT_{min}$ values that has happened until September are indeed related to the malfunctioning tool, **but did not happen on intention by TenneT**.

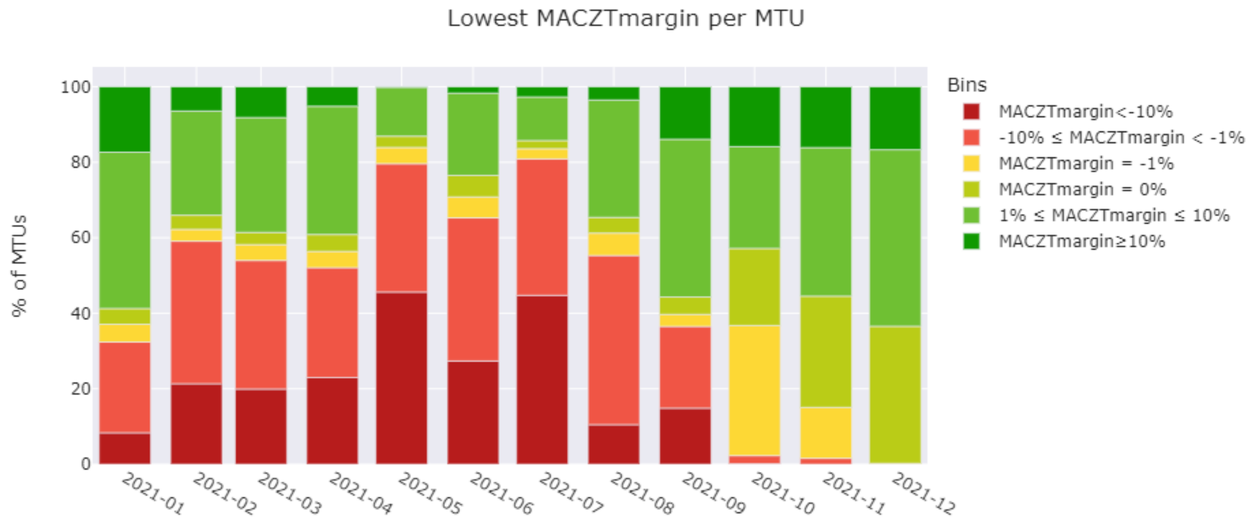



**Figure 2: Percentage of time when the minimum capacity margins have been met (green), and how much capacity was provided above or below the minimum margin, per month of 2021. For each MTU, the CNEC with the lowest $MACZT_{margin}$ was selected and categorised to one of the ranges. CWE CCA, considering third countries.**

However, despite that for 50% of the time insufficient MACZT was provided on one or more CNECs, this only had a very limited effect on the market. Only for 1.0% of the time, there was a CNEC of TenneT with insufficient MACZT which limited the day-ahead market coupling. This aspect is further elaborated upon in chapter 6. Also, TenneT wants to stress that in the particular months that the electricity prices have been soaring (October-December 2021), TenneT did provided sufficient or near to sufficient MACZT.

### 5.1.2 Assessment of the offered MACZT

The figures of $MACZT_{margin}$ are helpful to evaluate the compliance of TenneT, but as such do not provide information on the level of MACZT which was provided. Therefore, also the 'standard' categorisation as introduced by ACER showing the percentage of time when the relative MACZT was within a certain range, is given in Figure 3. The figure shows that for the majority of time, the lowest relative MACZT was in the range of 20-40%.

Please note that this figure cannot be used as basis to assess the compliance, as this figure does not take into account the linear trajectory of the action plan and derogation applicable in NL.

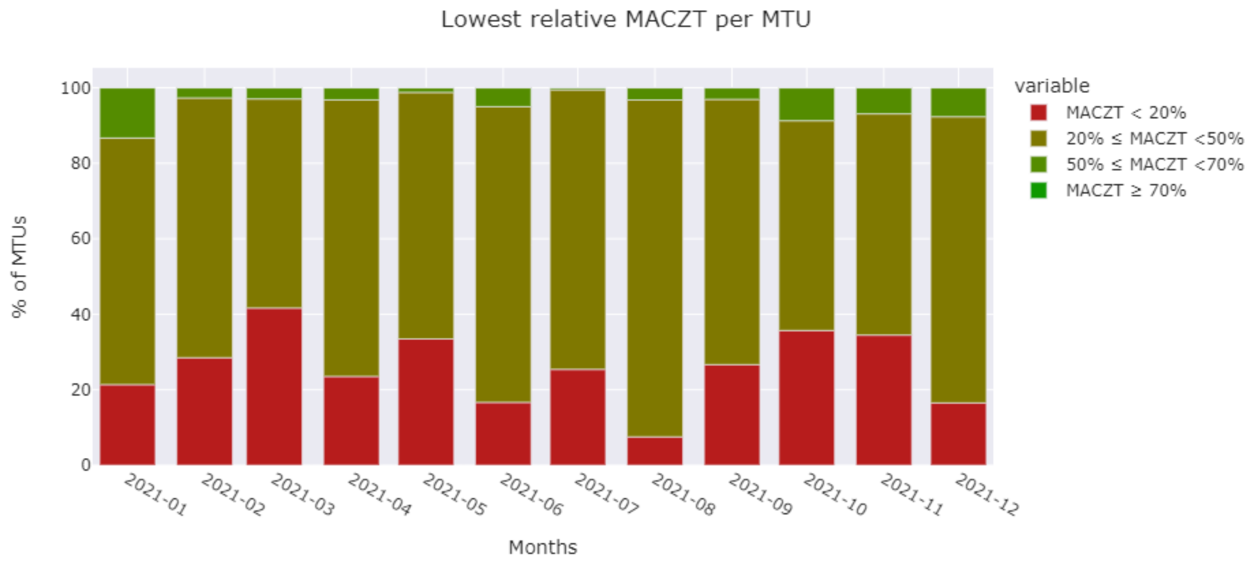



**Figure 3: Percentage of time when the minimum MACZT is met on all CNECs. For each MTU, the CNEC with the lowest relative MACZT was selected and categorised to one of the ranges. CWE CCA., considering third countries. Period January-December 2021**

In addition, TenneT also created the figure as used by ACER to report what percentage of time the transitional target is met on all CNECs for countries with a derogation or an action plan, see Figure 4. This figure has been created to allow to verify whether the analysis as performed by TenneT and ACER is consistent.

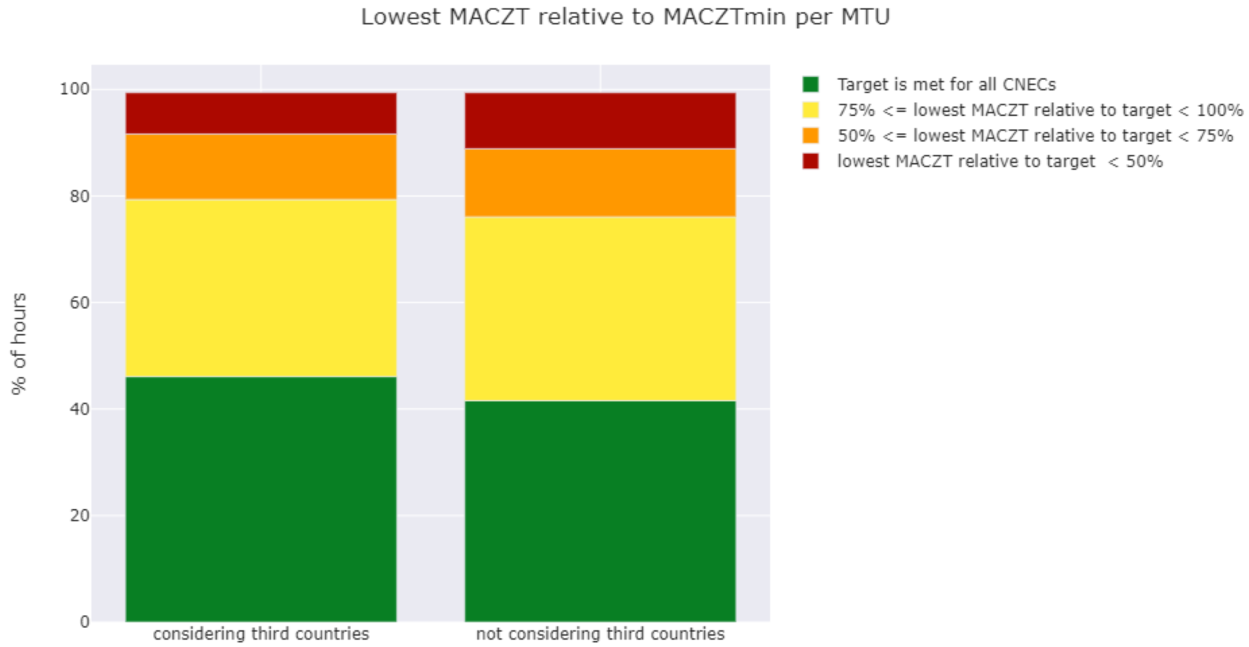



**Figure 4: Percentage of the time when the transitional target is met on all CNECs, using the categorisation as applied by ACER in their MACZT monitoring report. Period January-December 2021**

According to this classification, TenneT met the transitional target for 46% of the time when third countries are considered, and for 42% of the time if third countries are not considered. These results differ from what is reported based on Figure 1 and Figure 14, being that the target is met 50% of the time when third countries are considered and 44% of the time if third countries are not considered.

The underlying cause for this difference is a combination of rounding effects and that ACER uses a different classification (MACZT relative to $MACZT_{min}$) than TenneT applies ($MACZT_{margin}$) to evaluate whether the target has been met. Both TenneT and ACER apply a rounding of 99.5%, but ACER applies this relative to $MACZT_{min}$ where TenneT applies this relative to Fmax. The effect is that TenneT applies a ‘fixed margin’ of 0.5% irrespective of the level of $MACZT_{min}$, while the margin applied by ACER varies depending on the level of $MACZT_{min}$ and is smaller when $MACZT_{min}$ is lower. E.g. For a CNEC with a MACZTmin of 28%, ACER considers the target met if the MACZT was ≥ (99.5% * 28% = 27.86%), while TenneT considers the target met if the MACZT was ≥ (28% - 0.5% = 27.5%).

### 5.1.3 Assessment of the offered MCCC

For assessing the compliance with the CWE 20% minRAM, the process for evaluation as set out in subsection 4.2.2 has been carried out. The results of that evaluation are included in this section.

In Figure 5 the distribution of the lowest relative MCCC per MTU is given. In total, during 49 unique MTUs (0.6% of the time) there were one or more CNECs which had a MCCC <20%. However, for all these CNECs the cause for undershooting the 20% minRAM lies within the application of minRAM exclusion during these MTUs for reasons of operational security. Therefore, it is considered that the reductions during these hours have been appropriate, and that the 20% minRAM obligation has been fully complied with within 2021.

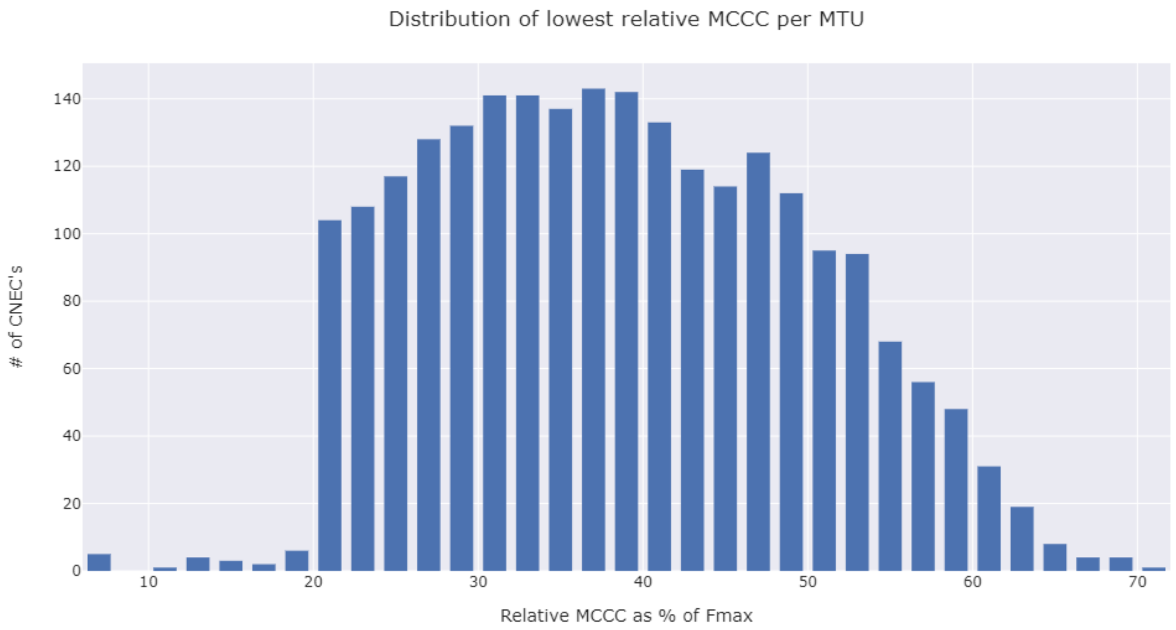



**Figure 5: Distribution of the lowest hourly relative MCCC of the Netherlands for the CWE CCA, considering third countries. Period Jan-Dec 2021**

## 5.2 CWE additional MACZT assessment

Next to the main assessments required to evaluate the compliance with the minimum capacity margins that needed to be made available in CWE, this section contains some additional assessments which have been carried out on the basis of the MACZT data. The data from this section is not strictly required to assess the compliance, but it provides some additional insights in the amount of MACZT that has been provided on the Dutch CNECs included in CWE FB DA CC.

