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Final report on the study on 70% target for electricity interconnection capacities to be made available to market participants

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Final report of the

Study on the 70% Target for Electricity Interconnection Capacities to be made available to Market Participants

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Content:

LIST OF ABBREVIATIONS

ACER	Agency for the Cooperation of Energy Regulators
AL	Albania
ATR	Auto transformer
BA, BiH	Bosnia and Herzegovina
BtB	Back-to-back
BZ	Bidding zone
BZB	Bidding zone border
CACM GL	Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management
CCM	Capacity calculation methodology
CCR	Capacity calculation regions
CEP	Clean Energy Package for all Europeans
CGES	Crnogorski elektroprenosni sistem a.d., Montenegrin Transmission System Operator
CHP	Combined heat and power
CMU	Cabinet of Ministers of Ukraine
CNE	Critical network element
CNEC	Critical network elements associated with a contingency
DTR	Dynamic thermal rating
Elektroprijenos BiH	Transmission Company in Bosnia and Herzegovina
EnC	Energy Community
ENTSO-E	European association for the cooperation of transmission system operators for electricity
ERE	Albanian Energy Regulatory Authority
EU	European Union
GSK	Generation shift key
HPP	Hydro Power Plant
HTLS	High temperature low sag
IGM	Individual Grid Model
IPS/UPS	The Integrated Power System (IPS) portion of the network includes the national networks of Kazakhstan, Kyrgyzstan, Belarus, Azerbaijan, Georgia, and Mongolia. The Russian portion of this interconnection is known as Unified Power System of Russia (UPS).

MACZT	Margin available for cross-zonal trade
MC	Ministerial Council
MCCC	Margin from coordinated capacity calculation
MD	Moldova
ME	Montenegro
MNCC	Margin from non-coordinated capacity calculation
MTU	Market time units
NEURC	National energy and utilities regulatory commission of Ukraine
NRA	National Regulatory Agency
NTC	Net Transfer Capacity
OHL	Overhead line
RAM	Remaining Available Margin
RES	Renewable energy sources
RS	Republic of Serbia
SEE	Southeast Europe
SS	Substation
SECI model	Southeast Europe Cooperation Initiative Transmission Network Development model
TYNDP	Ten-Year Network Development Plan
ToR	Terms of reference
TR	Transformer
TSO	Transmission system operator
TTC	Total Transfer Capability
UA	Ukraine
WB6	Western Balkan 6 countries (Albania, Bosnia and Herzegovina, Serbia, Kosovo*, North Macedonia, Montenegro)

EXECUTIVE SUMMARY

With the entry into force of the Clean Energy Package (hereinafter: CEP) in the EU, especially **Regulation (EU) 2019/943** of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity **(hereinafter: Regulation (EU) 2019/943)**, the European transmission system operators (hereinafter: TSOs) have been given a series of tasks to make available **maximum possible transmission infrastructure capacity** for the needs of uninterrupted transmission of electricity, which is a prerequisite for a truly unified electricity market in Europe.

The Regulation (EU) 2019/943 sets clear tasks and obligations to the TSOs to operate within the maximum extent of safety limits, all in order to facilitate the implementation of a fully integrated, interconnected and digitalized European electricity market by making available maximum possible level of **cross-zonal transmission capacities**. The TSOs across Europe are considering various measures to achieve one of the most important Regulation's requirements – cross-zonal capacity minimum 70% target (later in the text referred to as 70% target). In simple, 70% target is a regulatory requirement that all TSOs must make 70% of the capacity of transmission system infrastructure critical for electricity flows across bidding zones available for trade. The TSOs are also required to implement a harmonized approach in calculating transmission capacities. The legal framework, calculation methodology and implementation process to reach 70% target is a very complex and challenging task. The Agency for the Cooperation of Energy Regulators (hereinafter: ACER) defined and recommended the methodology for calculating this target and monitors the EU countries in fulfilling their obligations according to this methodology [10, 11].

The Energy Community (EnC) Ministerial Council incorporated the CEP in the EnC acquis, including the electricity market integration package by Decisions 2021/13/MC-EnC of 30 November 2021 and 2022/03/MC-EnC of 15 December 2022. With the former Decision, the EnC Ministerial Council adapted and adopted the Directive (EU) 2019/944 on common rules for the internal market for electricity (hereinafter: Directive (EU) 2019/944l and the Regulation (EU) 2019/941 on risk-preparedness in the electricity sector (hereinafter: Regulation (EU) 2019/941). The latter Decision of the EnC Ministerial Council updated these two acts adopted in 2021 and incorporated two more regulations: the Regulation (EU) 2019/943, Regulation (EU) 2019/942 establishing a European Union Agency for the Cooperation of Energy Regulators (hereinafter: Regulation (EU) 2019/942). In addition, by the same decision of 2022, the EnC Ministerial Council adapted and adopted the following Network Codes and Guidelines: Commission Regulation (EU) 2016/1719 establishing a guideline on forward capacity allocation (hereinafter: FCA GL), Commission Regulation (EU) 2015/1222 establishing a guideline on capacity allocation and congestion management (hereinafter: CACM GL), Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing (hereinafter: EB GL), Commission Regulation (EU) 2017/1485 establishing a guideline on electricity transmission system operation (hereinafter: SO GL) and the Commission Regulation (EU) 2017/2196 establishing a network code on electricity emergency and restoration (hereinafter: ERNC). In addition to Decision 2022/03/MC-EnC, the Ministerial Council adopted a Procedural Act 2022/01/MC-EnC on Regional Market Integration (hereinafter: Procedural Act 2022/01/MC-EnC). For the sake of clarity, when the acts of the Energy Community are being referred to throughout the study, they are preceded by EnC before the name of the act.

The main aim of this study is to provide the TSOs, National Regulatory Authorities (hereinafter: NRAs) and Ministries in charge of energy of the EnC with an **in-depth understanding of the legal and regulatory framework governing the implementation of the 70% target** and to offer **technically and economically optimal** ways to satisfy this requirement. Accordingly, this study has 7 main objectives:

1. Address forthcoming **obligations** by the EnC Contracting Parties pursuant to the Regulation (EU) 2019/943
2. Estimate the **existing situation** in each Western Balkan 6 (hereinafter: WB6) Contracting Parties related to the 70% target
3. Analyze and reflect on the 70% target in cases of perspective application of **flow-based** (hereinafter: FB) **capacity calculation approach and allocation through market coupling and** demonstrate the effect of applying the **FB calculation**
4. Estimate the **future situation** in each Contracting Party (except Georgia) related to the 70% target
5. Identify **structural congestions** within the power transmission networks of the WB6 Contracting Parties[1]
6. Organize two workshops about the 70% analysis for the EnC Contracting Parties, demonstrating the calculations and presenting the study results
7. Suggest, based on the calculations, **activities and measures** in the EnC Contracting Parties (except Georgia) as a basis for possible action plans to fulfil the 70% target by 31 December 2027, as defined by Article 15 of the EnC Regulation (EU) 2019/943.

The study consists of 15 chapters written on 207 pages with 87 figures and 87 tables, which is quite comprehensive material, but it was inevitable since it covers large geographical area of 8 power systems. In the introductory Chapter 1 project background and study purpose and objectives are discussed. Chapter 2 covers the legal framework relevant for this topic. In Chapter 3 relevant experience of EU organizations and Member States with 70% target fulfillment is given. Input data overview with special emphasis on the treatment of Ukrainian and Moldovan systems are described in Chapter 4. In Chapter 5 transmission network general characteristics for all eight analyzed power systems are listed. In Chapter 6 calculation methodology is explained in detail and presented on the calculation example. In Chapter 7, 70% target fulfillment in the existing network is calculated using relevant methodology on two characteristic power system regimes – third Wednesday in January 2021 and third Wednesday in July 2021, both at 19:30 h. Two calculation methodology approaches have been used here: Net Transfer Capacity (hereinafter: NTC) approach and flow-based (FB) approach. **FB approach is usually more efficient in heavily meshed networks and set as default in CACM GL, which will be discussed later.**

In Chapter 8, the exercise is performed for the same but predicted two characteristic snapshots in future time horizon of 2028: third Wednesday in January 2028 and third Wednesday in July 2028, both at 19:30 h. In Chapter 9 structural congestions in WB6 Contracting Parties are identified, while

[1] ToR defined that "… and estimate the possible existence of structural congestions within the power transmission networks of Ukraine and Moldova". However, this was not possible by using the same methodology for all Contracting Parties, since structural congestions were identified based on 2020, 2021 and 2022. These two countries were not operating synchronously with ENTSO-E until March 16th 2022).

in Chapter 10 proposal of activities and measures in Contracting Parties to fulfill 70% target is elaborated.

Chapter 11 recaps all study conclusions. These nine chapters are followed by a literature list and then by an appendix with TSO questionnaire responses. In addition to this textual study, detailed numerical background and results are available on the following link.

The most important study calculation results are given as follows:

1. **70% target fulfillment in the existing network**: the current **level of fulfillment of 70% target in WB6 is very low in the two selected snapshots**. On 20 January 2021 at 19:30 h with the NTC approach between 0% (North Macedonia) and 26% (Montenegro) of all considered elements fulfilled this requirement. On the regional level (all WB6 countries) only 11 out of 176 (around 6%) of considered elements fulfilled 70% target.

   Similar results are found on the other analyzed scenario on 21 July 2021 at 19:30 h. With the NTC approach between 3% (Bosnia and Herzegovina) and 22% (Montenegro) of all considered elements fulfilled 70% requirement. On the regional level only 14 out of 176 (around 8%) of the considered elements fulfilled 70% target. This clearly indicates that in given scenarios adequate steps and measures have to be taken as soon as possible to increase current values and to reach 70% target.

2. **Comparison between NTC and FB approach on the existing network**: with FB approach in the existing network the calculation results would be much better. On 20 January 2021 at 19:30 h with NTC approach the range of 70% target fulfillment was around 6% of all considered elements in the region, while with FB approach it would be around 26%.

   Similar results are obtained on 21 July 2021 at 19:30 h: with NTC approach only around 8% of all considered elements fulfilled 70% target, while with FB approach it would be around 53% of all considered elements in WB6.

3. **70% target fulfillment in the future network:** 70% target fulfillment in the future is analyzed for the same characteristic snapshots, using only FB approach, as agreed in the Inception Report. On 19 January 2028 at 19:30 h between ~23% (Kosovo*) and ~43% (Serbia) of all considered elements fulfills 70% target. On the WB6 regional level 67 out of 181 (around 36%) of considered elements fulfills 70% target, which is around 10% better result than in 2021. Better results in 2028 were expected due to planned network reinforcements, that were not enough to fully reach 70% target. If the results for Ukraine and Moldova are added, the result would be around 38%.

   On 19 July 2028 at 19:30 h in WB6 between ~53% (Albania) and ~96% (North Macedonia) of all considered elements fulfill 70% target. On the WB6 regional level, 117 out of 174 (around 67%) of considered elements fulfills 70% target, which is relatively good result and around 14% better result than in 2021. If the results for Ukraine and Moldova are added, it would be ~56% on the EnC level.

4. **Structural congestions**: In this study elements with more than 5% of hours in a year with the Margin available for cross-zonal trade (hereinafter: MACZT) value below 70% are considered as

elements with structural congestion[2]. Calculations are performed for three-year time frame 2020-2022 on hourly timeframe. In WB6 Contracting Parties in total **there are 78 identified structural congestions.** Most of them (57 or 73%) are detected on 400 kV voltage level, while the remaining 21 (27%) are in 220 kV network. Around half of all structural congestions (40 out of 78) are detected on cross-border lines. So, it can be concluded that around **half of the structural congestions in the WB6 are identified on the internal networks, while the remaining half on the interconnections**. These results are consequence of the definition of structural congestions used in this study as well as quite low bilateral NTC input data values, currently used in practice.

To recap, the calculations are done for four selected characteristic snapshots, two in 2021 and two in 2028, as well as for 3-year timeframe (2020, 2021 and 2022) on hourly basis, covering around 26.280 snapshots for every single considered element. In total, the analysis is based on around 180 considered elements for 26280 hours, which resulted with more than 4,6 million numerical results. The results are available both in table and graphic format for every single critical network element, per each Contracting Party and per each timeframe. This is a very comprehensive set of calculation results that was carefully selected and interpreted in the study to preserve study readability.

The Contracting Parties have three options to ensure compliance with the 70% target:

1. **To prove that 70% target is fully satisfied** (or more precisely to provide enough capacity and the monitoring ex-post has to be proofing) – even though the **NRAs are in charge to verify it** this is probably **not an option,** since the calculations of selected scenarios have shown that level of fulfillment of 70% target in Contracting Parties is very low (it should be stressed that 70% must be satisfied for each hour in a year, while this study is based on two snapshots per year only as defined in Terms of reference, hereinafter: ToR). If they cannot fulfill 70% target, they have the following two options.

2. **To request the derogation for a short timeframe** – TSOs may request from the NRA to grant a derogation from the 70% target fulfillment, but it can be granted for no more than one-year at a time, or, provided that the extent of the derogation decreases significantly after the first year, up to a maximum of two years. Study authors **strongly recommend not to use derogations repetitively**, but, if needed, to use it just to adequately prepare, calculate and find solutions to reach the 70% target. In any case, derogations are not solution for structural congestions.

3. **To prepare and adopt Action Plan for structural congestions** - the most common option used around EU to reach 70% target is preparation of the Action Plan[3]. Action Plan needs to be prepared pursuant to Article 15 of the EnC Regulation (EU) 2019/943, which is discussed in detail in Chapter 10.

Additional theoretical option to ensure compliance with the 70% target is the bidding zone review. However, this option is not likely to be realistic in the short to mid-time frame, as explained later in the study.

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[2] There is no unified definition of structural congestions throughout the EU, and more clarity is expected to come from a study commissioned by ACER by the end of 2023.
[3] ACER: Action plans: Overview and main characteristics, 16 June 2023

Finally, based on the above-mentioned calculations, in Chapter 10 proposal of activities and measures in the EnC Contracting Parties is given to fulfil the 70% target by 2028. **Even though only the NRAs can confirm if 70% target is fulfilled, this study shows scenarios in which this is not the case in EnC Contracting Parties.** Therefore, after NRA verifications, probably two other options will remain: derogation or Action Plan. It is important to note that Action Plans are not needed for derogation decisions. These are two different types of processes/actions. In case of structural congestions (and the respective report approved in a Contracting Party), the Contracting Parties need to define Action Plans pursuant to Article 15 of the EnC Regulation (EU) 2019/943. On the other side, derogations are based on Article 16(9) of the EnC Regulation (EU) 2019/943 and should only deal with problems not related to structural congestions. In practice, it is possible to have derogation in parallel with the Action Plan. Derogations shall be granted for no more than one-year at a time, or, provided that the extent of the derogation decreases significantly after the first year, up **to a maximum of two years**. But, with repetitive derogations the problem of inefficient usage of transmission capacities will not be resolved, especially not till 31 December 2027 deadline. A long derogation period would result with even more challenging system conditions due to new network users, deviation from the activities and measures in the neighbouring systems, pressure from market participants to increase network capacities etc. Therefore, it is **strongly recommended not to use derogations repetitively**. If derogations are nonetheless considered, they should be used in one-year timeframe just to adequately prepare, calculate and find solutions to reach the 70% target and to prepare an Action Plan. In Chapter 10, the **general structure of an Action Plan is proposed**, along with main activities suggested and valid for all Contracting Parties:

1. Operationalization of the capacity calculation regions (hereinafter: CCR) Shadow SEE and EE[4] in given deadlines should be a priority and would increase existing MACZT values;
2. Adoption of coordinated capacity calculation methodology, going from existing bilateral NTC to coordinated NTC, but even more to FB approach would make capacity available. ECS's "Interconnectivity study" [26] shows that these systems are very well interconnected, so changing the approach of calculating will improve situation with structural congestions;
3. More efficient usage of existing and construction of new overhead lines (OHLs), if needed and beneficially to increase cross-zonal capacities to 70%, enables each TSO to get closer to 70% target. However, half of congestions under given conditions are found in internal network. It indicates that there is no need to build many new interconnectors if the calculation methodology is improved;
4. Reinforcement (nominal capacity increase with conductor cross-section upgrade, HTLS technology etc.) of the existing 220 kV network in the WB6 countries should also be carefully considered;
5. TSO should consider other relevant existing and new technologies (smart metering systems, dynamic thermal rating etc.),
6. Remedial actions (redispatching, demand side response, topology changes, energy storages, active power flow control etc.) should also be considered to improve system security.

[4] EnC CCRs are already established by Decision 2022/03/MC-EnC, incorporating CACM GL.

The proposed actions are not listed on the basis of priority and whether one or another action will be taken depends on the specificities of each Contracting Party.

With all above-mentioned aspects the main aim of the study is achieved: to provide TSOs, NRAs and Ministries in charge of energy in the EnC with an **in-depth understanding of the legal and regulatory framework governing the implementation of the 70% target** and to offer **technically and economically optimal** ways to satisfy 70% requirement.

As a follow-up to this study it is suggested to perform improved calculation of structural congestions and additional studies on optimal network configuration in the region using adequate measures to maximize MACZT values on bidding zone borders since this exercise was more on the educational purpose, based on just two analyzed snapshots for 2021 and 2028 and the calculation is based on existing bilateral NTC approach.

1 INTRODUCTION

1.1 Project background

The **Clean Energy Package for all Europeans** (hereinafter: CEP) should ensure that by 2050 almost half of the households in the European Union (hereinafter: EU) produce electricity from renewable energy sources (hereinafter: RES) in a fully decarbonized environment. To implement the CEP in all EU Member States, a number of regulations, directives, guidelines, opinions and recommendations have been adopted, which should facilitate the path to the set goal and an energy neutral continent. This package includes changes in all segments of the EU functioning (Figure 1), and the Energy Union and climate policy are at its center. The development of the energy transition will largely depend on the speed of implementation of reforms, the extent to which citizens will be active participants in the transition, public acceptance of certain technologies with low emissions and no carbon emissions, and on the deadline for their application to reach sufficient proportions. This justifies the establishment of a series of appropriate policies and an incentive framework that stimulates this change. This framework, which is based on the progress achieved so far in the establishment of the Energy Union, should consider all the major trends shaping the future of the EU economy and society, such as climate change and the environment, digitalization, aging and resource efficiency.

With the entry into force of the CEP, especially the **Regulation (EU) 2019/943** of the European Parliament and of the Council on the internal market for electricity (hereinafter: Regulation (EU) 2019/943) [1], the European transmission system operators (hereinafter: TSOs) have been given a series of tasks to make available **maximum possible transmission infrastructure capacity** for the needs of uninterrupted transmission of electricity, which is a prerequisite for a truly unified electricity market in Europe.

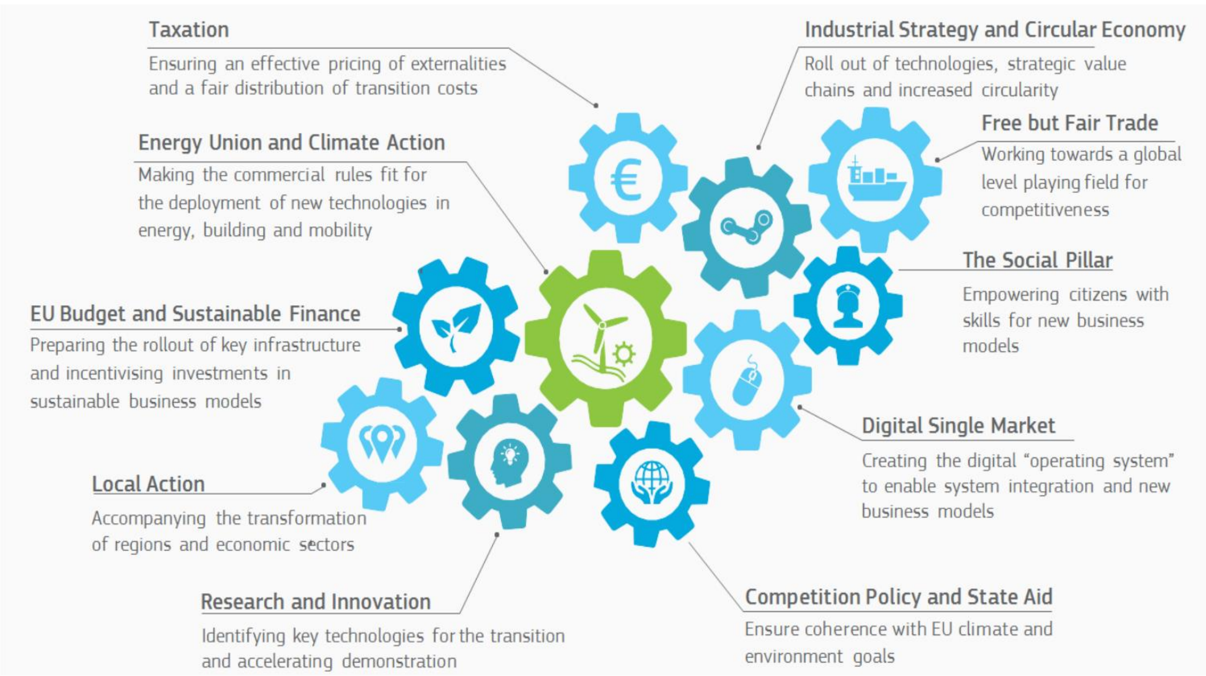


Figure 1 Energy Union and Climate Action surrounding in EU (source: CEP)

The TSOs are obliged operate within the maximum extent of safety limits, all in order to facilitate the implementation of a fully integrated, interconnected, and digitalized European electricity market by making available maximum possible level of **cross-zonal transmission capacities**. The TSOs can take different measures to meet the requirements of the Regulation (EU) 2019/943.

The TSOs across Europe have been implementing different measures to achieve one of the most important requirements of the Regulation (EU) 2019/943 – cross-zonal capacity minimum 70% target. Namely, the CEP foresees that a minimum of 70% of the maximum cross-zonal transmission capacity shall be available for cross-zonal trading. This requirement therefore guarantees sufficient cross-zonal trade capacity to optimize the European transmission grid, while respecting operational security limits. The TSOs can meet the minimum 70% target by efficiently managing or removing their network congestions.

Some of the measures that the TSOs could take include are the application of different:

- Remedial actions (non-costly and costly)
- Network reconfiguration
- Redefinition of the bidding-zones[5]
- Cost efficient network development and investments
- Improved coordination in the calculation of cross-zonal capacities in different timeframes
- Introduction of various systems for dynamic monitoring of transmission network elements loading or the implementation of program support for better calculations of cross-border transmission capacities.

The TSOs furthermore have to increase coordination by applying adequate common capacity calculation methods. They are required to select and implement adequate method of calculating transmission capacities. The options are: non-coordinated (bilateral[6]) Net Transfer Capacity (hereinafter: NTC) **method,** coordinated **NTC method** and coordinated multilateral capacity calculation method **(cNTC),** applied within a region and **based on flow-based** (hereinafter: FB) **approach**. The Regulation (EU) 2015/1222 establishing a guideline on capacity allocation and congestion management applies and asks for FB approach as default and cNTC (not bilateral NTC), if justified and approved by the National Regulatory Authority (hereinafter: NRA).

During 2022, the European Commission conducted a study on "*Extension of the EU energy and climate modelling capacity to include the Energy Community and its nine Contracting Parties*". Its results were the basis for an intensive interaction with Contracting Parties at political level to agree on energy and climate headline targets for the post-2020 period.

With the adoption of the Decisions 2021/13/MC-EnC of 30 November 2021 and 2022/03/MC-EnC of 15 December 2022 by the EnC Ministerial Council, the Contracting Parties and the energy market stakeholders including the TSOs are obliged to comply with the requirements of the incorporated acts. This includes also an obligation to comply with the minimum 70% target.

[5] A bidding zone is the largest geographical area within which market participants are able to exchange energy without capacity allocation.
[6] Actually, in current practice it is unilateral rather than bilateral, since lower between two unilateral NTC values is used
*this designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICI Opinion on the Kosovo declaration of independence

1.2 Study purpose and objectives

This “*Study on the 70% Target for Electricity Interconnection Capacities to be made available to Market Participants*” covers all EnC Contracting Parties except Georgia, with different levels of detail. WB6 countries (Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia, and Serbia) are analyzed in detail, including their current compliance with the 70% target, because they were in the past operating synchronously with the Continental Europe. Ukraine and Moldova are analyzed in lower level of details since they started synchronous operation with Continental Europe in March 2022. There is not enough historical data on common operation to be analyzed and to be relevant for the 70% target compliance evaluation in these two countries. In other words, there are no Ukraine and Moldova in the grid model for 2021 and winter 2022. Because of that, as given in the ToR, the 70% target analysis for Ukraine and Moldova is simplified and focused on the future time frame (2028). Relevant and available data for the neighboring grids/markets are considered to the extent needed to obtain the most accurate modelling results possible.