### 5.2.1 Distributions of MACZT for all CNECs

The figures in the previous section each looked at the least performing CNEC, with respect to either $MACZT_{margin}$ or MACZT, and classified this into large categories. In this subsection, histograms are included with the results of:

- Lowest hourly relative MACZT for all MTUs in 2021: Figure 6
- Relative MACZT of all CNECs for all MTUs in 2021: Figure 7
- $MACZT_{margin}$ of all CNECs for all MTUs in 2021: Figure 8

In Figure 6, it is clearly visible that for the majority of MTUs the CNEC with the lowest hourly relative MACZT is close to the minimum $MACZT_{target}$ value of 28% (se+e Table 1). However, when looking at all CNECs in Figure 7, it can be observed that the majority of CNECs actually have a much higher relative MACZT. The average relative MACZT of all CNECs is 90%, which is significantly above the Electricity Regulation target of 70%, and the peak of the distribution for all CNECs also lies around a relative MACZT of 90%, Furthermore, Figure 8 shows that the vast majority of CNECs have had a positive $MACZT_{margin}$, and thus comply with the minimum margins for cross-zonal trade that have to be offered.

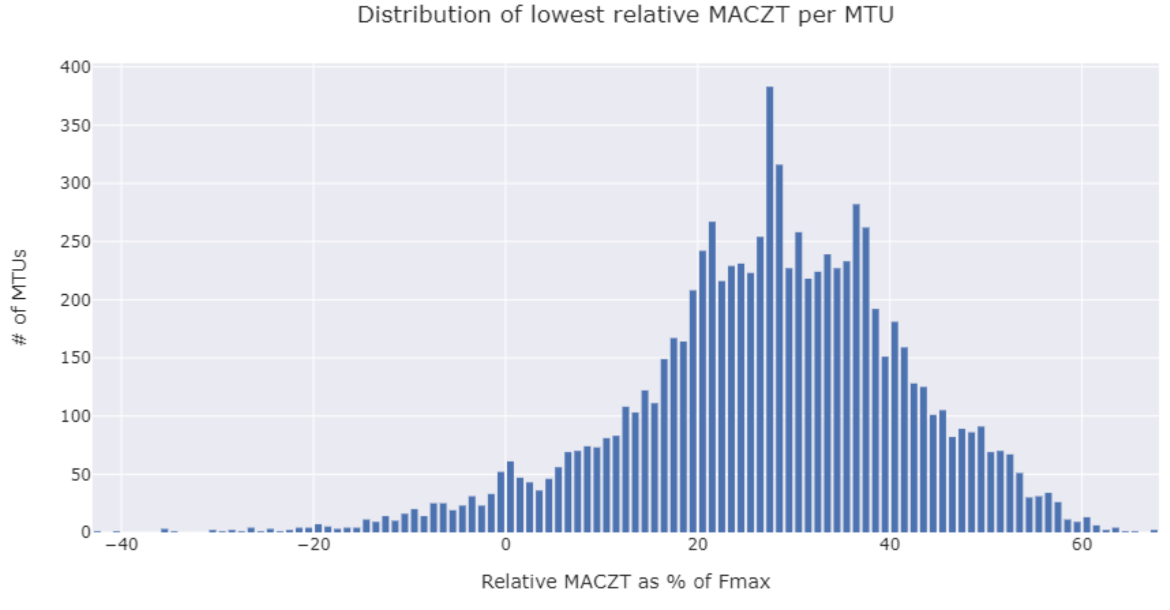



**Figure 6: Distribution of the lowest hourly relative MACZT of the Netherlands for the CWE CCA, considering third countries. Period Jan-Dec 2021**

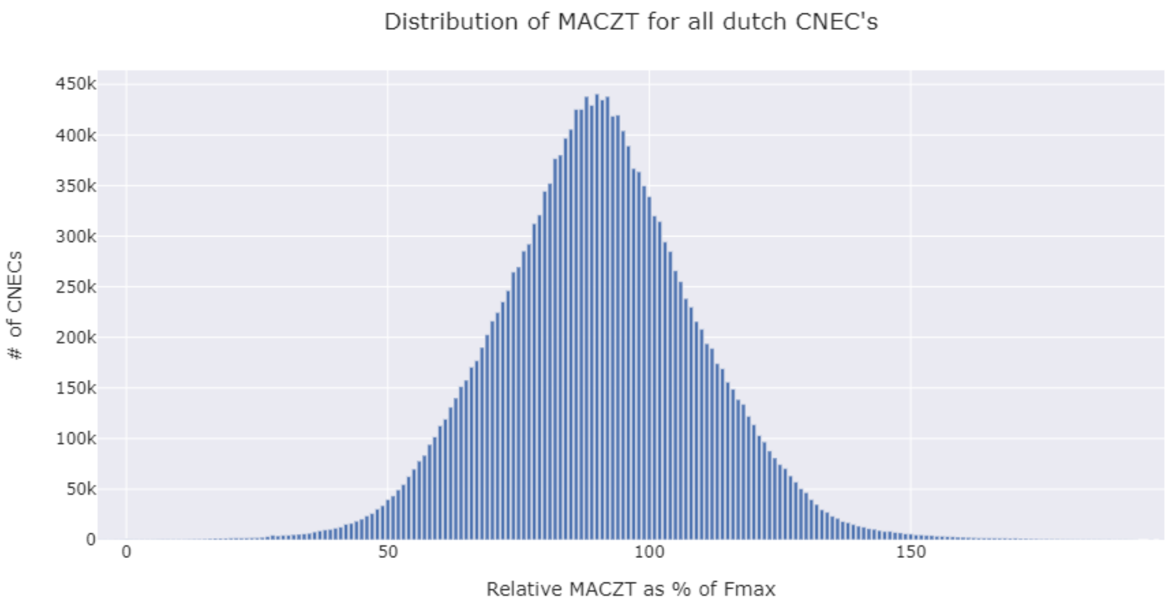



**Figure 7: Distribution of the relative MACZT for all CNECs of the Netherlands for the CWE CCA, considering third countries. Period Jan-Dec 2021**

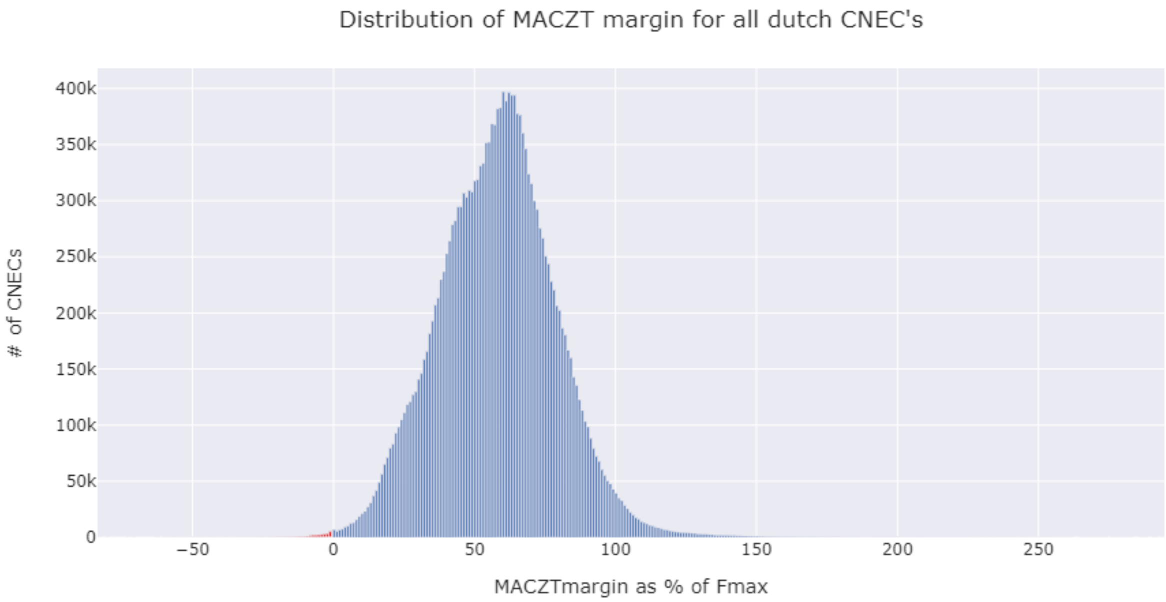



**Figure 8: Distribution of the $MACZT_{margin}$ for all CNECs of the Netherlands for the CWE CCA, considering third countries. Period Jan-Dec 2021**

### 5.2.2 MACZT breakdown per CNE

Based on the action plan, individual $MACZT_{target}$ values have been established per CNE. In order to provide more insight into what level of capacity is made available per CNE, a breakdown of the lowest hourly relative MACZT per CNE per direction is given in Figure 9 and Figure 10.

An explanation how to read the figures is given in the box below the figures. A list with the full names of the network elements is given in Table 4 of annex 3. Most of the time, between two high voltage substations there are pairs of high voltage lines, where the individual lines haves have the same names but are denoted with a different suffix (‘W’, ‘Z’ etc.). Each high voltage line is individually included as CNE in the CWE FB DA CC, and therefore also individually depicted in Figure 9 and Figure 10. Typically, these CNEs are connected in parallel between the same substations and have the same grid characteristics, and therefore the flows and MACZT for both CNEs are also very comparable.

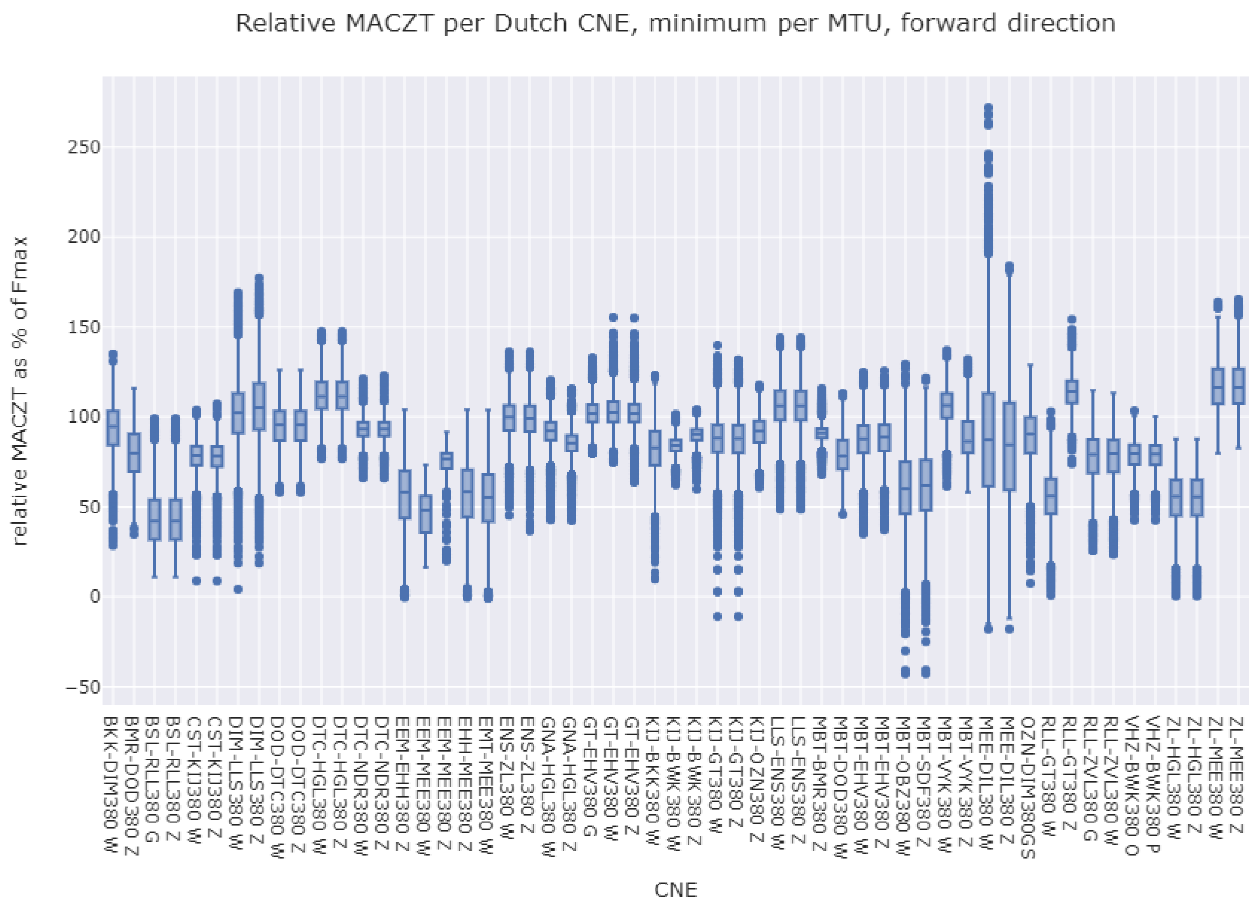



**Figure 9: Relative MACZT per Dutch CNE included in CWE CCA in the forward direction, based on the lowest relative MACZT per CNE per MTU, considering third countries. Period Jan-December 2021**