The objective of the study is to provide the TSOs, NRAs and Ministries in charge of energy in the Contracting Parties with an **in-depth understanding of the legal and regulatory framework governing the implementation of the 70% target** and to offer **technically and economically optimal** ways to satisfy this requirement in the EnC Contracting Parties, including calculation of 70% target fulfilment, the monitoring process, identification of structural congestions in their power transmission networks and preparation of possible action plans needed to address the identified congestions by the 31 December 2027.

This project consisted of 12 project tasks:

- 5 online meetings
- 1 task dedicated to all relevant regulation analysis, including experience in selected EU countries with the 70% target compliance and its monitoring as well as structural congestion reports, the application of Action Plans or derogations
- workshops about 70% target regulation, methodology and calculation results
- 1 TSO input data questionnaire
- tasks on the modelling and analyses and
- document deliveries (Inception, Draft final and Final reports).

The most challenging parts of the project were related to the: 1) input data collection and 2) modelling and analyses:

1) Adequate grid models of the whole European power system for required two sample regimes have been used: 3rd Wednesday 19:30 in January and in July 2021. The models include the main characteristics of the power system (generation, loads and grid topology) in a consistent way. In this study, two characteristic snapshots are selected. The grid models for 2021 do not include Ukraine and Moldova, since these two countries were not in synchronous operation with the rest of Europe till March 2022. Grid models for 2028 have Ukraine and Moldova included.
2) Modelling and analyses tasks were divided in four steps as follows:
    1) **Modelling, calculation, and analysis of the existing situation – it consisted of the:**

- Input data verification/approval
- Calculation of MACZT as defined in ACER Recommendation [11] (given in detail in Chapter 6) for the NTC-based approach for the given two 2021 market time units (MTUs)
- Analysis and presentation of the calculation results

2) **Identification of structural congestions** – this activity was realized as follows:
   - Calculation of MACZT for full year timeframe based on the data available on ENTSO-E Transparency Platform [2]
   - Usage of power transfer distribution factors (PTDF) that was calculated based on the selected grid models
   - Existing NTC values and exchanges were taken from the ENTSO-E Transparency Platform [2] and TSO questionnaire and used for the purpose of extrapolation of 8760 timestamps that simulated the grid condition during a whole year
   - MACZT 10% intervals histogram were prepared
   - Potential list of structural congestions consists of the critical network elements associated with congestions (CNE(C)s) under clearly defined criterion used as best EU practice: more than 5% of the time with MACZT values were below 70%
3) **NTC and FB calculation comparison for existing situation** - this activity consisted of the:
   - Calculation of MACZT for the FB approach
   - Analysis/comparison of the results obtained with NTC and FB approaches
4) **Modelling, calculation, and analysis of the situation in 2028** - this activity consisted of the following:
   - Similar to the existing system analysis, two grid models for characteristic sample regimes were prepared for 2028 based on the grid models for the referent year and updated with the individual EnC Contracting Parties network development plans and ENTSO-e Ten-Year Development Plan (hereinafter: TYNDPs) and available grid models
   - Several iterations of the MACZT calculations for 2028 were performed, including proposed activities, grid reinforcements and measures to fulfil the 70% target.

In addition to the calculation part of the assignment, **two workshops were organized** for all relevant stakeholders to:

- Explain 70% target details, how it is defined and observed, how to calculate the average usage of the interconnectors based on ACER's recommendation and what is the current status of its implementation – held on 17 May 2023
- Present all study results including proposal of the future actions to fulfil 70% target – held on 26 September 2023.

2 RELEVANT LEGAL FRAMEWORK

2.1 Regulation (EU) 2019/943 as adapted and adopted in the EnC

Since 2015 a series of regulations have been proposed, discussed, and adopted with the intention to integrate the European electricity system and market. The Commission Regulation (EU) 2015/1222 establishing a guideline on capacity allocation and congestion management comprehensively regulates the process of coordinated capacity calculation and allocation on cross-zonal lines, and it deals with strengthening of the Energy Union. The minimum capacity that should be used for the coordinated capacity calculation should be the percentage of capacity of the critical network element, as defined after the selection process in accordance with the CACM GL, respecting unforeseen events and technical limits.

In order to integrate the operation of transmission power systems, sets of EU Regulations were adopted which regulate:

1) Grid connection issues
2) System operation procedures and
3) Electricity market functioning.

Traditional **deterministic** understanding of transmission power network operation and safety has been continuously upgraded. **Stochastic** methods of system operation analysis and system forecasting are now also applied. For this reason, some provisions of the EU Regulations are written in a way that more and more cross-zonal transmission capacities are allocated. The proposed calculation methods put on each TSO and each Member State the challenge of taking various measures to meet the requirements of the Regulation (EU) 2019/943, commonly called the "70% target". In the following chapters, this criterion, its consequences, and the way to reach them are discussed. **The implementation of Article 16(8) 8 of the Regulation (EU) 2019/943 is the main subject of this study.**

In The Energy Community (EnC) Ministerial Council incorporated the CEP in the EnC acquis, including the electricity market integration package by Decisions 2021/13/MC-EnC of 30 November 2021 and 2022/03/MC-EnC of 15 December 2022. With the former Decision, the EnC Ministerial Council adapted and adopted the Directive (EU) 2019/944 on common rules for the internal market for electricity (hereinafter: Directive (EU) 2019/944 and the Regulation (EU) 2019/941 on risk-preparedness in the electricity sector (hereinafter: Regulation (EU) 2019/941). The latter Decision of the EnC Ministerial Council updated these two acts adopted in 2021 and incorporated two more regulations: the Regulation (EU) 2019/943, Regulation (EU) 2019/942 establishing a European Union Agency for the Cooperation of Energy Regulators (hereinafter: Regulation (EU) 2019/942). In addition, by the same decision of 2022, the EnC Ministerial Council adapted and adopted the following Network Codes and Guidelines: Commission Regulation (EU) 2016/1719 establishing a guideline on forward capacity allocation (hereinafter: FCA GL), Commission Regulation (EU) 2015/1222 establishing a guideline on capacity allocation and congestion management (hereinafter: CACM GL), Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing (hereinafter: EB GL), Commission Regulation (EU) 2017/1485 establishing a guideline on electricity transmission system operation (hereinafter: SO GL) and the Commission Regulation (EU) 2017/2196 establishing a network code on electricity emergency and restoration (hereinafter: ERNC). In addition to Decision 2022/03/MC-EnC, the Ministerial Council adopted a Procedural Act 2022/01/MC-EnC on Regional Market Integration (hereinafter: Procedural Act 2022/01/MC-EnC).

For the sake of clarity, when the acts of the Energy Community are being referred to throughout the study, they are preceded by EnC before the name of the act.

The Ministerial Council Decisions of 2021 and 2022 adapted and adopted the acquis to the specifics of the Energy Community institutional framework and the specificities of the Contracting Parties. Article 5 of the Decision [3] defines specific adaptation of the Regulation (EU) 2019/943. Special attention is given to Articles 14, 15 and 16 which are discussed in subchapter 2.2. The 2022 Decision defined provisions which lead to integration of the electricity markets within the EnC and it is a legal basis for ensuring compliance with the 70% target by the EnC Contracting Parties.

The general principles of capacity allocation and congestion management are given in Article 16(1) of the EnC Regulation (EU) 2019/943. This article 1 defines that the *network congestion problems (between the Parties to the Energy Community) shall be addressed with* ***non-discriminatory market-based solutions*** *that give efficient economic signals to the market participants and transmission system operators involved*. *Network congestion* ***problems shall be solved by means of non-transaction-based methods****, namely methods that do not involve a selection between the contracts of individual market participants*. *When taking operational measures to ensure that its transmission system remains in the normal state, the transmission system operator shall take into account the effect of those measures on neighbouring control areas and coordinate such measures with other affected transmission system operators as provided for in the EnC Regulation (EU) 2015/1222.*

Regional coordination centres (hereinafter: RCC) established by the Regulation (EU) 2019/943 shall carry out **coordinated capacity calculation** and their role is defined in detail. They shall *calculate cross-zonal capacities respecting operational security limits using data from transmission system operators including data on the technical availability of remedial actions, not including load shedding*. *Every three months thereafter, the* ***regional coordination centres for EU Member States shall submit a report*** *to the relevant regulatory authorities and to ACER on any reduction of capacity or deviation from coordinated actions and shall assess the incidences and make recommendations, if necessary, on how to avoid such deviations in the future*. ***The RCCs for the EnC*** shall also submit same type of report pursuant to Article 16(3) of EnC the Regulation (EU) 2019/943, to the relevant NRAs, to the Energy Community Regulatory Board (hereinafter: ECRB) and, to the extent Member States are affected, to the ACER.

If the ACER, acting in accordance with Article 2 of the Procedural Act 2022101/MC-EnC, or the ECRB concludes that the prerequisites for a deviation pursuant to this paragraph are not fulfilled or are of a structural nature, the ACER, acting in accordance with Article 2 of the Procedural Act 2O22/01/MC-EnC, or the ECRB shall submit an opinion to the relevant NRAs, to the European Commission and to the Energy Community Secretariat (hereinafter: EnCS). Before issuing an opinion, the ECRB and the ACER shall consult each other. The competent regulatory authorities shall take appropriate action against TSOs or RCCs pursuant to Article 59 or 62 of EnC Directive (EU) 2019/944, if the prerequisites for a deviation pursuant to this paragraph were not fulfilled.

Article 16 (4) of the Regulation (EU) 2019/943 state that ***the maximum level of capacity*** *of the interconnections and the transmission networks affected by cross-border capacity (between Parties* *to the Energy Community)* ***shall be made available to market participants*** *complying with the safety standards of secure network operation. Counter trading and redispatch, including cross-border redispatch, shall be used to maximise available capacities* to reach the 70% target. Crucial paragraph 8 of Article 16 of the Regulation (EU) 2019/943 gives the exact numbers (percentage of capacity) that should be made available to market participants:

8. *Transmission system operators shall not limit the volume of interconnection capacity to be made available to market participants as a means of solving congestion inside their own bidding zone or as a means of managing flows resulting from transactions internal to bidding zones. Without prejudice to the application of the derogations under paragraphs 3 and 9 of this Article and to the application of Article 15(2), this paragraph shall be considered to be complied with where the following minimum levels of available capacity for cross-zonal trade are reached:*
   (a) For borders using a coordinated ***net transmission capacity approach****, the minimum capacity shall be* ***70%*** *of the transmission capacity respecting operational security limits after deduction of contingencies, as determined in accordance with the EnC CACM GL;*
   (b) *For borders using a* ***FB approach****, the minimum capacity shall be a margin set in the capacity calculation process as available for flows induced by cross-zonal exchange. The margin shall be* ***70%*** *of the capacity respecting operational security limits of internal and cross-zonal critical network elements, taking into account contingencies, as determined in accordance with the EnC CACM GL*.

   The total amount of 30% can be used for the reliability margins, loop flows and internal flows on each critical network element.

In order to ensure compliance with the 70% target, according to Article 14(7) of the Regulation (EU) 2019/943, the Contracting Parties have to perform either a bidding zone review or to adopt and action plan.

The bidding zone review process is defined in Article 14 of the EnC Regulation (EU) 2019/943. ***Bidding zone borders*** *shall be based on long-term, structural congestions in the transmission network. Bidding zones shall not contain such structural congestions unless they have no impact on neighboring bidding zones, or, as a temporary exemption, their impact on neighboring biding zone is mitigated through the use of remedial actions and those structural congestions do not lead to reductions of cross-zonal trading capacity in accordance with the requirements of Article 16*.