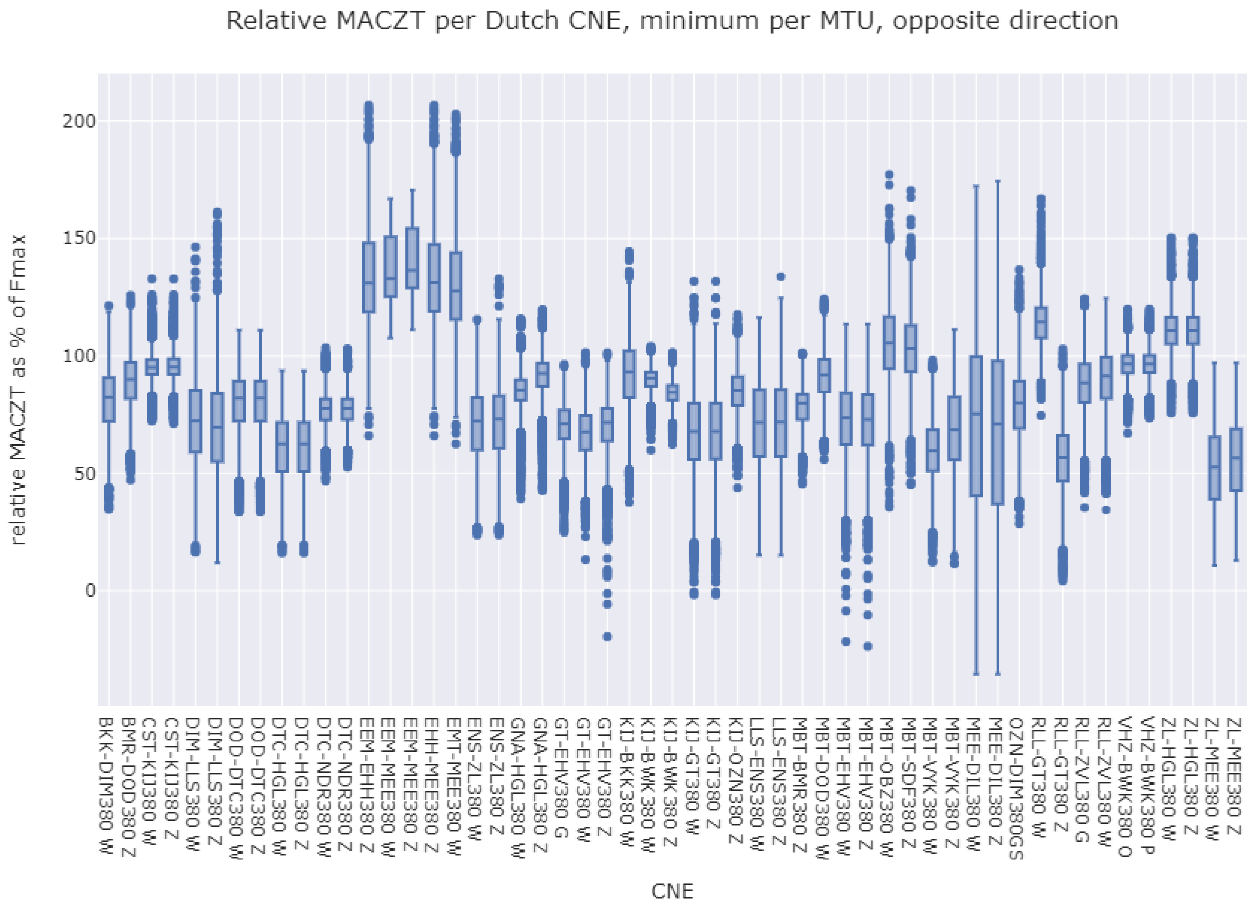



**Figure 10: Relative MACZT per Dutch CNE included in CWE CCA in the opposite direction, based on the lowest relative MACZT per CNE per MTU, considering third countries. Period Jan-December 2021**

**Box plot explanation**

- Each box + whiskers represent the data for a single CNE. For each CNE per direction, the CNEC with the lowest relative MACZT per MTU is taken.
- The box shows the range of the first quartile (Q1) to third quartile (Q3) of the data. (thus 25% - 75% of the data points is included in the box
- The blue horizontal line per CNE is the median of the data (the line which splits the dataset in half)
- Whiskers show the total range of the data, capped to a maximum of 1.5 * IQR from Q1 to Q3, where IQR is the inter-quartile range of Q3-Q1. Outliers are plotted as separate dots.

### 5.2.3 Overview of least performing CNECs w.r.t MACZT and MACZTmargin

Figure 11 shows what percentage of time a certain CNE has been the least performing CNE with respect to $MACZT_{margin}$, including whether they had a positive $MACZT_{margin}$ (green bar) or a negative $MACZT_{margin}$ (red bar). These are the elements which have actually set the performance with respect to $MACZT_{margin}$, as shown in Figure 1 and Figure 2.

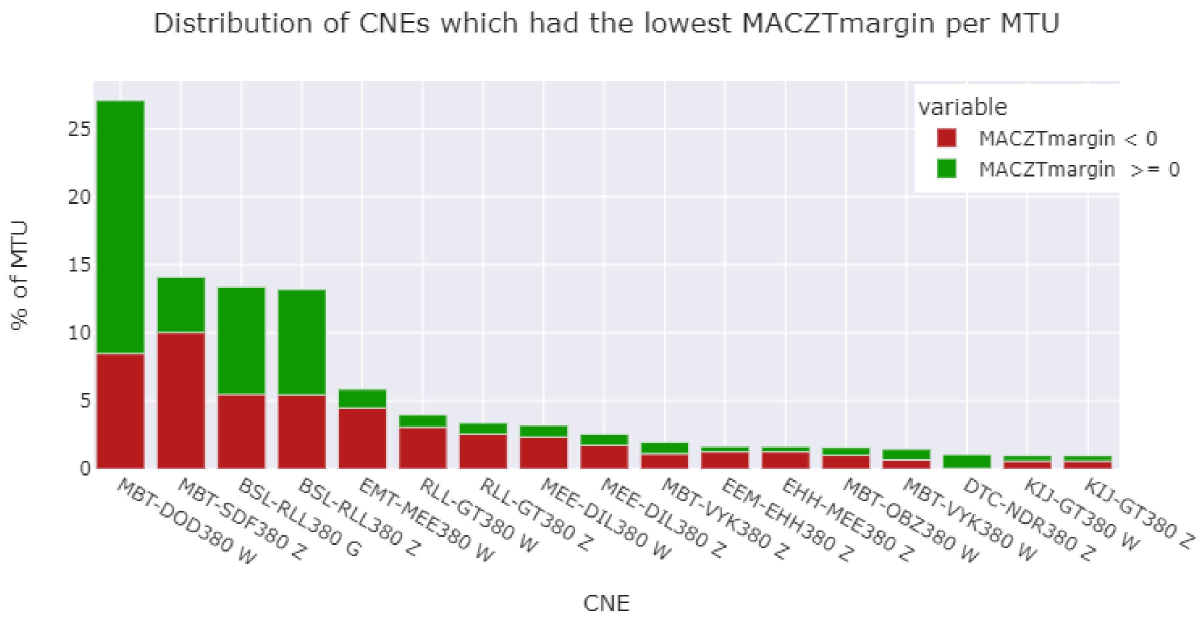



**Figure 11: Overview of least performing CNEs w.r.t. MACZTmargin. It has been determined what percentage of time an individual CNE has been the CNEC with the lowest $MACZT_{margin}$ per MTU. The green part of the bar indicates the percentage of time that the CNE had a positive $MACZT_{margin}$ the red part indicates the time that the CNE had a $MACZT_{margin}$ <0. CWE CCA, considering third countries. All CNEs occurring <1% of the time are excluded from the graph. Period Jan-Dec 2021**

Four network elements in particular pop up (in total ~63% of the time), which we will hereby elaborate upon:

- First of all, the CNE Maasbracht-Dodewaard 380 Wit has been the defining CNE for $MACZT_{margin}$ for more than 27% of the time. However, this network element is actually hardly ever popping up as active constraint in the day-ahead market coupling and therefore in practice has no impact on the market[15], but it is still the defining element for the MACZT performance. The reason is that this CNE already has a $MACZT_{target}$ value of 70% which is significantly above the $MACZT_{target}$ values of all other Dutch CNEs included in CWE FB DA CC. Still, for the majority of the time, it still had a positive $MACZT_{margin}$.

[15] See section 6.1 for further explanation on active constraints

- After that, the cross-border CNE of Maasbracht-Siersdorf 380 Zwart follows. This most likely has to do with the fact that this element has a higher $MACZT_{target}$ value (46% in 2021, see Table 3) than other neighbouring CNEs, including the parallel CNE Maasbracht-Oberzier 380 Wit ($MACZT_{target}$=36% in 2021).
- Third and fourth in the list, are the parallel CNEs Borssele-Rilland 380 Grijs and Zwart. These are often the defining CNEs for MACZTmargin because they carry a relatively large amount of internal flows, which originate from generators feeding in in the province of Zeeland and which flow to the rest of the Netherlands or to Belgium. However, also these CNEs hardly ever pop up as active constraints in the day-ahead market coupling.

Figure 12 shows what percentage of time a certain CNE has been the least performing CNE with respect to $MACZT_{margin}$, including whether they had a positive $MACZT_{margin}$ (green bar) or a negative $MACZT_{margin}$ (red bar). These are the elements which have actually set the performance with respect to $MACZT_{margin}$, as shown in Figure 3.

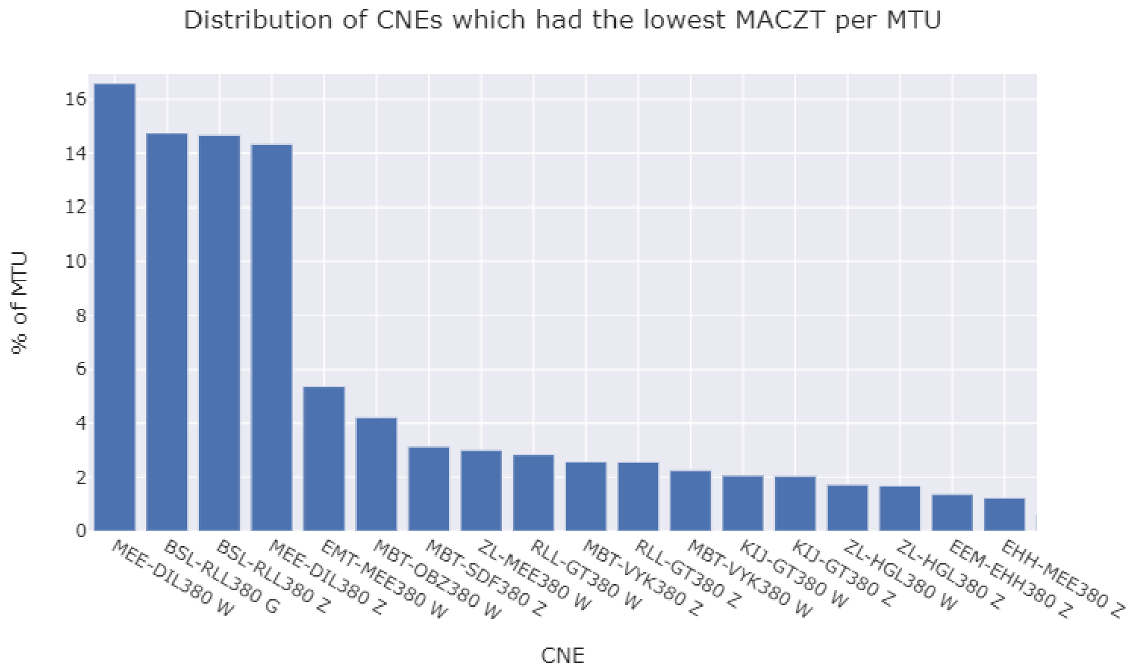



**Figure 12: Overview of least performing CNEs w.r.t. MACZT. It has been counted how often individual CNEs have been the CNEC with the lowest MACZT per MTU. CWE CCA, considering third countries. All CNEs occurring <1% of the time are excluded from the graph. Period Jan-Dec 2021**

Just as in Figure 11, the CNEs of Borssele-Rilland 380 Grijs and Zwart pop up as third and fourth defining elements. So next to often containing the lowest $MACZT_{margin}$ values, these also typically contain the lowest MACZT values. However, the first and second defining CNE are different from Figure 11. With respect to the lowest level of MACZT, the cross-border CNEs Meeden-Diele 380 Wit and Zwart are together the most defining elements w.r.t. MACZT for around 30% of the time. This is not surprising, given that these CNEs have a relatively low Fmax (1053 MW) and typically carry a high amount of loop flows, which is shown in the next subsection.