Every three years, the ENTSO-E shall report on structural congestions and other major physical congestions. When reporting on structural congestions and other major physical congestions between and within bidding zones, including the location and frequency of such congestions, in accordance with the EnC CACM GL, the ENTSO -E, acting in accordance with Article 3 of the Procedural Act 2022/01/MC EnC, shall extend this report to include the EnC Contracting Parties. To the extent the report covers bidding zones located outside the Continental Europe synchronous area, the Energy Community Secretariat shall coordinate the contributions by the transmission system operators concerned to the report. The EnC Contracting Parties shall deal with structural congestions by applying set of the measures proposed in chapter 10 of this study.

Bidding zones are essential for the pan-European electricity market. The main presumption is that there are no congestions within the bidding zone, so market participants are not required to allocate transmission capacity. *In order to ensure an optimal configuration of bidding zones, a bidding zone review shall be carried out for the EnC Contracting Parties for bidding zones in the same CCR established in accordance with Article 15 of the EnC CACM GL, at the latest six months following the first report by the ENTSO-E in accordance with paragraph 2, but not later than 31 December 2025. That review shall identify all structural congestions and shall include an analysis of different configurations of bidding zones in a coordinated manner with the involvement of affected stakeholders from all relevant Contracting Parties and Member States, in accordance with Articles 32 and 33 of the EnC CACM GL.*
For those EnC Contracting Parties that have opted to amend the bidding zone configuration pursuant to paragraph 7, the relevant EnC Contracting Parties in the same CCR established in accordance with Article 15 of the EnC CACM GL, shall reach a unanimous decision within six months of the notification.

Another action that the Contracting Parties could take to ensure compliance with the 70% target is the adoption of an action plan.

Article 15 of the EnC Regulation (EU) 2019/943 deals with **action plans**. The EnC Contracting Party with identified structural congestion shall develop an action plan in cooperation with its regulatory authority to reach 70% target and the plan should be approved on national level. *That action plan shall contain a concrete timetable for adopting measures to reduce the identified structural congestions within four years* (Article 15(1) of the Regulation (EU) 2019/943. The cross-zonal trade capacity should increase on an annual basis until the minimum capacity provided for in Article 16(8) of the Regulation (EU) 2019/943 is reached. *Those annual increases shall be achieved by means of a **linear trajectory**. The starting point of that trajectory shall be either the capacity allocated at the border or on a critical network element in the year before adoption of the action plan or the average during the three years before adoption of the action plan, whichever is higher*.

Structural congestion is defined in the Regulation (EU) 2019/943 *as congestion in the transmission system that is capable of being unambiguously defined, is predictable, is geographically stable over time, and frequently reoccurs under normal electricity system conditions*. Relevant TSO should report to their NRA about structural congestions in their power system. Market congestion is indicated by the active constraints of market participants and can be approximation for structural congestions. **The EU best practice determine that structural congestion exist if a significant amount of the time per year (> 5%) active constrains occur in power system** [4], [5], [6].

Every year, during the **implementation of the action plan until end of 2027** and within six months of its expiry, the relevant TSOs shall assess for the previous 12 months whether the available cross-border capacity has reached the linear trajectory or not complied defined target. TSO assessments should be sent to **ECRB and to the NRAs**. NRA should approve relevant data before TSO starts to draft the report regarding linear trajectory fulfillment during the implementation of action plan.

Article 15(7) of the EnC Regulation (EU) 2019/943 anticipates the option where no action plan is established within six months of identification of structural congestion. The relevant TSOs shall, and in that case within 12 months of identification of such structural congestion, assess whether the available cross-border capacity has reached the minimum capacities provided for in Article 16(8) of the EnC Regulation (EU) 2019/943 during the previous 12 months and shall submit an assessment report to the relevant regulatory authorities and to the ECRB.

Six months before the expiry of the action plan, the Contracting Parties with identified structural congestion shall decide whether to address remaining congestion by ***amending its bidding zone or whether to address remaining internal congestion with remedial actions*** *for which it shall cover the costs* (Article 15(6) of the EnC Regulation (EU) 2019/943).

Before performing any of its tasks pursuant to those provisions, the ACER, acting in accordance with Article 2 of Procedural Act 2022/01/MC-EnC, shall consult the ECRB.

According to Article 16(9) of the EnC Regulation (EU) 2019/943, *at the request of the transmission system operators in a CCR, the relevant NRAs may grant a* ***derogation*** *from paragraph 8 of Article 16 of the Regulation (EU) 2019/943*. *Before granting a derogation, the relevant NRA shall consult the regulatory authorities of other Member States and Contracting Parties forming part of the affected CCRs. Where a regulatory authority disagrees with the proposed derogation, the ECRB and, to the extent Member States are affected, the ACER, acting in accordance with Article 2 of the Procedural Act 2022/01/MC-EnC, shall decide whether it should be granted pursuant to Article 62(1)(f) of the EnC Directive (EU) 2019/944. The justification and reasons for the derogation shall be published. Before taking a decision, the ECRB and the ACER shall consult each other*.

In case of disagreement of affected regulatory authorities of other Member States and Contracting Parties forming part of the CCR, in case the EU Member States are affected – ACER or if only Contracting Parties are concerned – ECRB, are responsible for taking a final decision.

If the derogation proposal has been rejected, Member State or EnC Contracting Party should fulfil 70% target using all available measures including option for addressing remaining congestion through remedial actions for which they bear the costs.

Unlike the action plan which includes measures in mid-term period, derogation can be granted for shorter period (one year with possibility to renew it) and it requires permission from the neighboring regulatory authorities.

2.2 ACER decisions and recommendations

Based on the Regulation (EU) 2019/943, ACER adopted decisions and recommendations for minimum 70% target calculation. The most relevant ACER documents are:

1. Decision No 29/2020 of the European Union agency for the cooperation of energy regulators of 24 November 2020 on the methodology and assumptions that are to be used in the **bidding zone review process and for the alternative bidding zone configurations** to be considered
2. Decision No 04/2021 of the European Union agency for the cooperation of energy regulators of 7 May 2021 on the **determination of CCRs**
3. ACER Decision on the Amendment of the determination of CCRs: Annex III, the **determination of CCRs** in accordance with Article 15(1) of the Commission Regulation (EU) 2015/1222 of 24

July 2015 establishing a Guideline on Capacity Allocation and Congestion Management, 31 March 2023

4. ACER Decision on Core CCM: Annex I, **Day-ahead capacity calculation methodology** of the Core CCR, 21 February 2019 [7]
5. ACER Decision on Core CCM: Annex I, **Intraday capacity calculation methodology** of the Core CCR, 21 February 2019 [7]
6. ACER Decision on Core CCM: Annex II, **Intraday capacity calculation methodology** of the Core CCR, full amended version, 19 April 2022
7. Recommendation No 01/2019 of the European Union agency for the cooperation of energy regulators of 8 August 2019 on the **implementation of the minimum MACZT** pursuant to Article 16(8) of the Regulation (EU) 2019/943.

ACER's decisions and recommendations are followed by numerous documents, presentations, workshops, etc. to clarify all details about MACZT calculation. The methodology used in this study is explained in detail in Chapter 6, while in this chapter a general overview of methodology and input data selection is given based on relevant ACER and ENTSO-E documents.

It is important to note that EnC Contracting Parties as non-EU Member States are not included in ACER decisions and recommendations. Anyway, representing major agreement on EU level, for the purpose of this study ACER methodology implemented in the EU Member States is applied on EnC Contracting Parties.

2.2.1 Capacity calculation regions and bidding zones

The first step in the capacity calculation process is determination of nodes, elements, borders, or coordination areas to be modeled. As the first step, adequate **network model** and **calculation methodology** should be clarified and agreed.

The European electricity market is based on the zonal pricing model. Geographical regions and countries are divided into bidding zones with a basic principle: **transmission capacity in a bidding zone is assumed to be unlimited which results in uniform electricity price within that bidding zone**. Congestions may occur between the bidding zones, and consequently limit the market transaction and lead to market price differences. Therefore, a bidding zone is the largest geographical area in which market participants can exchange energy without capacity allocation.

Technical Report [8] is prepared every three years by the ENTSO-E according to Article 34 of CACM GL and sent to ACER. According to Article 14(2) of the EnC Regulation (EU) 2019/943, a bidding zone review shall be prepared by ENTSO-E at the latest six months following the report on structural congestions and other major physical congestions, but not later than 31 December 2025. The ENTSO-E report also identifies geographical locations of congestions and their frequency for three different timeframes (years). In addition, it includes TSO expert assessment and clarifications of the local grid constraints. The report also provides indications on the expected evolution of the network congestions over the next ten-year timeframe. Next reports should include the EnC Contracting Parties and will present overview of the structural and physical congestions in all CCRs covered by ENTSO-E. Contracting Parties may use the results presented in this report to evaluate the level of structural and physical congestions in their network and identify the starting point in the MACZT fulfillment process.

CCRs are geographic areas in which a coordinated capacity calculation is applied. Therefore, a CCR defines the set of bidding zone borders among which the tasks of capacity calculation are coordinated among TSOs (Figure 4 [9]). The CCRs including EnC Contracting Parties and Member States (for their interconnections with Contracting Parties) are established by Annex 1 of the EnC CACM GL.

In the Decision on the Amendment of the determination of CCRs (Annex III) ACER determined the current CCRs in the EU according to Article 15 of the CACM GL [10] (hereinafter: ACER Decision on CCRs). EU and Norway are divided in eight CCRs and each CCR consists of several bidding zones borders. Graphical representation of CCRs and bidding zone borders in EnC Contracting Parties, Central and South-East Europe is given on Figure 3 established.

It is important to note that EnC Contracting Parties are not considered in the ACER Decision on CCRs. EnC CCRs are defined in the Annex I of the EnC CACM GL. Three CCRs are established: Shadow SEE CCR, EE CCR, IT-ME CCR. These CCRs include bidding zones borders between EnC Contracting Parties and between EnC Contracting Parties and Member States and can be amended by a proposal of all EU TSOs to ACER (which would then include them directly in the abovementioned ACER decision on CCRs). The gographical representation of EnC Contracting Parties CCRs is given in Figure 2.

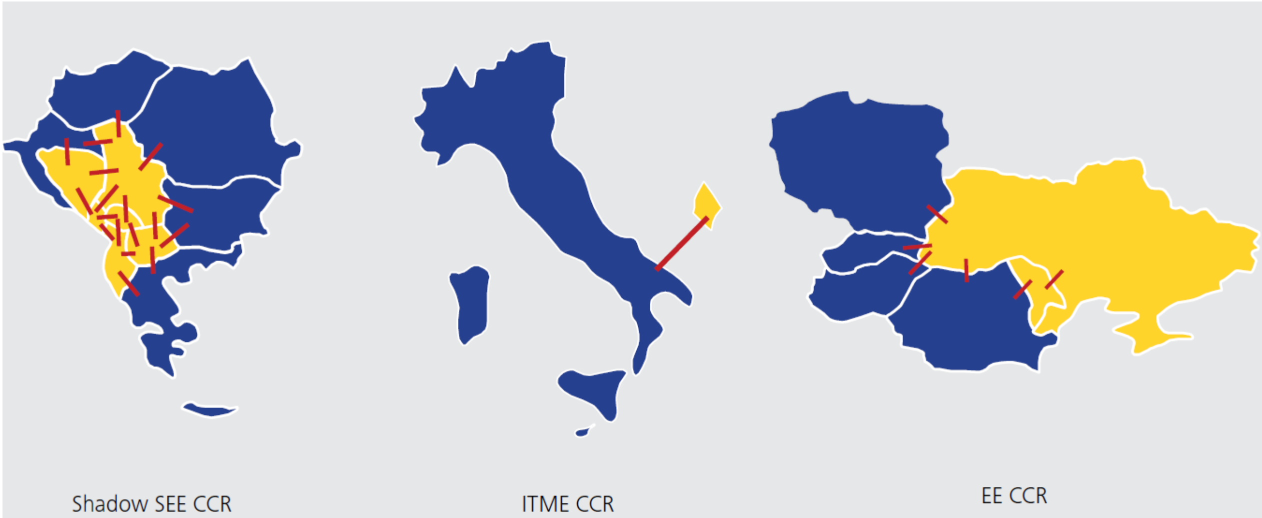


Figure 2 CCRs and bidding zones borders in EnC Contracting Parties

Figure 3 Bidding zones borders in Central and South-East Europe according to ACER's Decision

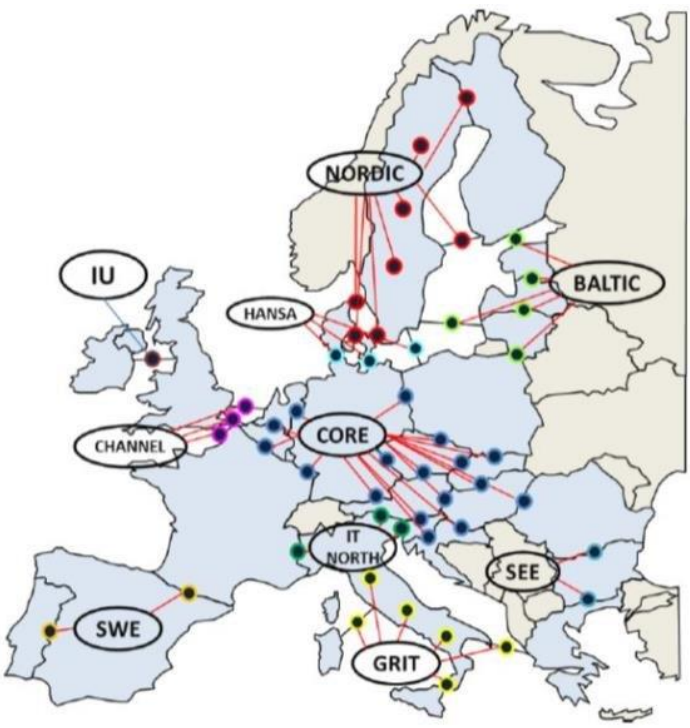


Figure 4 CCR borders in Central Europe according to the ACER’s Decision

Coordinated capacity calculation in EU Member States is performed by five regional security coordinators (RSC, after CEP implementation Regional Coordination Centers (RCCs) are introduced).