### 5.2.4 Loop flow breakdown per CNE

One of the key elements from the applicable derogation is that it reduces the minimum margins that TenneT needs to make available for cross-zonal trade, in case loop flows exceed a certain predefined threshold (see section 2.2). In order to make the impact of this derogation more clear, a breakdown of the calculated loop flows per CNE is given in Figure 13. There is no figure included for the opposite direction, as the figure contains average loop flows and the average loop flows in the opposite direction would just be a mirror of this picture.

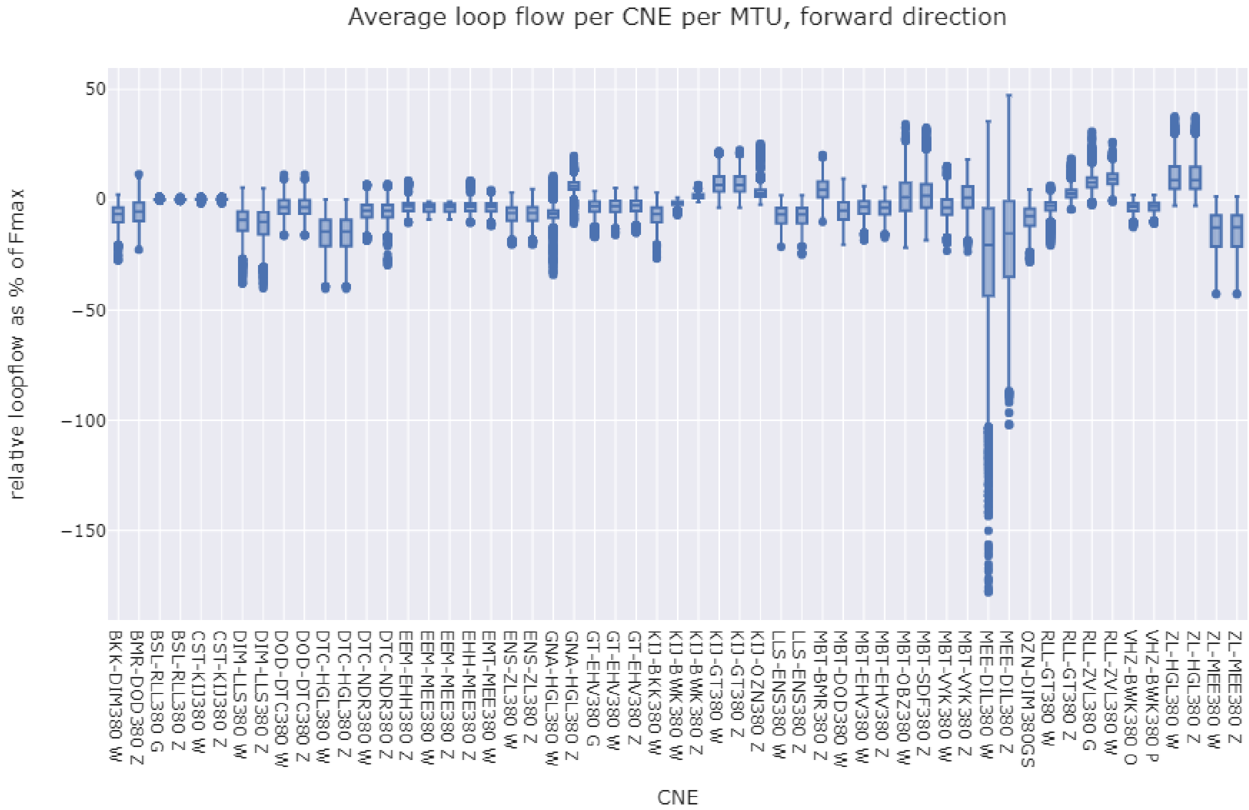



**Figure 13: Average relative loop flow per Dutch CNE per MTU. Positive values indicate loop flows in the forward direction, negative values indicate loop flows in the opposite direction. CWE CCA, considering third countries. Period Jan-December 2021**

In particular, the very high level of loop flows on the cross-border CNE Meeden-Diele 380 W and Z really stand out from the rest. These CNEs stand out because they have a relatively low amount of Fmax (1053 MW), and are in a place in the grid where they carry a relatively high amount of loop flows which typically originate from wind in Northern Germany and flow to loads in southern Germany via the Dutch transmission network. The variability of wind can also be seen in the variability of the loop flow, as the bar is also relatively long for these CNEs. In operations, TenneT deals with these loop flows via the operation of Phase Shifting Transformers (PSTs) which are installed at the substation of Meeden and which can reduce the amount of loop flows. But even with the operation of PSTs, a significant amount of loop flows remain in the system, which is why the loop flow derogation is crucial for TenneT to be able to respect the minimum capacity margins and maintain operational security

When looking at the other network elements, it can generally be observed that loop flows enter the Netherlands from Germany at the substation of Meeden and then flow to Zwolle. At Zwolle, the loop flows separate in two paths:

- A path soutwards via the eastern part of the TenneT 380 kV transmission network via Zwolle → Hengelo → Doetinchem → Dodewaard → Maasbracht. A significant share of the loop flows on this path exit the Netherlands again via the interconnectors Doetinchem-Niederrhein or Maasbracht-Siersdorf / Maasbracht-Oberzier, but there is also a part that flows to Belgium via Maasbracht – van Eyck.
- The second path is via the western part of the TenneT 380 kV transmission network via the path Zwolle → Ens → Lelystad → Diemen and then southwards to eventually exit the Netherlands via the interconnector Rilland – Zandvliet towards Belgium.

### 5.2.5 Impact of exclusion of third country flows

In its decision on the MACZT monitoring report 2020, ACM requested TenneT to in the future also present figures excluding third country flows in order to be able to see the impact that third country flows have on the level of MACZT that has been provided. Figure 14 and Figure 15, show the differences for MACZTmargin and MACZT when flows from third countries are either considered or not considered as contributing towards the MACZT. In annex 5 section 3, it is specified which countries have been regarded as third country.

Overall, the impact of (not) considering third countries or not considering them is:

- Meeting the minimum capacity margins for all CNECs for 50% of the time (including third countries) versus meeting the minimum margins for 44% of the time (excluding third countries).
- Providing less than 20% MACZT on the least performing network CNEC for 26% of the time (including third countries) versus 30% of the time (excluding third countries)

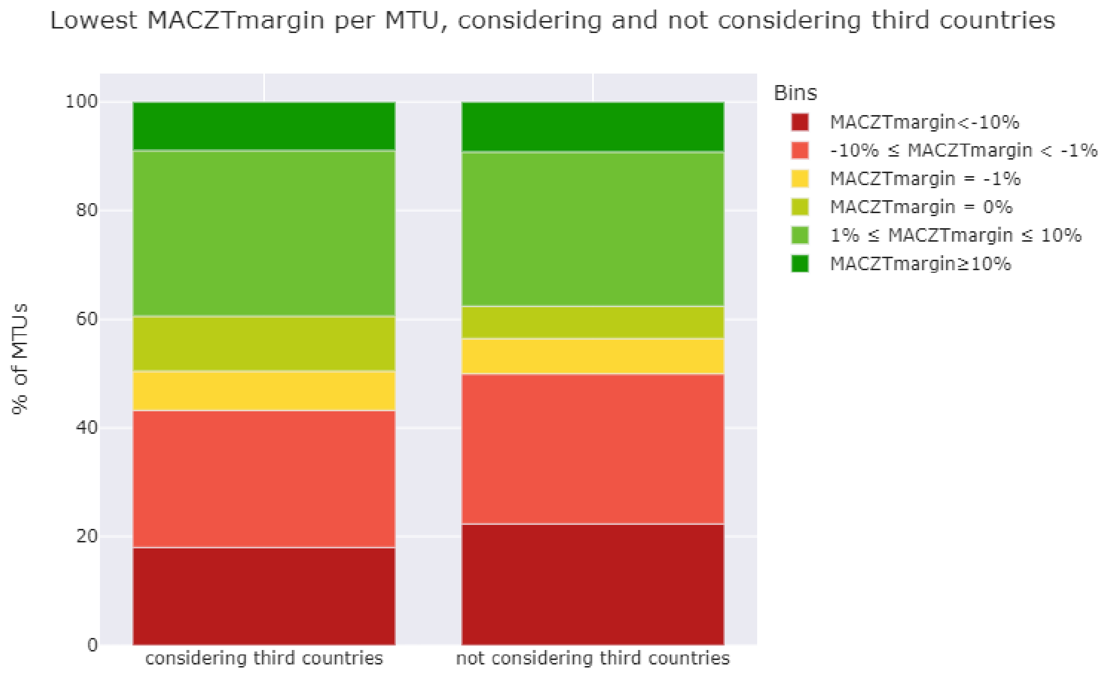



**Figure 14: Percentage of time when the minimum capacity margins have been met (green), and how much capacity was provided above or below the minimum margin, for the situation including and excluding third country flows. For each MTU, the CNEC with the lowest $MACZT_{margin}$ was selected and categorised to one of the ranges. CWE CCA. Period January-December 2021**

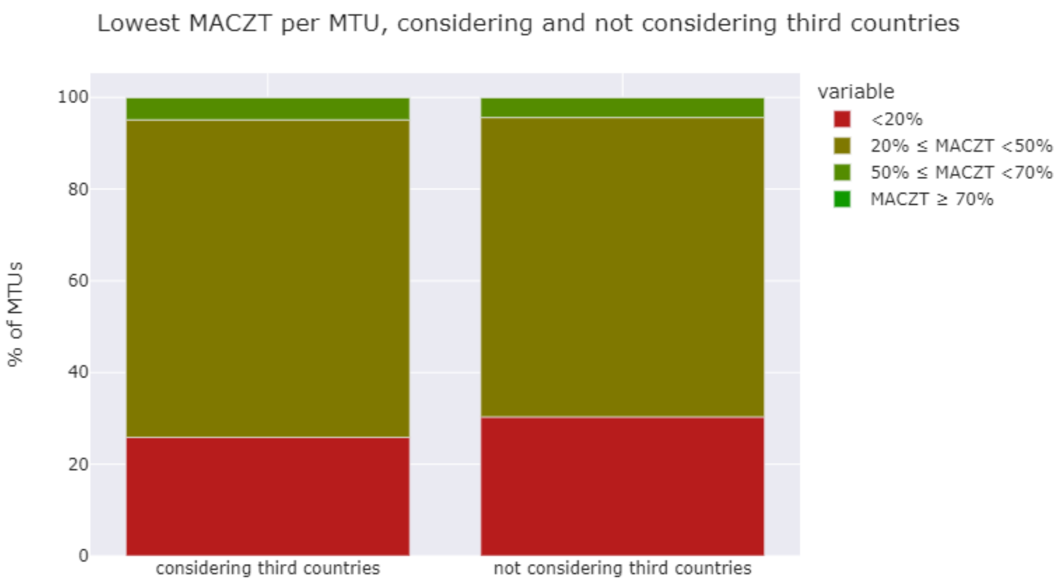
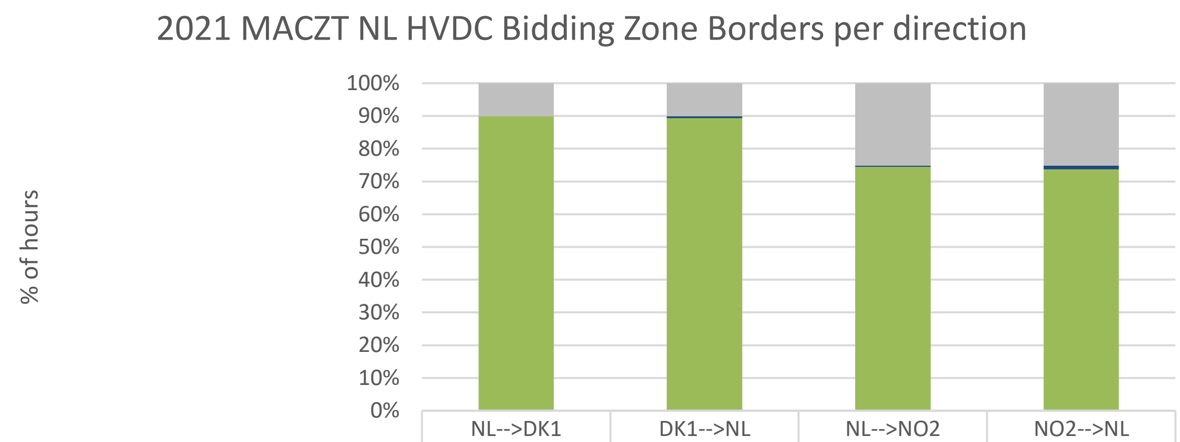



**Figure 15: Percentage of time when the minimum MACZT is met on all CNECs, for the situation including and excluding third country flows. For each MTU, the CNEC with the lowest MACZT was selected and categorised to one of the ranges. CWE CCA. Period January-December 2021**

## 5.3 HVDC Bidding Zone borders

### 5.3.1 Result of the MACZT compliance assessment for the HVDC bidding zone borders

For the HVDC bidding zone borders, the process for evaluation as set out in section 4.3 has been followed. In Figure 16 the percentage of time when the relative MACZT is above 70%, is given for the HVDC bidding zone borders. The figure shows that in 2021 for 100% of the time for all HVDC bidding zone borders, TenneT offered a MACZT equal or larger than the required minimum level of 70%. There have been some MTUs where reductions were applied which led to a MACZT below 70%, but these were all triggered by Energinet or Statnett and not by TenneT.




| | NL-->DK1 | DK1-->NL | NL-->NO2 | NO2-->NL |
|---|---|---|---|---|
| Interconnector outage | 10.1% | 10.1% | 25.1% | 25.1% |
| MACZT<70% because of reduction by Energinet/Statnett | 0.0% | 0.6% | 0.5% | 1.2% |
| MACZT<70% because of reduction by TenneT | 0.0% | 0.0% | 0.0% | 0.0% |
| MACZT>70% | 89.9% | 89.3% | 74.4% | 73.7% |

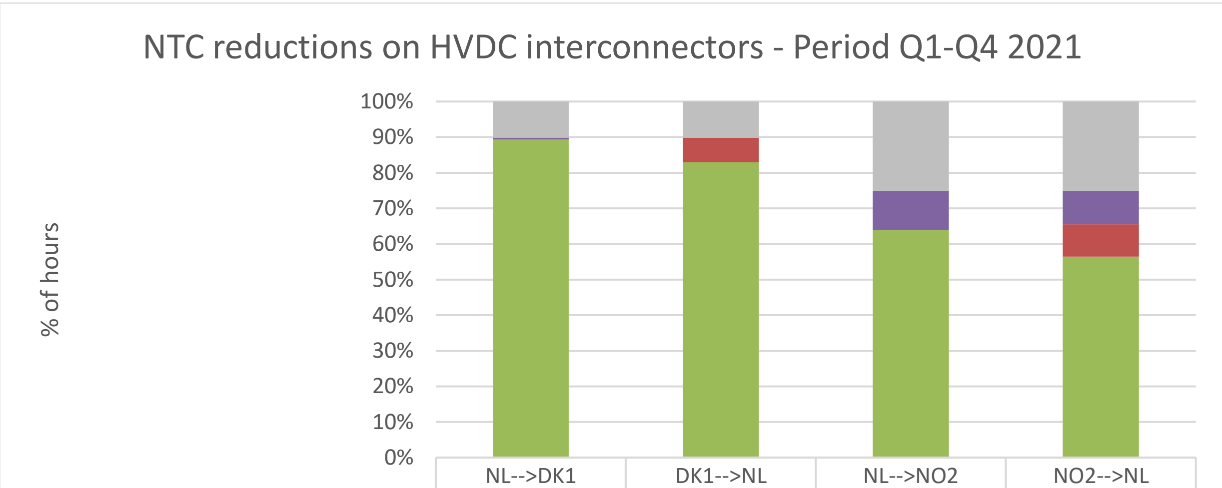
**Figure 16: Percentage of the time when the relative MACZT is above 70% on the NL HVDC borders, per direction, for the full year 2021**

Within 2021 TenneT has still at times reduced the NTC capacity on HVDC bidding zone borders during significant and longer duration outage situations on critical network elements in order to prevent violation of operational security limits in the Dutch transmission network. However, in contrast to 2020 all of the reductions that took place in 2021 respected the 70% MACZT target. A more in depth overview on the reductions is given in the next subsection.

### 5.3.2 Overview of reductions applied on the HVDC bidding zone borders

Figure 17 provides an overview of the amount of hours that a reduction of the NTC capacity has been applied on the HVDC bidding zone borders, and whether the reduction was triggered by an interconnector outage or by one of the TSOs because of other reasons. A detailed overview of the available NTC per bidding zone border as offered throughout the year is given in Figure 18 and Figure 19.

Figure 17 shows that TenneT applied a limited amount of reductions of 7% of the time for DK1->NL and 9% of the time for NO2->NL, and no reductions for the other directions. The majority of these reductions took place in the period November / December, because of a planned outage on DIM-LLS (for a capacity upgrade in line with the commitments of the Dutch action plan). Therefore, *in addition* to the application of remedial actions such as negotiated restriction agreements and redispatch, a reduction of the NTC capacity had to be applied in order to prevent expected violations of operational security limits. However, as shown in Figure 16 all of these reductions respected the minimum MACZT of 70%.




| | NL-->DK1 | DK1-->NL | NL-->NO2 | NO2-->NL |
|---|---|---|---|---|
| NTC reduction because of interconnector outage | 10.1% | 10.1% | 25.1% | 25.1% |
| NTC reduction by Statnett/Energinet | 0.6% | 0.0% | 11.0% | 9.4% |
| NTC reduction by TenneT | 0.0% | 7.0% | 0.0% | 9.0% |
| No NTC reduction | 89.3% | 82.9% | 63.9% | 56.5% |

Figure 17: Overview of the causes of NTC reductions on the NL HVDC bidding zone borders

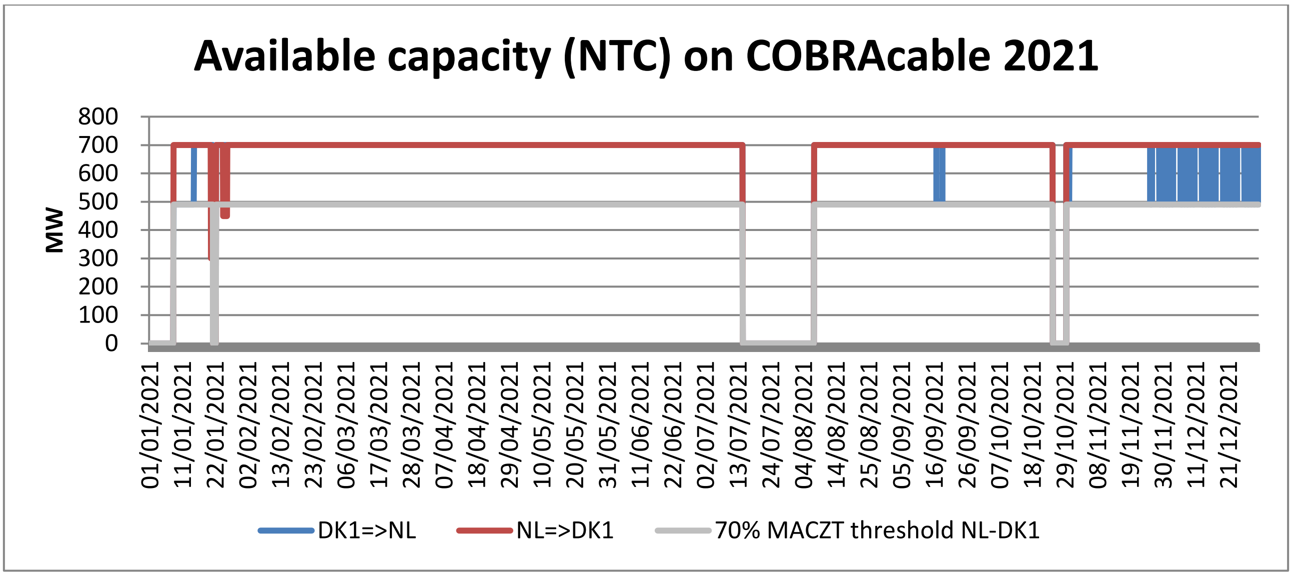



**Figure 18: Available capacity (NTC) on the NL-DK1 bidding zone border. Period Jan-Dec 2021**

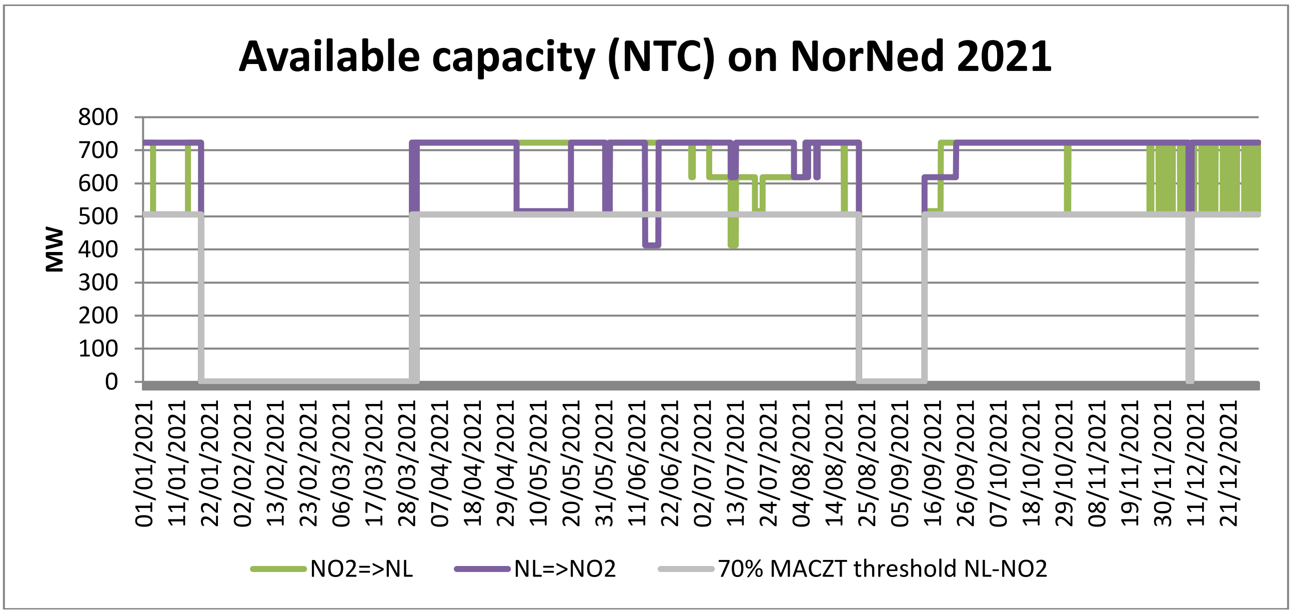



**Figure 19: Available capacity (NTC) on the NL-NO2 bidding zone border. The values as included in the figure are including a correction for the application of implicit loss handling. Period Jan-Dec 2021**

# 6. High-level assessment of market impact of MACZT deficits in CWE CCA

Given the observation from Figure 1 that for 55% of the time insufficient MACZT was provided, mostly because unintentionally the local tooling that used to calculate MNCC was malfunctioning, TenneT deemed it important to have a more in-depth assessment on what has been the (potential) market impact of this.

## 6.1 Method – Focus on active constraints

It is certainly not a given that CNECs with insufficient MACZT are also limiting cross-zonal exchanges. In order to evaluate whether market exchanges were actually impacted, we need to dive deeper into the results of the day-ahead capacity allocation to determine what were the CNECs that were actively constraining the opportunity for additional exchanges to the market – the so-called 'active constraints'.

The active constraints can be identified by checking which CNECs as included in the CWE flow-based capacity domain have a shadow price associated to them as result from the capacity allocation via the market coupling algorithm of Euphemia. If a network element had a shadow price of zero, it did not limit market exchanges. The shadow price quantifies the monetary value of an additional margin for cross-zonal trade amounting to one MW on a CNEC, in € per MW.

Besides enabling to determine which network elements actually limited market exchanges, the shadow price also serves as a good first indicator of the monetary impact that an active constraint has had. By comparing the shadow price of an active constraint with the shadow prices of other active constraints, it is possible to evaluate whether the network element had a comparatively high or low impact on the economic surplus as obtained via the day-ahead market coupling. However, the shadow price cannot be used to determine the total welfare effect that an active constraint has had, nor the amount of additional economic surplus that could be obtained if the margin would be increased by more than 1 MW. This is the case because the shadow price is only valid for the specific market clearing point resulting from the day-ahead market.