The RCCs are service providers to the TSOs, contributing to the operational security of the power system. The same concept is defined in the EnC and the establishment of the RCCs is a legal obligation, according to Ministerial Council Decision 2021/13/MC-EnC Article 35 and Annex IV [3].

Additionally, Decision [3] modifies Annex I Regulation (EU) 2019/943 and puts Annexes II and III of Regulation (EU) 2019/943 out of force in the EnC Contracting Parties. Annex IV (Regional coordination centres for the system operation regions) and Annex V (system operation regions in the Energy Community) are added. Annexes IV and V are crucial for capacity calculation methodology because they:

- Defined jurisdiction of RCCs for the Shadow South-East Europe System Operation Region (SOR) and Eastern Europe System Operation Region (SOR)
  - *For the bidding zone borders between Member States and Contracting Parties, the Regional Coordination Centres in Thessaloniki (Greece) or Munich (Germany) shall assume the roles of Regional Coordination Centres in the Shadow South-East Europe System Operation Region unless all concerned neighbouring transmission system operators of the EU agree to a Regional Coordination Centre located in a Contracting Party.*
- Specified the TSOs and its SORs covered with Decision, bidding zones (BZ), bidding zone borders and CCR.
  - *TSOs from SORs in the EnC should cooperate with TSOs from regions established under Regulation (EU) 2019/943 and consult in particular with those TSOs where system operation regions overlap with CCRs*
  - *TSOs of each SOR shall take the utmost account of the views expressed by the TSOs included in a CCR but not incorporated in the SOR of the mentioned CCR*
  - The system operation regions shall be defined as follows:
    - Shadow SEE SOR includes Albania, Bosnia and Hercegovina, Kosovo*, Montenegro, North Macedonia and Serbia, Shadow SEE CCR bidding zone borders, ITME CCR bidding zone borders
    - EE SOR includes Ukraine and Moldova and their bidding zones borders.

As mentioned above, in Chapter 6 detailed calculation methodology applicable for EnC CCRs is presented and illustrated on simple example, including complete mathematical and calculation background.

2.2.2 General provisions of MACZT calculation methodology

ACER released Recommendation No. 01/2019 on August 8, 2019, regarding the implementation of the minimum margin allowed for cross-zonal trade in accordance with Article 16(8) of the Regulation (EU) 2019/943 [8]. This recommendation's objectives are to support TSOs in achieving the 70% capacity target, support regulatory agencies in their monitoring efforts, and guarantee consistency among all stakeholders.

According to ACER, MACZT should be monitored for the **day-ahead capacity calculation timeframe,** so day-ahead capacity methodology should be used. Calculation methodologies are adopted separately for each CCR.

The deadline for Contracting Parties to transpose Regulation (EU) 2019/943 with certain changes is 31 December 2023 and respective activities are ongoing in all Contracting Parties. The TSOs of the CCRs established in the EnC should have developed and submitted common capacity calculation methodology including bidding zone borders to neighboring EU Member States and between Contracting Parties. The deadline for this activity was 15 June 2023, but the process is delayed and no common capacity calculation methodology has been submitted for approval by none of the EnC CCRs and the whole transposition process is in significant risk of delay.

There are differences in calculation approach among CCRs (FB approach is used in Core CCR, NTC approach is used in Italy). Therefore, for this study ACER Decision on Core CCM (Annex I, Day-ahead capacity calculation methodology of the Core CCR from 21 February 2019) is used [7]. According to Article 20(1) of the CACM GL for the day-ahead market timeframe and intraday market time-frame the approach used in the common capacity calculation methodologies shall be a FB approach, except in case where the TSOs jointly request the competent regulatory authorities to apply the coordinated NTC approach.

Also, ACER states that in the cases when coordinated capacity calculation is implemented on the intraday timeframe and in some circumstances where TSOs are unable to reach the MACZT target on the day-ahead timeframe, the intraday timeframe may also be taken into account in the monitoring of the 70% MACZT target.

MACZT should be calculated on each element (line or transformer) where zone-to-zone power transfer distribution factor (PTDF) is higher than 5%. PTDF indicates incremental change in active power flow that occurs on considered element due to active power transfers between two regions. These regions can be defined as areas, zones, single buses, injection groups or the system slack[7]. It is clear that the calculation of PTDF's is possible only using adequate power network model. The following basic steps should be followed in MACZT calculation for every single element:

1. Calculation of PTDF values for every single node
2. Calculation of PTDF values for every biding zone
3. Creation of CNE(C) list
4. Definition of coordinated and non-coordinated areas
5. Calculation of MCCC and MNCC values
6. Finally, calculation of MACZT value.

ACER recommendation [11] and its block diagram is shown on the following Figure. However, only basic principles of calculation are presented here, while more details are given in Chapter 6. The MACZT calculation technique appears to be very complex. It necessitates thorough expertise in process automation and power flow simulations.

[7] In electrical power systems a slack (or swing bus) is used to balance the active and reactive power in a system while performing load flow studies.

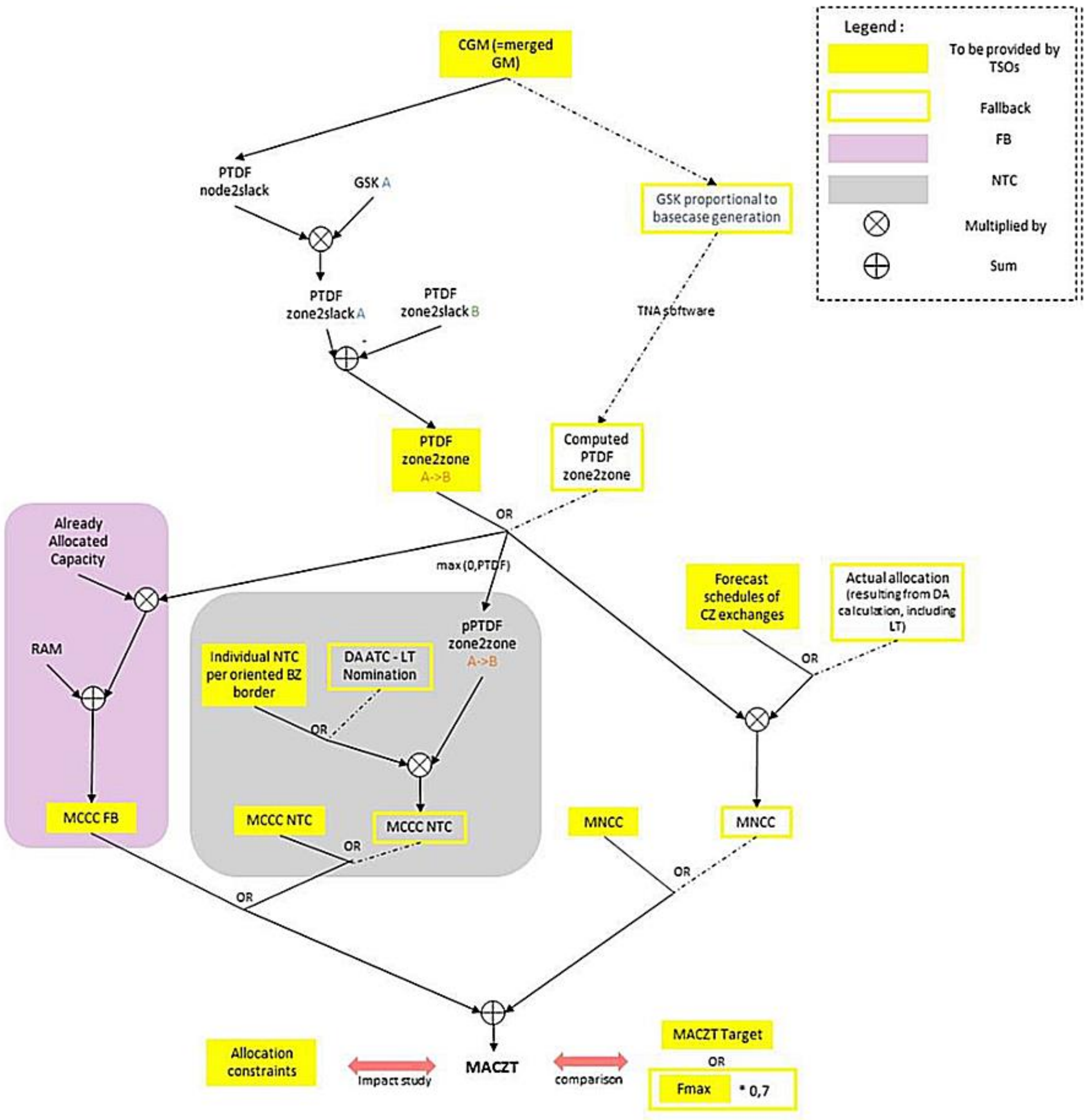


Figure 5 MACZT calculation process as defined in ACER recommendation (FB and NTC approaches)

There are two possible approaches for MACZT calculations: 1) NTC approach and 2) FB approach. Till recently in all CCRs NTC approach was applied for years. Today, the Core region uses a coordinated FB approach, while it is also expected to be applied in Nordic region, too. FB approach includes RAM (remaining available margin), which is quite complex to calculate. It is not presented in the Recommendation 01/2019 [12]. The RAM component is the key difference between these two approaches, and it makes FB approach more accurate and reliable. It takes into account the actual condition of the transmission network, i.e., the net position of all countries in the region for which the calculation is performed. However, in order to apply a FB approach, it is necessary to develop more complex information infrastructure to enable more precise calculation and the actual flows on the transmission network elements.

3 RELEVANT EXPERIENCE OF EU BODIES AND MEMBER STATES

Cross-zonal capacity calculation legal framework and its implementation principles are given in the Regulation (EU) 2019/943 and ACER decisions and recommendations, as described in chapter 2.2.2. Responsible TSOs, NRAs and ENTSO-E are obliged to implement it on actual power flows, respecting primarily security of the power system operation and other technical limits.
ACER requires that **on ALL observed elements (critical network elements (CNE) or critical network elements with contingencies CNE(C)) MACZT value should be higher than 70% of the maximum thermal power capacity in ALL time units for which the calculation is performed**. This requirement is unambiguous, but very strict and quite difficult to achieve in most of the power systems in Europe. Transmission system element loadings are fluctuating over time, so it is expected to be difficult to achieve the 70% requirement on every single element in every single time unit. Even though ENTSO-E and some EU Member States have had different opinions and discussions about 70% requirement, it was widely agreed and accepted.