For the evaluation, TenneT has performed the following steps:

1) Gather the set of active constraints from the CWE flow-based capacity domain for the day-ahead market for the year 2021;
2) Map the Dutch CNECs which have been an active constraint to the CNECs in the MACZT dataset;
3) Count the amount of unique MTUs that a Dutch CNEC has been an active constraint for the day-ahead market;
4) Count the amount of unique MTUs that one or more of the Dutch CNECs was an active constraint and had a MACZTmargin ≤ 0.
5) Determine the averages shadow price for the individual Dutch active constraints, and compare these to the averages of the shadow prices of all CNECs from CWE. This allows to see the relative impact on the market of the Dutch active constraints, in comparison to the average impact of all CWE active constraints.

## 6.2 Results

First of all, we have made a breakdown of what CNEs included in CWE FB DA CC have been an active constraint in the day-ahead market coupling during 2021. In total, for 1087 MTUs one or more Dutch CNEs from CWE FB DA CC has/have been an active constraint in the day-ahead market coupling. However, only for 88 MTUs (1,0% of the time), one or more of the Dutch active constraints for that MTU had a negative $MACZT_{margin}$ .

If we break this down in light of the total amount of MTUs for the full year and combine with the data as depicted in Figure 1 , we can create the following overview of Figure 20.

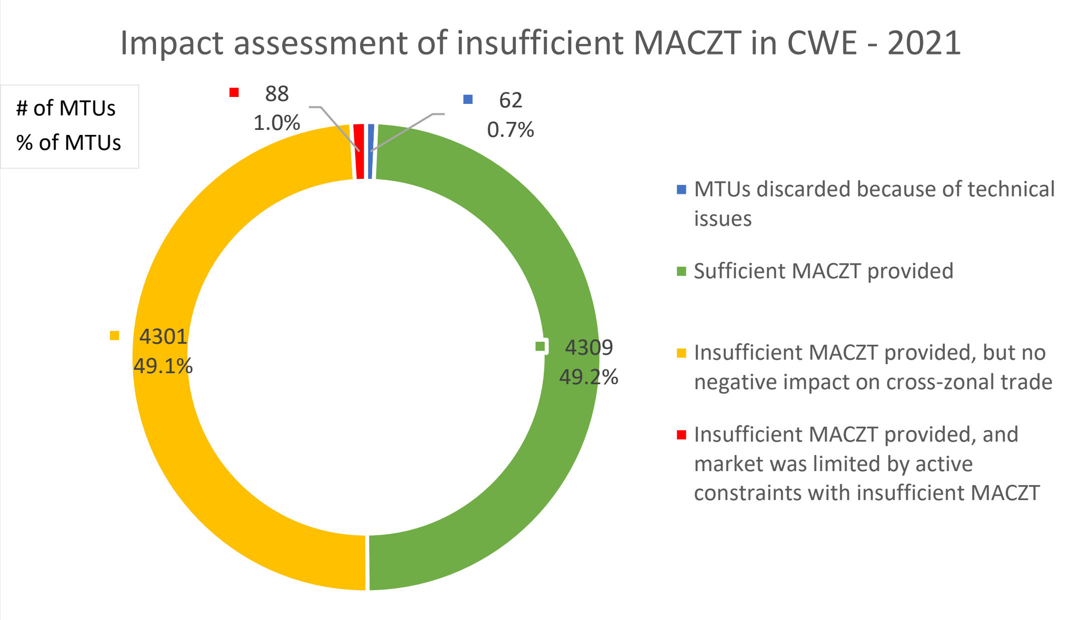



**Figure 20: High-level assessment of market impact of MACZT deficits in the CWE CCA. Period Jan-Dec 2021**

The figure shows a breakdown for all MTUs in 2021:

- 62 MTUs (0.7% of the time) were discarded because of technical issues (see annex 4)
- 4309 MTUs (49.2% of the time), sufficient MACZT was provided[16]
- 4301MTUs (49.1% of the time), insufficient MACZT was provided, but this did not have a negative impact on cross zonal trade as for these MTUs there was no Dutch active constraint that had a negative $MACZT_{margin}$
- For 88 MTUs (1.0% of the time), insufficient MACZT was provided and one or more Dutch CNECs with a negative MACZTmargin was an active constraint within

In addition to the full overview, TenneT also created a breakdown which CNEs have been an active constraint, whether or not they had a positive $MACZT_{margin}$ when they were an active constraint, and what was the average shadow price for the active constraint. This breakdown is given in Figure 21.

[16] Note that in the conclusions from Figure 1 this was rounded to 50% as in that figure the 4309 MTUs with sufficient MACZT were divided over a total of 8698 assessed MTUs (8760 MTUs in total in 2021– 62 MTUs that were discarded), which leads to 49.54%.

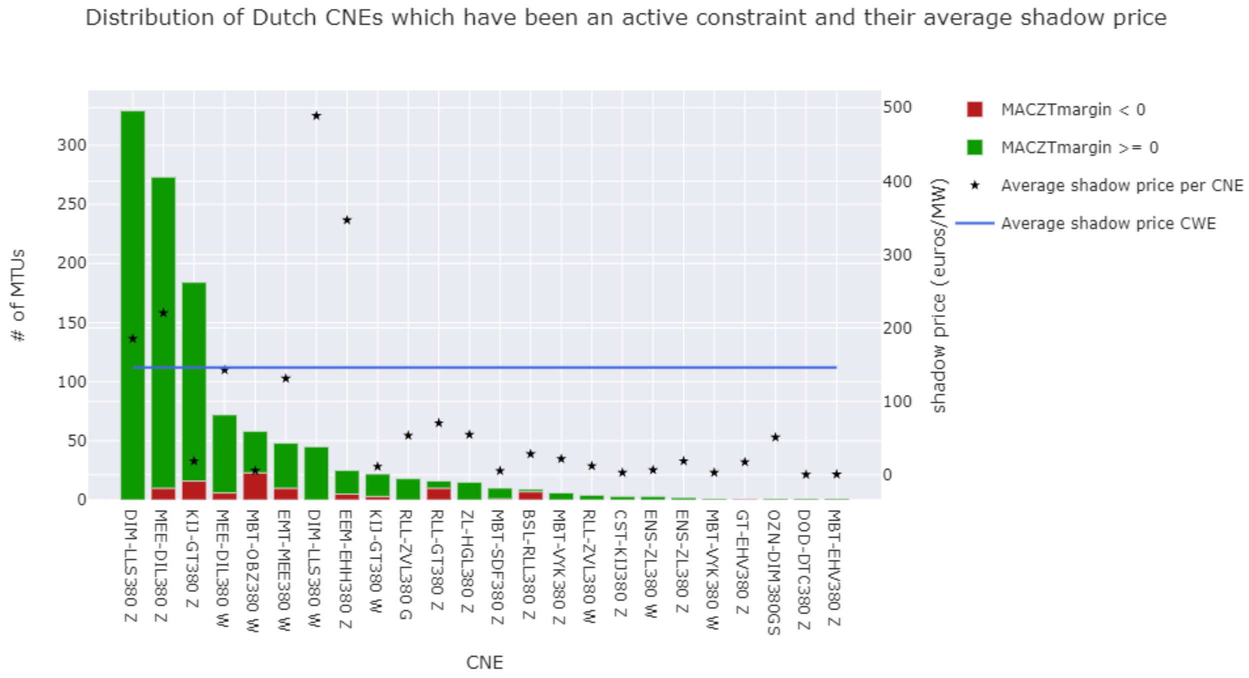



**Figure 21: Overview of Dutch active constraints in the day ahead market and their average shadow price. The green part of the bar indicates the amount of MTUs (left axis) that the CNE had a positive $MACZT_{margin}$ the red part indicates the amount of MTUs that the CNE had a $MACZT_{margin}$ <0, considering third countries. For each CNE, also the average shadow prices is depicted by a star (right axis). Period Jan-Dec 2021**

Below follow some observations based on this figure:

- The top four active constraints with respect to occurrence, most of the time had a positive $MACZT_{margin}$.
- The high occurrence of CNE Diemen-Lelystad 380 Zwart as active constraint is related to the capacity upgrade of its parallel CNE Diemen-Lelystad 380 Wit for which it was out of service for 4.5 months because new physical lines with more capacity have been installed. As a result of that, the CNE Diemen-Lelystad 380 Wit became very often the most constraining element as this had to carry all flows on the corridor Zwolle → Diemen without being able to share it with a parallel CNE.
- The CNE which most often had a negative $MACZT_{margin}$ if it was an active constraint, was Maasbracht-Oberzier 380 W. However, when this CNE was an active constraint, it had (fortunately) only a very limited average shadow price of just 5.6 €/MWh.
- The CNEs with the highest shadow prices, near to always had a positive $MACZT_{margin}$

Overall, in addition to the previous conclusion that only for 1.0% of the time a Dutch CNE with insufficient MACZT was an active constraint in the day-ahead market, it appears that the market impact of those CNEs was relatively modest as the shadow prices were comparatively low. The average shadow price of the Dutch active constraints with MACZT deficits, was only 26 €/MW, which is significantly below the CWE average shadow price of 146 €/MW. **So in the end the conclusion is that despite that for 50% of the time there has been a MACZT deficit on one or more Dutch CNECs, this has only had a very limited impact on the market.**

# 7. Conclusions

Based on the results as set out in chapter 5 and 6, TenneT has arrived at the following conclusions for the relevant capacity calculation areas:

For the **Central West Europe (CWE) CCA**:

- For 50% of the time, TenneT has provided capacity margins at or above the required minimum levels on all its network elements
- For 50% of the time, TenneT has offered insufficient capacity margins. The main underlying reason, is that the local tooling that TenneT used to calculate MNCC was unintentionally providing erroneous MNCC values. After an updated tool was taken in operation per Business Day 2/10/2021, the results improved significantly.
- Fortunately, the insufficient capacity margins have only had a very limited impact on cross-zonal trade. This because only 1.0% of the time a Dutch CNEC with insufficient MACZT has limited cross-zonal exchanges in the day-ahead market coupling. Also, the welfare effect of these active constraints has been comparatively small, when compared to the average effect of active constraints from the CWE region.

For the **HVDC bidding zone borders (NL-DK1, NL-NO2)**:

- For 100% of the time, TenneT has provided capacity margins at or above the required minimum level of 70% for the NL-DK1 and NL-NO2 bidding zone border.
- For 7% of the time for the DK1→NL and 9% of the time for the NO2→NL bidding zone border, TenneT has applied a reduction of NTC capacity on these borders, but none of the reductions was below the minimum level of 70%.

TenneT expects that for 2022 a significant improvement for the capacity margins as offered within CWE CCA is realistic. The results for October-December 2021 show that with the updated tooling, it has been possible to meet the minimum levels on all the network elements. Also, after the go-live of Core flow-based day-ahead capacity calculation the need for a separate local tooling for the calculation of MNCC as an intermediate step in the calculation process is obsolete, as MNCC will be calculated as an integral part of the Core tooling. This should increase the robustness of the MACZT calculation process.

Therefore, with updated local tooling for CWE and go-live of Core flow-based day-ahead capacity calculation, it should in principle be possible for TenneT to meet the minimum levels of capacity margins in 2022.

# 8. Annex 1: List of Abbreviations

| Acronym | Meaning |
|---|---|
| **AC** | Alternating Current |
| **ACER** | Agency for the Cooperation of Energy Regulators |
| **ACM** | the Dutch national regulatory Authority for Consumers and Markets |
| **BD** | Business Day, meaning the day for which the (capacity calculation) results are applicable |
| **BE** | (the Bidding Zone of) Belgium |
| **CACM** | Capacity Allocation and Congestion Management (electricity) |
| **CCA** | Capacity calculation area |
| **CCM** | Capacity calculation methodology |
| **CCR** | Capacity calculation region |
| **CEP** | Clean Energy (for all Europeans) Package |
| **CNE** | Critical Network Element |
| **CNEC** | Critical Network Element with contingencies |
| **cNTC** | Coordinated Net Transfer Capacity |
| **Core DA CCM** | The day-ahead flow-based capacity calculation methodology for the Core Capacity Calculation Region. |
| **CWE** | Central West Europe (electricity region) |
| **CWE FB DA CC** | The day-ahead capacity calculation process taking place in the Central West Europe electricity region |
| **CWE FB MC** | The day-ahead flow-based market coupling taking place in the Central West Europe electricity region |
| **D2CF** | Two Day ahead Congestion Forecast |
| **DACF** | Day-Ahead Congestion Forecast |
| **DC** | Direct Current |
| **DE** | (the Bidding Zone of) Germany |
| **DK1** | Bidding Zone DK1 in Denmark |
| **EC** | European Commission |
| **EEA** | European Economic Area |
| **ENTSO-E** | European Network of Transmission System Operators for Electricity |
| **EU** | European Union |
| **FB** | Flow-based |
| **FLD** | Full Line Decomposition (methodology) |
| **Fmax** | Maximum admissible flow on critical network elements, respecting operational security limits |
| **FRM** | Flow Reliability margin applied on a CNEC in flow-based capacity calculation |
| **GB** | (the Bidding Zone of) Great Britain |
| **GSK** | Generation Shift Key |
| **HVDC** | High-voltage direct current |

| | |
|---|---|
| **LF** | Loop Flow |
| **LTA** | Long-Term Allocated Capacities |
| **MACZT** | Margin available for cross-zonal trade |
| **$MACZT_{margin}$** | The amount of MACZT made available above or below the minimum level of MACZT |
| **$MACZT_{min}$** | Minimum level of MACZT |
| **$MACZT_{target}$** | Target minimum level of MACZT |
| **MCCC** | Margin from coordinated capacity calculation |
| **$MCCC_{min}$** | Minimum level of MCCC |
| **minRAM** | Minimum Remaining Available Margin, term used within CWE FB DA CC |
| **MNCC** | Margin from non-coordinated capacity calculation |
| **MS** | Member State |
| **MTU** | Market Time Unit. In this report, 1 hour given that the MTU for the day-ahead market in 2020 was 1 hour. |
| **NL** | (the Bidding Zone of) The Netherlands. |
| **NO2** | Bidding Zone NO2 in Norway |
| **NTC** | Net Transfer Capacity |
| **PST** | Phase shifting transformer |
| **PTDF** | Power Transfer Distribution Factor |
| **RAM** | Remaining Available Margin |
| **TSO** | Transmission System Operator |

# 9. Annex 2: Linear Trajectory

**Table 3: Overview of $MACZT_{target}$ values per Dutch CNE of the linear trajectory as set by the Dutch Action plan. See Table 4 of Annex 3 for full names of the abbreviations, used in the CNE name.**

| CNE | type | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 |
|---|---|---|---|---|---|---|---|---|
| BKK-DIM380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| BMR-DOD380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| BSL-GT380 | internal | 25% | 33% | 40% | 48% | 55% | 63% | 70% |
| BSL-RLL380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| CST-KIJ380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| DIM-LLS380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| DOD-DTC380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| DTC-HGL380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| DTC-NDR380 | cross-border | 58% | 60% | 62% | 64% | 66% | 68% | 70% |
| EEM-EOS380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| EEM-EHH380 / EEM-MEE380 / EEH-MEE380 / EHH-MEE380[17] | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| ENS-ZL380 | internal | 21% | 30% | 38% | 46% | 54% | 62% | 70% |
| GNA-HGL380 | cross-border | 39% | 44% | 49% | 54% | 60% | 65% | 70% |
| GT-EHV380 | internal | 29% | 36% | 43% | 50% | 56% | 63% | 70% |
| KIJ-BKK380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| KIJ-BWK380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| KIJ-GT380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| KIJ-OZN380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| LLS-ENS380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| MBT-BMR380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| MBT-DOD380 | internal | 70% | 70% | 70% | 70% | 70% | 70% | 70% |
| MBT-EHV380 | internal | 30% | 37% | 44% | 50% | 57% | 63% | 70% |
| MBT-OBZ380 | cross-border | 30% | 36% | 43% | 50% | 57% | 63% | 70% |
| MBT-SDF380 | cross-border | 41% | 46% | 50% | 55% | 60% | 65% | 70% |
| MBT-VYK380 | cross-border | 29% | 36% | 43% | 50% | 56% | 63% | 70% |
| MEE-DIL380 | cross-border | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| OZN-DIM380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| RLL-GT380 | internal | 29% | 36% | 43% | 50% | 56% | 63% | 70% |
| RLL-ZVL380 | cross-border | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| VHZ-BWK380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| ZL-HGL380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |
| ZL-MEE380 | internal | 20% | 28% | 37% | 45% | 53% | 62% | 70% |

[17] In December 2020, the CNE of EEM-MEE380 was split into 2 when a transformer was looped into the high voltage line at substation Eemshaven het Hogeland. This substation was initially abbreviated as EEH, and per 26/12/20 as EHH.

# 10. Annex 3: Full names of abbreviations used in network element names

A network element is depicted by its name from a certain substation to another substation. In general, the following notation for CNEs is used throughout this report:

[substation A] – [substation B] [Voltage level] [Circuit symbol]

Where:

- Typically, three letter abbreviations for the substation names are used. In Table 4, the full names for the substations (nodes) belonging to the abbreviations is given.
- The voltage level is in kV, and in this report only 380 kV network elements are included
- A symbol is used to identify individual circuits, where:
    - 'W' stands for 'Wit' (white)
    - 'Z' stands for 'Zwart' (black)
    - 'P' stands for 'Paars' (purple)
    - 'O' stands for 'Oranje' (orange)
    - 'G' or 'GS' stands for 'Grijs' (grey)

Within the report, also the term 'direction' is used to denote whether flows / capacity is from substation A to substation B, or vice versa

- In case of 'forward direction', the (capacity for) flows in the direction from 'substation A' to 'substation B' are meant.
- In case of 'opposite direction', the (capacity for) flows in the direction from 'substation B' to 'substation A' are meant.

**Table 4: Full names for the abbreviations of substations as used in the network element names**

| Abbreviation | Full name | Remarks |
|---|---|---|
| **BKK** | Breukelen Kortrijk | |
| **BMR** | Boxmeer | |
| **BSL** | Borssele | |
| **BWK** | Bleiswijk | |
| **CST** | Crayestein | |
| **DIL** | Diele | German substation |
| **DIM** | Diemen | |
| **DOD** | Dodewaard | |
| **DTC** | Doetinchem | |
| **EHH** | Eemshaven Het Hogeland | |
| **EHV** | Eindhoven | |
| **ENS** | Ens | |
| **GNA** | Gronau | German substation |
| **GT** | Geertruidenberg | |
| **HGL** | Hengelo | |
| **KIJ** | Krimpen aan den IJssel | |

| | | |
|---|---|---|
| **LLS** | Lelystad | |
| **MBT** | Maasbracht | |
| **MEE** | Meeden | |
| **NDR** | Niederrhein | German substation |
| **OBZ** | Oberzier | German substation |
| **OZN** | Oostzaan | |
| **RLL** | Rilland | |
| **SDF** | Siersdorf | German substation |
| **VHZ** | Vijfhuizen | |
| **VYK** | Van Eyck | Belgian substation |
| **ZL** | Zwolle | |
| **ZVL** | Zandvliet | Belgian substation |

TenneT TSO B.V.

# 11. Annex 4: Source data

This annex clarifies what data is used to perform the MACZT assessment for the Netherlands as included in this report.

## 11.1 CWE Capacity Calculation Area

### 11.1.1 Source data

In Table 5 an overview is given what data is used to assess the compliance for the CWE capacity Calculation Areas. This data is also publicly available via the JAO Utility Tool.[18] A description of the source files is given in Table 6.

**Table 5: Source data used for assessing compliance of the CWE Capacity Calculation area**

| Data | Name under which this is published in JAO Utility Tool | Source file |
|---|---|---|
| **CNE name and EIC code** | CriticalBranchName | F206 files |
| **Contingency name and EIC code** | OutageName | F109+F206 files |
| **Fmax** | Fmax | F206 files |
| $MACZT^{CNEC}_{target}$ | MACZTmin[19] | F206 files |
| $MCCC^{CNEC}$ | RemainingAvailableMargin (MW) | F206 files |
| $MNCC^{CNEC}$ | MNCC | F206 files<br>Recalculations |
| $MNCC^{CNEC}_{min}$ | MinRAMFactor | F206 files<br>Recalculations |
| $LF^{CNEC}_{calc}$ | LFcalc inside minramjustification | F206 files<br>Recalculations |
| $LF^{CNEC}_{accept}$ | LFaccept inside minramjustification | F206 files |
| **Data on minRAM exclusions** | JAO TSO message board | F204 files |

**Table 6: Explanation of dataflow files from CWE FB DA CC**

| Dataflow file | Source description |
|---|---|
| **F104** | CNEC definition file (input to CWE flow-based capacity calculation) |
| **F109** | D2CF grid models in UCTE (input to CWE FB DA CC) |
| **F204** | Flow-based domain before LTA inclusion (output of CWE FB DA CC) |
| **F206** | Final flow-based domain (output of CWE FB DA CC) |

[18] http://utilitytool.jao.eu/Util

[19] Until BD 05-02-2021, this was reported in the JAO utility tool under the name of MACZTtarget. This was adjusted to bring it in line with the terminology used in other places, including this monitoring report.

For the market impact assessment as performed in chapter 6, also data had to be gathered for active constraints and shadow prices. This data was gathered from the so-called 'NRA reports' which are submitted on monthly basis by the CWE TSOs to the CWE NRAs.

### 11.1.2 Missing data / time stamps

For the CWE CCA, in 2021 the TSO Common System failed to produce full results for in total 62 MTUs (0.7% of all MTUs in 2021). This was caused because during those MTUs in operation, either:

- Default flow-based parameters have been applied when data for a full Business Day or several MTUs could not be calculated; or
- 'Spanning' was applied to interpolate flow-based results when data for some MTUs was missing

In both cases, not all data from the TSO Common System that is necessary as input for the local tooling was available. And as result, not all the necessary data from the local tooling to assess compliance could be determined. Therefore, these MTUs were excluded from the assessment performed in this report. The MTUs for which the local tooling failed and the cause why, are given in Table 7.

**Table 7: Business days excluded from the NL MACZT assessment**

| MTU (UTC) | Reason |
|---|---|
| 6-2-2021 14:00 | Spanning |
| 28-2-2021 16:00 | Spanning |
| 11-3-2021 whole day | Default Flow-Based Parameters |
| 13-3-2021 09:00 | Default Flow-Based Parameters |
| 13-3-2021 10:00 | Default Flow-Based Parameters |
| 13-3-2021 11:00 | Default Flow-Based Parameters |
| 13-3-2021 12:00 | Default Flow-Based Parameters |
| 13-3-2021 13:00 | Default Flow-Based Parameters |
| 27-3-2021 11:00 | spanning |
| 4-4-2021 07:00 | spanning |
| 6-4-2021 19:00 | Spanning |
| 6-5-2021 07:00 | Spanning |
| 28-5-2021 08:00 | Spanning |
| 28-5-2021 09:00 | Spanning |
| 25-8-2021 10:00 | Spanning |
| 10-11-2021 whole day | Default Flow-Based Parameters |

### 11.1.3 Data corrections for erroneous MNCC values

As explained in annex 6, an issue occurred in the calculation of MNCC values and consequently the calculation of the $MCCC_{min}$ value via formula (4). This means that for this assessment report, several parameters had to be recalculated and not all the data as published via the JAO utility tool[18] could be used directly as basis for this monitoring report.

The updated local tooling from 02/10/2021 was used to recalculate several parameters, while using the same historical input data as was used in production. The following parameters were recalculated for each CNEC in the period Q1-Q3 2021: MNCC, loop flows and $MCCC_{min}$. This data was combined with data from production to determine the MACZT and $MACZT_{margin}$ which have been offered by TenneT. This recalculated data has been used in this report to assess whether the minimum levels of capacity margins that TenneT needs to make available for cross-zonal trade in 2021 have been met.

### 11.1.4 Other Data corrections

In order to on time have the 2022 $MACZT_{target}$ values from the linear trajectory of the action plan in operation, the $MACZT_{target}$ values were already adjusted to the 2022 values per Business Day 16/12/2022.[20] For the assessment in this report, the data as published for CWE FB CC has been adapted to take into account the applicable 2021 $MACZT_{target}$ values.

### 11.1.5 Processing of CNECs with LTA Inclusion

In this assessment, for assessing the compliance of TenneT for the CWE CCA the dataset of CWE FB DA CC after the application of LTA inclusion has been taken.

LTA corners and minRAM exclusion CNECs are considered special cases, and have a different naming in the publication on JAO. For this assessment, their names have been converted to “normal” CNECs, in order to be able to map them to these CNECs for the assessments as performed in chapter 5. All other data for these ‘special’ CNECs are handled in the same way as data for “normal” CNECs.

### 11.1.6 Update of MACZT report between March 2022 and July 2022

Following the publication of ACER’s MACZT report for 2022[21], TenneT compared the numbers as reported by ACER for NL with the numbers as reported by TenneT in this report. In principle, apart from potential methodological differences such as explained at the end of section 5.1.2, the reported numbers should be the same as the same underlying dataset is used. However, TenneT observed small differences in the numbers reported for all figures including third countries. After some investigation, TenneT concluded that somewhere during the processing of the numbers, an error was introduced when data of capacity in MW was transferred to values in percentages relative to Fmax. Following this conclusion, TenneT decided to recalculate the percentages and verified this update against the numbers as reported by ACER, after which they were consistent. Then a correction was made of all impacted figures and numbers in this report, and a new version of the report was submitted to ACM.

Although the correction increased the percentage of time that TenneT has provided capacity margins at or above the required minimum levels on all its network elements from 45 to 50%, the overall conclusions and observations from the report were not impacted by this correction.