3.1 ENTSO-E position on 70% target implementation

Since the Regulation (EU) 2019/943 entered into force, ENTSO-E has taken a number of activities to coordinate TSOs in establishing common methodologies for MACZT calculation and in reviewing bidding zones. Before the adoption of Regulation (EU) 2019/943, ENTSO-E has considered bidding zone definition and issued technical report on bidding zone configuration in 2018 [13]. The report is based on the simulations carried out on a complete European power network model, using PTDF values as a sensitivity indicator, i.e., the influence of individual generators and zones on critical elements. The report is based on the input data from the period 2015 - 2017.

ENTSO-E regularly monitors and comments on ACER reports on the 70% target fulfilment. Technical comments [14] on ACER's *Report on the result of monitoring the margin available for cross-zonal electricity trade in the EU* in the first semester of 2020 clearly identified differences in implementation interpretation between ACER and ENTSO-E. Even though ENTSO-E understands ACER's intention to harmonize approaches all around EU, it is on the position that NRAs are only responsible for assessing the fulfilment of the 70% criterion.

ENTSO-E technical comments on the ACER Report refer to the calculation method and presentation of the results. Important ENTSO-E note is that ACER, insisting on the full application of the 70% criterion, does not take into account the wholesale prices convergence as a relevant indicator of the transmission systems development and connectivity. It is emphasized that transmission system operators made efforts to increase mutual coordination, cross-zonal capacity availability and price convergence, which was not recognized in ACER's Report. Furthermore, ENTSO-E is of the opinion that flows with third countries should be fully taken into account when appropriate. The TSOs of Contracting Parties should implement a common capacity calculation methodology based on ACER recommendations and it should not consider price convergence as a parameter. MACZT calculation is based on day-ahead capacity calculation and applying principles that come out from accomplished trade (day-after) may lead to incorrect capacity allocation and market participant discrimination.

On behalf of all European TSOs, ENTSO-E stands at the position that European TSOs would like to continue the dialogue with ACER to align monitoring principles and ensure that divergences between the TSOs' views on 70% target fulfilment and the views of ACER and national NRAs are mitigated [14]. A continuation of the dialogue can be expected to standardize the criteria for MACZT monitoring as well as the method of reporting on monitoring. Bidding zones of Contracting Parties will be covered in the next ENTSO-E congestion reports, so the relevance of ENTSO-E position is important for future communication and understanding.

3.2 EU Member States experience with 70% target fulfillment

In the last few years, the EU Member States have taken actions to consider the impact of 70% target on their power systems and markets. ACER and NRAs regularly monitor and report about implementation process [15], [16].

According to ACER Report of 2020 [15] EU Member States have serious challenges to achieve 70% target. Moreover, in most of the Member States MACZT values are very low and target is not reached (Austria, Bulgaria, Greece, Croatia, Romania, Slovenia etc.). Significant improvement is detected in 2023, but lot of barriers detected in previous reports are still there, so final aim to reach 70% target in all bidding zones at the beginning of 2026 seems quite difficult to achieve [16].

The current power systems operation and methodology adopted for MACZT calculation does not fulfil Article 16(8) of the Regulation (EU) 2019/943. Moreover, most of the Member States are not even close to the 70% target. So, EU Member States had to take adequate measures to improve this situation. FB capacity calculation approach and consideration of third countries in calculations would certainly increase MACZT values [15], [16]. Most of the NRAs stand that third countries should be used in consideration so ACER reports on both, the results of MACZT values considering or omitting effects of third countries. In Core CCR, FB capacity calculation approach was in testing phase until 8 June 2022 and fully in use from 9 June 2022. The positive impact of FB approach on 70% target compared to the previously used NTC approach is clear from the monitored MACZT values.

Figure 6 shows the percentage of hours when the minimum 70% target was reached for countries of continental Europe (neighboring WB6 Contracting Party) where a coordinated capacity calculation is not yet implemented, for the whole year of 2022 or relevant periods [16].

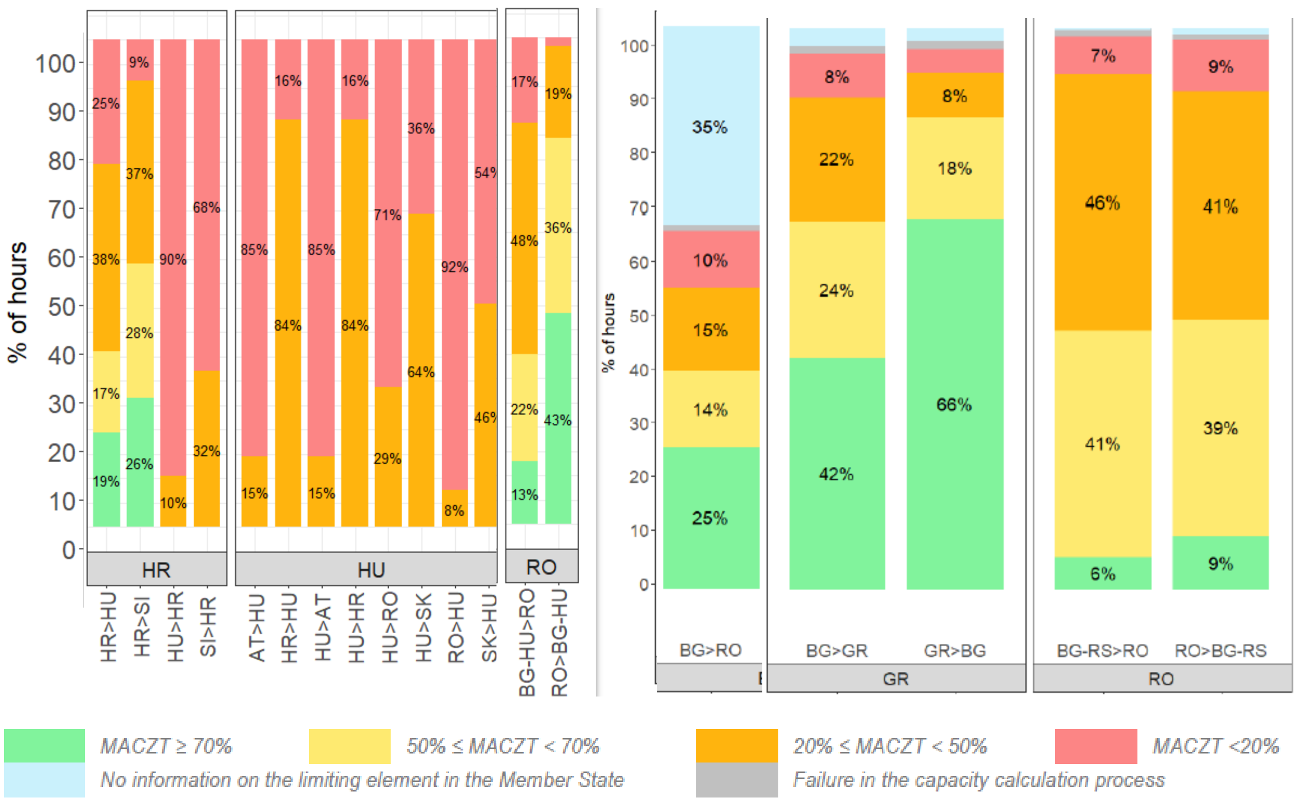


Figure 6 Percentage of hours when the minimum 70% target was reached per bidding zone border in 2022 considering third countries

3.3 Derogations and Action Plans around the EU

Derogation and action plan for fulfilment of 70% target are two basically very different approaches to fulfil the Regulation (EU) 2019/943 Article 16(8). **Derogation simply postpones this obligation** and gives additional time for analyses and preparation of new proposals and measures to fulfill the target. However, it is not supposed to be used continuously, it should not be used for structural congestions issues, and it doesn't change the final target. On the other side, **the action plan** specifies concrete measures and timeframe to adopt changes in power system and methodology to reach the target with linear trajectory checkpoints. **Important note** is that granting the derogation should be approved by relevant NRAs in the same CCR, while action plan adoption is only in domain of the national TSO, NRA, and government. Additionally, action plans may be multinational to address congestion in some region controlled by more NRAs.

Figure 7 gives an overview of the derogation and action plan adoption process in EU in the period 2020 - 2022. Clearly, in 2020 only Germany adopted an Action Plan, followed by Romania in 2021 and then Austria, Poland and the Netherlands that combined action plan with derogation. Current status around the EU is as follows:

- Action Plan adopted (Germany)
- Derogation granted along with adopted Action Plan (Netherlands, Poland, Austria, Croatia, Hungary, Romania)

- Derogation granted in 2020 (2021) and reached 70% target fulfilment (France)
- Only derogation granted (Belgium, Check Republic, Slovakia, Bulgaria, Greece, Spain, Portugal)
- No action needed is declared by Slovenia.

Lot of discussions are still underway about maximum derogation duration and its repetition. Derogation shall be granted for no more than one-year at a time, or, provided that the extent of the derogation decreases significantly after the first year, up to a maximum of two years. Although, some TSOs (like Belgium TSO) use the derogations repetitively and in this manner extend the duration of this measure for more than two years.

Overview and main characteristics of action plans and derogation decisions are given in ACER report on the result of monitoring the margin available for cross-zonal electricity trade in the EU [17]. All relevant details of action plans and derogation requests from 2020 are given including information regarding structural congestions reports, bidding zones borders or CNE(C)s and linear trajectory MACZT targets per years.

3.3.1 France

French regulatory authority (CRE) prepared the report on implementation of the minimum threshold of 70% on interconnection capacities for cross-border trade at French borders [18]. CRE specifically paid attention on the internal elements in France that can limit cross-border capacities available for market participants and timeframes in which the capacity given by the TSO is limiting power exchanges and preventing price convergence in CCR. In the case of price convergence on bidding zone borders any additional capacity would not lead to a cross-border exchange increase. CRE accordingly considers that these situations, in which no gain is possible on European scale, are also compliant with Article 16(8) of the Regulation (EU) 2019/943.

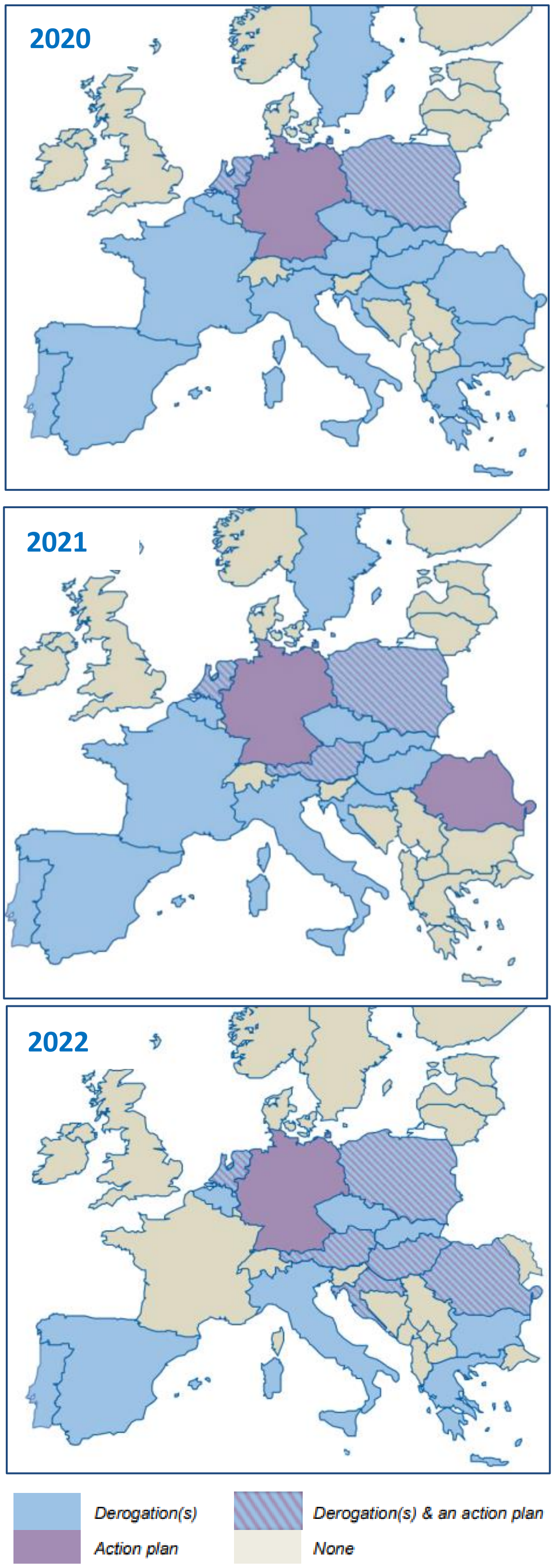


Figure 7 Overview of derogations and action plans

Thus, CRE determined the share of market time units when the TSO guarantees the 70% target provided at the European level and excluded market time units to the following criteria:

1. ***Unsaturated interconnection****: in situations when market coupling results with optimal allocated capacity lower than total interconnection capacity available for cross-border exchanges, there is no incentive to increase cross-border capacity. These are situations with price convergence in the CCR.*
2. ***Absence of a limiting network element in France****: non-limiting network elements, i.e. those that do not limit the domain available for capacity allocation, have no direct influence on the interconnection capacities made available to the market. Increasing their margin would not increase cross-border exchanges*.