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[20] https://www.jao.eu/news/implementation-linear-trajectory-cep-action-plan

[21] https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER%20MACZT%20Report%202021.pdf

## 11.2 HVDC bidding zone borders

Table 8 provides an overview what data is used to assess the compliance of the HVDC bidding zone borders NL-DK1 and NL-NO2:

**Table 8: Source data used for assessing compliance of the HVDC bidding zone borders**

| Data | Source description |
|---|---|
| **Hourly NTC values** | Export of historical NTC data for the bidding zone borders from the PCR Simulation Facility Tool. This data is also available as 'Implicit Allocations – Day-Ahead' on the ENTSO-E Transparency Platform[22] |
| **Cause for reductions** | In order to determine what was the cause for reductions, information was gathered from internal systems as well as information published in operational messages which party triggered a reduction and for what cause. |
| **Hourly Fmax** | This parameter was manually determined, based on the hourly NTC values and explanations published for reductions via TenneT Operational Messages[23] and unavailability published on ENTSO-E Transparency Platform[24]<br><br>The following principle was followed for reconstructing the Fmax:<br>• Fmax was set at 0, if NTC was 0, as reductions of NTC capacity to 0 MW typically only takes place in case the HVDC link and/or their convertor stations are in outage.<br>• For other time stamps with NTC >0, the Fmax was set at the maximum technical capacity of the HVDC interconnectors (i.e. 700 MW for the COBRAcable and 700 MW for NorNed), unless there was a specific technical reason why only part of the physical capacity was available on the HVDC interconnector. |

22 https://transparency.entsoe.eu/transmission-domain/r2/implicitAllocationsDayAhead/show
23 https://www.tennet.org/english/operational_management/Operationalreports.aspx
24 https://transparency.entsoe.eu/outage-domain/r2/unavailabilityInTransmissionGrid/show

# 12. Annex 5: Calculation of MNCC and loop flows

## 12.1 MNCC

As part of the calculation of $MCCC_{min}^{CNEC}$, also $MNCC^{CNEC}$needs to be calculated.

Article 4(5) of the applicable derogation stipulates that TenneT calculates the MNCC for CWE FB DA CC following the method as defined in Article 17(4) of the Core DA CCM. Article 17(4) of the Core DA CCM prescribes that the flow assumed to result from commercial exchanges outside the Core CCR is calculated for each CNEC by formula:

$$(6)\ \vec{F}_{uaf} = \vec{F}_{0,Core} - \vec{F}_{0,all}$$

Where

| | |
|---|---|
| $\vec{F}_{uaf}$ | flow per CNEC assumed to result from commercial exchanges outside Core CCR |
| $\vec{F}_{0,Core}$ | flow per CNEC in the situation without commercial exchanges within the Core CCR |
| $\vec{F}_{0,all}$ | flow per CNEC in a situation without any commercial exchange between bidding zones within Continental Europe and between bidding zones within Continental Europe and bidding zones of other synchronous areas |

Within the context of this report and the application of this concept for the CWE CCA:

- $\vec{F}_{uaf}$ is equal to $MNCC^{CNEC}$
- The applicable capacity calculation area is CWE, and not Core.

Therefore, in the local tooling for CWE FB CC, formula (6) is adjusted as follows to determine MNCC:

$$(7)\qquad MNCC^{CNEC} = \vec{F}_{0,CWE} - \vec{F}_{0,all}$$

For the calculation of $\vec{F}_{0,CWE}$, CWE Net Positions are determined by summing all exchanges on CWE borders in the RefProg (programme of expected exchanges per border on D-2). The CWE bidding zones are then shifted by these CWE Net Positions in the opposite direction (e.g. if Germany has a CWE net position of +8000 MW it is shifted by -8000 MW), according to their GSKs as submitted for use in the operational CWE FB DA CC process.

For the calculation of $\vec{F}_{0,all}$, Net Positions of all bidding zones in Continental Europe are taken from the CWE 'refprog' file which contains data of expected scheduled exchanges and net positions.[25] Zones are then shifted by these Net Positions in the opposite direction:

- CWE bidding zones according to their GSKs as submitted for use in the operational CWE FB DA CC process;
- non-CWE zones according to a "country GSK" (where each generator participates proportionally to its share in the country's swing capacity, according to the original dispatch values in the D2CF model).

## 12.2 Loop Flows

The loop flow $LF_{calc}^{CNEC}$ on each CNEC included in CWE FB DA CC is calculated by applying the Full Line Decomposition (FLD) methodology[26] on the $\vec{F}_{0,CWE}$ network model. The FLD methodology applies the following calculation steps:

- The $\vec{F}_{0,CWE}$ load flow serves as input.
- A nodal power exchange matrix for the full network is determined based on flow-tracing.
- Node-to-node PTDFs are calculated for all CNECs.
- The nodal power exchange matrix multiplied with the node-to-node PTDFs provides the flow over each CNEC as result of each nodal exchange.
- The nodal exchanges within the same zone, but different than the zone where the CNEC is located, result in loop flow over the considered CNEC.
- Aggregating the nodal results define the total loop flow over each CNEC.
- For each CNEC, $LF_{calc}^{CNEC}$ is equal to the loop flow computed following the above, divided by the Fmax of that CNEC.

NB: the FLD methodology is developed to calculate all ENTSO-E flow types (internal flows, loop flows, import/export flows and transit flows) as well as flows caused by PSTs (PST cycle flow) and HVDC connections (HVDC cycle flow), but in this particular application of FLD only loop flow is of relevance.

## 12.3 Specification of third countries

The following countries have been considered as third countries for the calculation of MACZT excluding third countries:

RU - BY - UA - MD - RS - BA - ME - KS - AL - TR - CH - MK - UK

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[25] In 2020, the net positions were calculated by TenneT individually by running a DC loadflow computation on the D-2 Congestion Forecast (D2CF) grid model. However, this led in 2021 to erroneous results for MNCC (see annex 6) and therefore in the course of 2021 the calculation approach was changed. The reason that TenneT did not yet apply this approach is because early 2020 when TenneT developed the local tooling, net positions of non-CWE countries were not yet available to TenneT in the CWE refprog file and therefore had to be calculated by TenneT individually.

[26] A detailed explanation of the FLD method is published in "CIGRE Science & Engineering, issue 9 (CSE 009)"

# 13. Annex 6: Issues with MNCC calculations during 2021

## 13.1 Explanation of the issue with MNCC values in Q1-Q3 2021 and what actions TenneT took to resolve the issue.

Triggered by ACER's initiative to gather data for S1 2021 for their MACZT report, TenneT started in July 2021 to gather the data required to monitor and assess the MACZT performance. During the assessment, it was concluded that the results for S1 2021 deteriorated compared to the results published in the 2020 MACZT assessment report. This was to TenneT's surprise, as TenneT had high trust that the methodological implementation via various formulas as put in place in 2020 should also guaranteed to meet the minimum levels of capacity margins that TenneT needs to make available for cross-zonal trade in 2021.

To determine what caused the MACZT values for 2021 to deteriorate, TenneT started an in-depth investigation what went wrong and what corrections were needed to apply to meet the minimum levels of capacity margins again. Figure 22 shows the high-level steps of this investigation and actions applied, which are detailed further below.

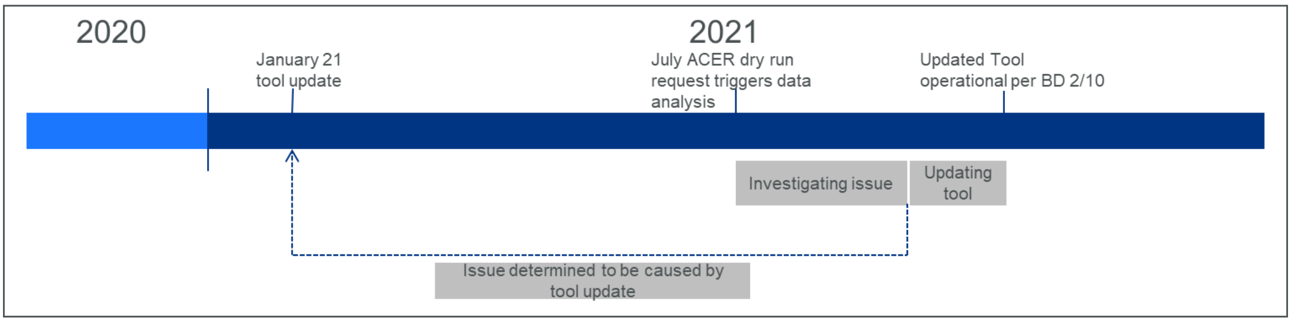


**Figure 22: Investigation and actions taken to correct faulty MNCC values in period Q1-Q3 2021**

In July to September 2021, TenneT performed the following actions:

- TenneT compared capacity calculation results and MACZT monitoring parameters for 2021 with 2020 on individual CNE level. In this analysis, TenneT observed that for some CNEs, extreme MNCC values of >-80% of Fmax were calculated in the local tooling which caused the MACZT values to deteriorate. In combination with a cap in CWE FB CC that MCCC values could not be higher than 100%, this led for several MTUs to negative $MACZT_{margins}$.
- A deep-dive into the MNCC results took place,
  - MNCC values of TenneT and Elia were compared for the NL-BE cross-zonal CNECs, and significant deviations were observed with TenneT calculating for some MTUs MNCC values of <-80% while Elia calculated MNCC values close to 0%
  - A flow decomposition analysis was performed, which provided MNCC values at a comparable level of Elia's values.
- Based on this, TenneT concluded that the local tooling used to calculate the required minRAM ($MCCC_{min}$) values for CWE FB DA CC was not functioning properly and calculated erroneous MNCC values. TenneT then adjusted the local tooling to resolve the issue and started to apply a different

calculation approach for calculating MNCC (see annex 5 and footnote [25]). This updated tooling went into operation per Business Day 02/10/2021.

Eventually, the errors in the MNCC values were traced back to a version of the local tooling which was taken in operation per Business Day 20/1/2021. This means that for the period of Business Day 20/1/201 until Business Day 01/10/2021 the minRAM ($MCCC_{min}$) values as applied on the basis of formula (4) have not been correct as erroneous MNCC values were taken into account in this formula.

## 13.2 Effect of the erroneous MNCC values

With the updated tooling and original source data, several parameters including MNCC, MACZT and $MACZT_{margin}$ have been recalculated for each CNEC in the period Q1-Q3 2021 (see subsection 11.1.3).

The recalculated MNCC values led to a significant adjustments of the levels of MACZT on the CNECs, and consequently their $MACZT_{margin}$:

- For some CNECs, where the $MACZT_{margin}$ was originally negative as result of very negative MNCC values, the $MACZT_{margin}$ is improving significantly due to higher MNCC values.
- However, on other CNECs there is a detrimental effect on the MACZT and $MACZT_{margin}$ levels, as the recalculated MNCC is lower than what was originally calculated. For some CNECs, originally positive $MACZT_{margin}$ values turn negative because of this.

This effect is illustrated in the example below.

Normally, in operations negative $MACZT_{margins}$ would be avoided by determining the appropriate $MCCC_{min}$ values, based on formula (4). However, in this case the MNCC has afterwards been recalculated and corrected to determine the $MACZT_{margins}$, while the $MCCC_{min}$ (and consequently the MCCC based on this $MCCC_{min}$) can't afterwards be adjusted as these are the final values provided as result from the CWE FB DA CC process. Therefore, the $MCCC_{min}$ values as used in production have either been higher or lower than what they should have been to ensure that the minimum levels of capacity margins are met with the corrected MNCC values. And in the end, thus the recalculation of MNCC has therefore led to CNECs not meeting their minimum capacity margins.

An elaboration on the effect of negative $MACZT_{margins}$ on market results, is given in chapter 6.

**Example of impact of recalculated MNCC values for MACZT levels** MTU: 23/1/2021, 16h-17h

- In production, the CNE MEE-DIL 380 Z sets the MACZT performance for this MTU as this CNE had the lowest $MACZT_{margin}$. Now when using the recalculated MNCC values, the MACZTmargin of this CNE increases from -14.3% to 119.1%, meaning that the minimum margins have been met, and the CNE is no longer the CNE with the lowest $MACZT_{margin}$
- However, based on the recalculated MNCC values, the MACZT margin on another CNE BSL-RLL 380 Z is decreased from 7.4% to -7.2% and now becomes the CNE which sets the MACZT performance for this MTU.
- So although using recalculated MNCC values improved the levels of MACZT and $MACZT_{margins}$ on some CNECs significantly, it also decreased the MACZT and $MACZT_{margins}$ on other CNECs.

| | $MACZT_{min}$ | MCCC | MNCC | MACZT | $MACZT_{margin}$ |
|---|---|---|---|---|---|
| **CNE: MEE-DIL 380 Z (direct)** | | | | | |
| **Values in production** | 28 | 100 | -86.3 | 13.7 | **-14.3** |
| **Recalculated MNCC values** | 28 | 100 | 47.1 | 147.1 | **119.1** |
| | | | | | |
| **CNE: BSL-RLL 380 Z (direct)** | | | | | |
| **Values in production** | 28 | 20 | 15.4 | 35.4 | **7.4** |
| **Recalculated MNCC values** | 28 | 20 | 0.8 | 20.8 | **-7.2** |