Using these modifications in monitoring methodology, CRE determined that *for the year 2021, the levels of interconnection capacity made available for cross-border exchanges by RTE meet the 70% criterion for more than 85% of the timeframes in the three regions evaluated*. This finding lead to the conclusion that there is no need to provide more cross-zonal capacity and reach 70% target.

ACER opposed to French NRA with the two main counterarguments on MACZT monitoring approach [19]:

1. Price convergence is established after capacity allocation is done, so the TSOs cannot estimate in advance necessary capacity allocation on bidding zone borders. In the case of incorrect anticipation of price convergence, the given capacity will not be enough and price convergence will not be reached.
2. Even in periods with price convergence, limits to cross-zonal trade capacity may still imply unwarranted discrimination between network users in different bidding zones. In certain cases, some market participants may be discriminated.

In practice, at the moment of non-provision of 70% it is not clear how the market will decide and the basic principles of market (non-discriminatory and transparent approach to all market participants) may be violated.

This position of French NRA leads to conclusion that Franch TSO does not need a new derogation. Also, they decided to use remedial actions to address congestions, so the adoption of action plan was not an option. Thanks to the investments made in the French electricity network, Franch TSO is able to modify the topology of the network and accordingly the electricity flows. This French specificity allows the network to be controlled in order to avoid congestions as much as possible and have a lower cost of remedial actions.

French approach to 70% target implementation shows that a combination of remedial actions and investments in the network along with optimized flow dispatch decrease the total costs and make the 70% target much closer.

3.3.2 Germany

MACZT value consists of coordinated (MCCC) and non-coordinated (MNCC) components as it is explained above in subchapter 2.2. German NRA has opted to estimate MNCC component differently from ACER recommendation [11], [12] and other NRAs practice. Their approach increases MNCC component and therefore increases MACZT value. This deviation is reported and noted in ACER Practical Note Monitoring the Margin of Capacity Available for Cross-Zonal Trade [20].

A common approach is that the MNCC is calculated using **forecasted exchanges** over the borders, which are not included in coordinated part of MACZT. On the contrary, German national monitoring framework calculates MNCC using the **NTC values** that are available for market participants on the bidding zone borders in both directions and include the maximal possible effect of the offered capacity (not the forecasted ones). Some of the consequences of this approach are [19]:

- Estimated (forecasted) flows and NTC values may differ and if NTC values are higher than forecasted flow (what is usually the case), MNCC value is higher. Therefore, the 70% target is easier to achieve.
- ACER recommendation [11], [12] approach is designed to allow the netting of flows which is not possible when using German NTC approach. Flow netting means that flows from other borders have an influence on the considered border and corresponding MNCC. The commonly adopted methodology can result in a negative MNCC, implying a need to make more capacity available via coordinated capacity calculation (the MCCC) to reach the target. On the contrary, German approach cannot result in a negative MNCC.

German NRA calculation results and ACER calculation results are significantly different. On the German – Poland and Czech Republic borders in 2021 Germany reported that in more than 80 of market time units 70% target was reached [21]. At the same time ACER declared significantly different results: 70% target on the direction CZ-PL->DE was fulfilled 25% of the time, while in direction DE->CZ-PL only 10% [22]. In other words, the German TSO and NRA declared the 70% target was met, while ACER declared it was not.

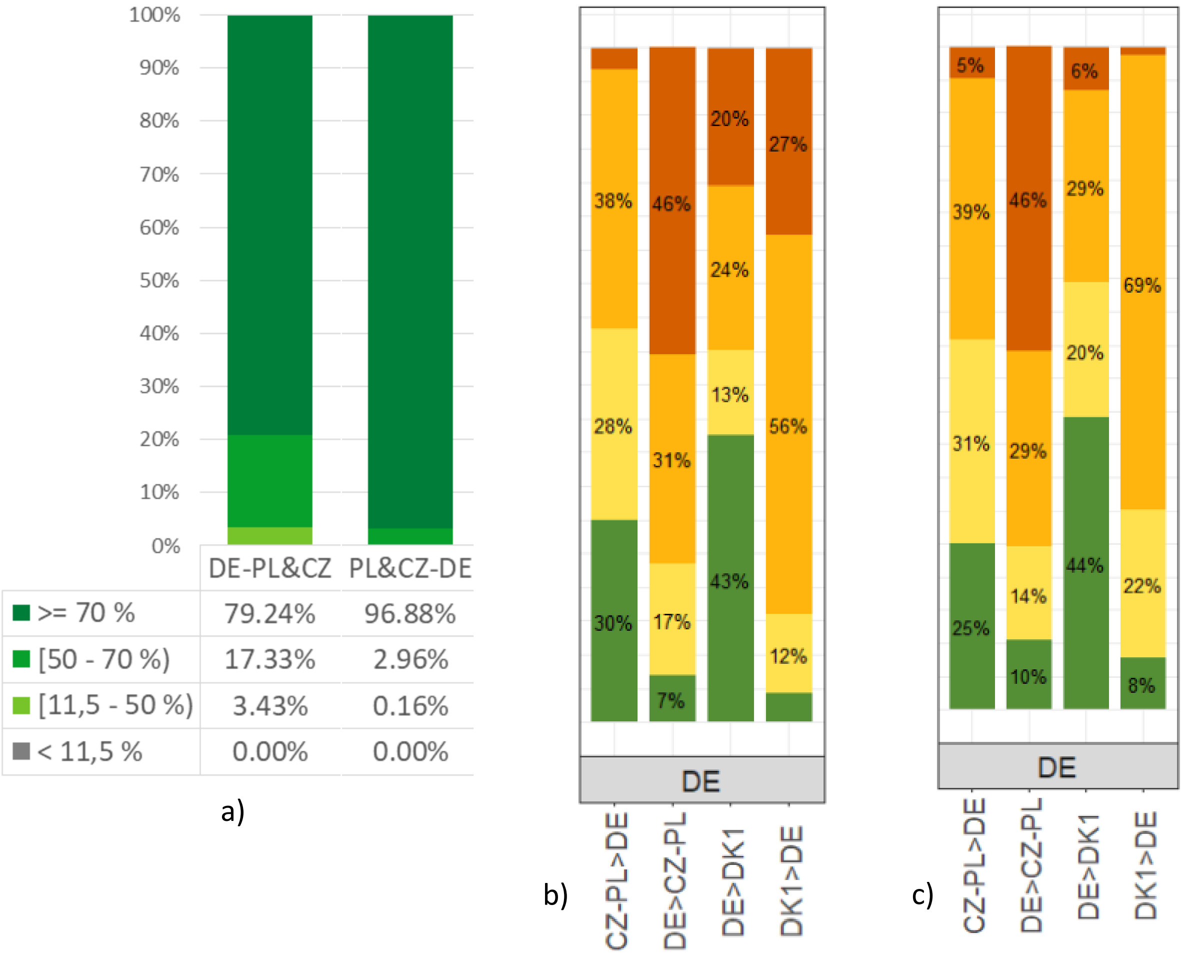


Figure 8 Percentage of the time when the 70% target was reached on DE->PL-CZ border in 2021

a) German TSO report
b) ACER report - Not considering third countries
c) ACER report - Considering third countries

From this simple comparison, it is obvious that modifications in the approach can lead to opposite conclusions. That's why the harmonization of MACZT calculation is imperative. With these inconsistencies many stakeholders emphasize that the 70% target is administrative and arbitrary. However, mathematical model is very precise, and the input data used for calculation should be agreed. As the mathematical model is very accurate, it is important to agree on the input data utilized in calculations. It appears that more clarification and complete harmonization of the methodological specifics are still needed.

The monitoring approach should be in line with the ACER recommendations and based on best practice adopted by EU TSOs. Any inconsistences with MACZT calculation based on ACER recommendations may lead to long process of proving the proposed methodology and discussions within EnC Contracting Parties, ECRB, ACER, and NRAs in affected CCR.

3.3.3 Poland

The Regulation (EU) 2019/943 assumes monitoring of 70% target, but also accounts all other possible allocation constraints imposed by the TSOs. ACER principle is [20]:

Two different MACZT values should be computed to assess the impact of allocation constraints on MACZT, i.e., how much an allocation constraint could potentially reduce the MACZT on CNECs:

- *Including allocation constraints and*
- *Without allocation constraints.*

All types of allocation constraints should be studied, including the allocation constraints needed for operational security or implemented for technical efficiency.

In [20] ACER reported that *the Polish NRA does not consider allocation constraints relevant for the monitoring of the MACZT and therefore NRA will not analyse their impact on the MACZT*.

Poland has an opportunity to limit the cross-zonal capacity on the HVDC links to Sweden and Lithuania (bidding zones SE4 and LT). Also, those HVDC links are used for trading between SE4 and LT bidding zones via Poland. Without going into hourly MACZT results of this case, constraints on HVDC links generally decrease maximum power transfer capacity, so the lower values of cross-zonal capacity allocation may be enough to reach 70% target. This is not in line with the Regulation (EU) 2019/943, but it has a basis in the CACM GL article 23(3):

If TSOs apply allocation constraints, they can only be determined using:

a) *Constraints that are needed to maintain the transmission system within operational security limits and that cannot be transformed efficiently into maximum flows on critical network elements or*
b) *Constraints intended to increase the economic surplus for single day-ahead or intraday coupling*.

In [12] there is the following note:

The impact of allocation constraints introduced pursuant to Article 23(3)(b) of the CACM GL Regulation on MACZT should not be monitored.

Polish approach relies on this note and currently the conclusions from MACZT values report in Polish bidding zone are founded on insufficient information. That may lead to incorrect findings of the 70% target fulfillment. Much better approach would be to coordinate with affected TSOs and NRAs and to agree on allocation constraint exemption.

3.3.4 Sweden

In the last few years Swedish case has drawn a lot of attention. In October 2021 Swedish TSO Svenska Kraftnät submitted a request for a derogation from 70% requirement to its NRA Energimarknadsinspektionen (EI). As mentioned in chapter 2.1, EI forwarded derogation request to the neighbouring regulatory authorities in their CCR and asked for their opinion. Finnish regulatory authority and Danish Utility Regulator expressed their formal disagreement with granting a derogation, so ACER was in charge to take a decision in this case. EI formally requested ACER to decide on these two considered borders, DK1-SE3 and FI-SE3, in line with the Article 16(9) of the Regulation (EU) 2019/943.

In October 2022, ACER took a Decision No 17/2022 on Svenska Kraftnät's request for a derogation from the 70% requirement pursuant to Article 16(9) of the Regulation (EU) 2019/943 [23]. ACER has decided not to grant the 70% target derogation to Swedish TSO. Their assessment confirmed that [23]:

- The derogation was not necessary to maintain operational security
- The derogation request did not provide the minimum capacity targets and
- The derogation request did not provide the methodology on how to avoid the discrimination between internal and cross-zonal exchanges.

In this interesting decision-making process numerous participants took an opportunity to express their opinion, both pro and contra requested derogation. Market participants always try to win as much capacity as possible at the lowest possible prices. For example, Green Power Denmark submitted comment on Svenska Kraftnät's request for derogation from the 70% requirement and strongly urged ACER to reject the request for derogation from the 70% requirement [24].

In the Swedish case, ACER has demonstrated that their approach to granting derogations is highly rigid, and the TSOs should make every effort to comply with the criteria of the Regulation (EU) 2019/943 or they will need to make very compelling justifications in their derogation requests.

3.4 Application of the EU experience in the EnC Contracting Parties

Interconnectivity requests agreed among the EU Member States are gradually applied in the EnC Contracting Parties. Detailed analysis on that is given in the EnCS report on electricity interconnection targets [25]. This report observes the EnC Contracting Parties electricity interconnectivity level with respect to the EU 2020 and EU 2030 interconnectivity criteria. The EU interconnectivity targets relate to the 10% criterion in 2020 (10% of NTC with respect to total production capacity) and the 15% criterion in 2030, defined through three sub-criteria as follows:

1. The wholesale price difference between two bidding zones should be lower than 2 €/MWh; the larger the difference, the greater the need for action
2. The ratio between nominal transmission capacity of interconnectors and peak load should be higher than 30%; if lower, urgent action is needed. TSOs should consider additional cross-border reinforcements if this ratio is between 30% and 60% and
3. The ratio between nominal transmission capacity of interconnectors and installed renewables generation capacity should also be higher than 30%; if lower, urgent action is needed. TSOs should consider additional cross-border reinforcements if this ratio is between 30% and 60%.

The transmission networks of the EnC Contracting Parties are more strongly interconnected than those of the majority of EU Member States today (in relation to the peak load and installed generation capacity). All observed countries comfortably satisfy the 10% interconnectivity target, only Ukraine is below this threshold.

Efficient usage and full exploitation of interconnectors is unfortunately still an issue due to low NTC values at the borders, leading to restricted market activities in the observed regions. The restricted NTC values are, however, sufficient to meet the EU interconnectivity target in 2020, but without going significantly above it even though it may be possible to use the existing cross-border infrastructure.

This study examines the wholesale energy market price criteria for 2030 and 2040 based on the market simulations conducted during the 2020 PECI/PMI selection process, without additional interconnectors included and with the current (limited) NTC values between countries. According to the findings, differences greater than 2 €/MWh may be expected for particular borders in specific scenarios depending on future generation development, integration of RES, and demand growth, but are also highly dependent on the use of existing interconnectors. The borders that could benefit the most from increasing the NTC are the ones between Ukraine and Hungary, Ukraine and Poland, Ukraine and Slovakia, Ukraine and Romania, Ukraine and Moldova, Moldova and Romania and Montenegro and Italy.

With the current number and transmission capacity of interconnectors, most of the observed countries will be able to meet the other two sub-criteria for determining interconnectivity level and compliance with the 2030 targets: the ratios between nominal transmission capacity of the interconnectors and peak load and installed renewable generation capacity. The results of the report clearly indicate that NRAs and TSOs should increase their focus on the efficient usage of the existing interconnectors. New cross-border projects should only be developed if existing interconnectors would not be capable of fully supporting market activities in the future. The study's findings unmistakably show that NRAs and TSOs should concentrate more on making the most use of the current interconnectors. Only if current interconnectors cannot fully support market activities in the future new cross-border projects should be initiated.

This study on the 70% target can therefore provide extra assistance to the NRAs and TSOs in EnC in the process of more effectively using internal networks in addition to the existing interconnectors. Options and positions presented in this chapter show that a slightly different approach on MACZT monitoring is used in some EU Member States which lead to discussion with ACER. Contracting Parties should continue the implementation process. The main step in that process is adoption of common capacity calculation methodology in EnC CCRs.

4 INPUT DATA AND TREATMENT OF UKRAINIAN AND MOLDOVAN POWER SYSTEM

According to the ToR "*Service Provider will be responsible for collecting all necessary input data and models, with the assistance of the Secretariat, if needed*" with "*…at least two sample regimes for 2022 (or 2021) depending on data availability…*". This ToR requirement was entirely met in this study, where 2021 was selected as a referent year since it is a pre-war condition.

EIHP prepared adequate power system models for characteristic winter and summer sample regimes and **used 2021 as a referent year**, as agreed in the Inception report. Year 2021 was used as an existing power system timeframe since:

1. In the region, there is little to no topological change between 2021 and 2022, and
2. Models for 2022 reflect consequences of the war in Ukraine. Accordingly, 2021 snapshots are closer to normal operating conditions.

For the future year 2028, official and publicly available transmission development plans of eight considered transmission system operators were used in the study, along with the data from the Southeast Cooperation Initiative – SECI regional transmission network development model [26].

In addition, the ToR also specified: "*Analysis of UA and MD should be simplified. Bidders are expected to propose how to treat UA and MD with respect to 70% target fulfilment…*". This requirement was also fulfilled in this study.

Power systems in Moldova and Ukraine are undoubtedly in a different position than power systems in WB6 from the standpoint of this study. There are numerous uncertainties in the Ukrainian (UA) and Moldovan (MD) power system data, especially for the 2028 timeframe. The start of commercial exchanges of electricity followed the successful synchronisation of the Continental Europe power system and the UA/MD power systems which was completed on 16 March 2022. Because of this, the year 2021 lacks long-term experience of common operations or adequate historical data. Therefore, power systems of Ukraine and Moldova were not analyzed in 2021 scenarios, but only in 2028 scenarios.

However, since recently, all Ukrainian power system data have been declared confidential. The new Ukrainian Transmission Network Development Plan is also not publicly available and probably no longer valid due to recent heavy war damages in Ukrainian power system. On the other side, 70% target should not be relevant nor applicable without fully recovered existing power network in Ukraine. Therefore, in the Inception report it was agreed with the EnCS to treat the **Ukrainian transmission network in 2028 as fully recovered,** with addition of OHL 400 kV Khmelnytskyi (UA) – Rzeszów (PL), which was previously operating on 750 kV, while now it is in operation on 400 kV voltage level. In 2028 in Moldova only one new internal network element was added to the current topology - OHL 400 kV Vulcănești – Chisinau. Another reinforcement candidate was new 400 kV interconnection line to Romania (OHL 400 kV Balti (MD) – Suceava (RO), but this line is expected in operation after 2028 and therefore it is not included in 2028 scenarios to stay at the safe side due to uncertainty of this line construction.

5 TRANSMISSION NETWORK GENERAL CHARACTERISTICS AND DEVELOPMENT PLANS

In this Chapter regional transmission network data are described in brief. It covers all EnC Contracting Parties, except Georgia: Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia, Serbia, Ukraine and Moldova. The input data are split into two major categories:

- Existing transmission network, and
- Planned transmission network.

Existing transmission network datasets are based on the status in 2021 - 2022. It covers set of basic transmission network data on the voltage level equal or higher than 220 kV.

For the 2028 timeframe analyzed in this study, official and publicly available transmission development plans were used, along with the regional transmission network development model data prepared under ENTSO-E umbrella through the South-East Cooperation Initiative – SECI [26]. In any case, this study is based on the **best available input data and can easily be updated later with new development plans. The main purpose of this exercise is to provide an in-depth understanding of the legal and regulatory framework governing the implementation of the 70% target.**

5.1 Albania

Electricity transmission system of Albania includes 400, 220, 150 and 110 kV lines and substations. Currently, Albania has more than 3400 kilometers of transmission lines in total. It includes interconnection lines to 3 neighboring systems:

- 3 interconnection lines 400 kV to Greece (one line), Montenegro (one line) and Kosovo* (one line)
- 2 interconnection lines 220 kV to Kosovo* (one line) and Montenegro (one line) and
- 1 interconnection line 150 kV to Greece.

There are fifteen main transmission substations in Albanian transmission network:

- 3 SS 400/220 kV with total transformer capacity of 1785 MVA
- 1 SS 400/110 kV with capacity of 300 MVA
- 10 SS 220/110 kV with capacity of 3096 MVA, and
- 1 SS 150/110 kV with capacity of 80 MVA.

There are sporadic congestions in Albania's existing transmission system operation. Along with the expected high level of RES integration in the near future (according to OST in 2022 there were 115 candidate power plants of (7172 MW, or 2.7 times the capacity of the existing power plants,) preparing to connect to the transmission network, there are needs and plans for transmission network reinforcements. On the following two figures existing Albanian transmission system map and single-line diagram are given.

Figure 9 Existing 400 kV and 220 kV transmission network in Albania

The latest approved 10-year Transmission Network Development Plan in Albania covers the 2015-2025 period [27]. It was approved by the regulatory authority in 2017. In the meantime, Transmission development master plan was prepared by the consultants and approved by OST. Accordingly, the Albanian transmission network will include seven additional elements planned to be commissioned until 2028.

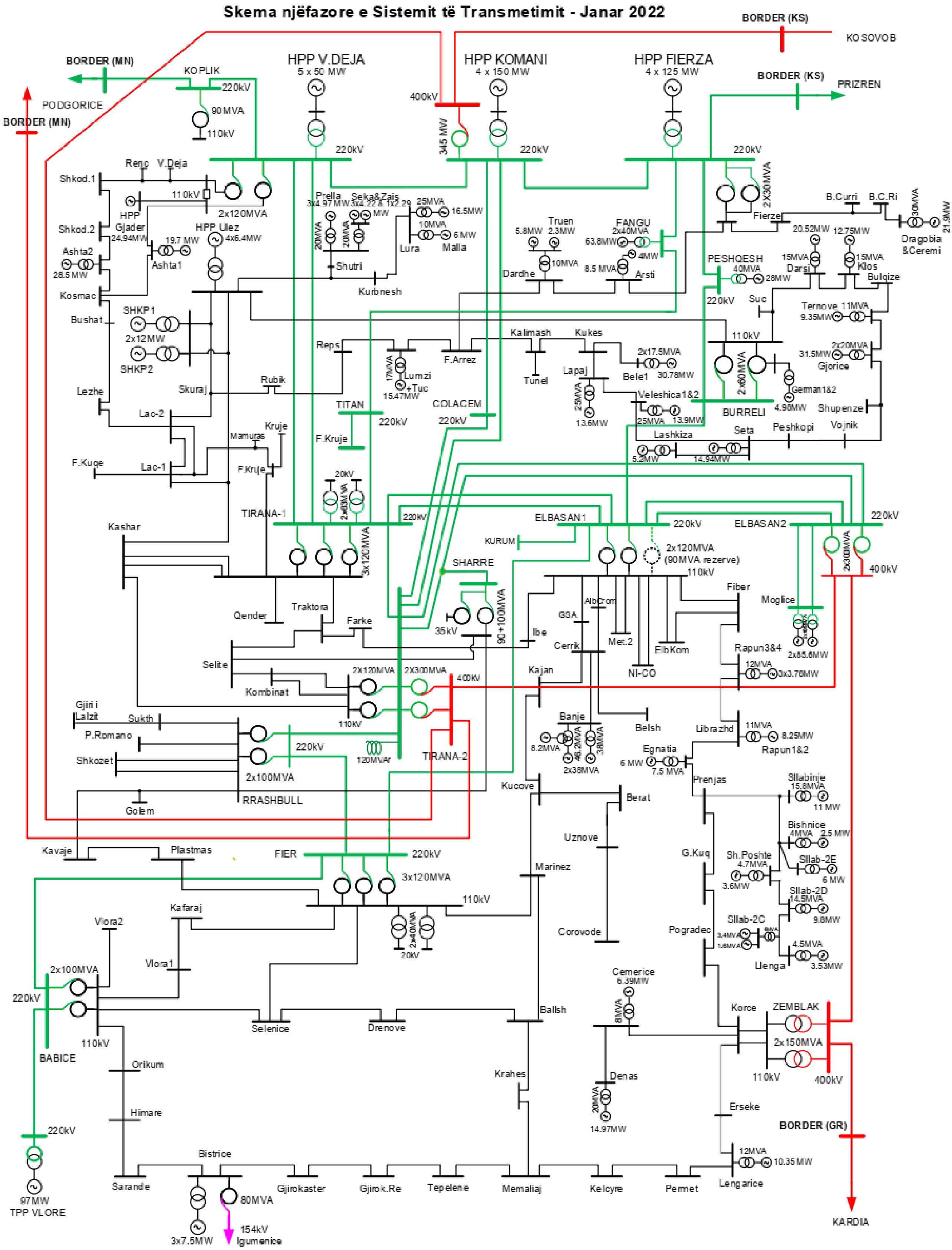


Figure 10 Single-phase diagram of the existing Albanian transmission system in 2022

5.2 Bosnia and Herzegovina

The transmission network in Bosnia and Herzegovina consists of 400, 220 and 110 kV elements. Total transmission lines length in Bosnia and Herzegovina is more than 6000 km. It includes interconnection lines to 3 neighboring systems as follows:

- 4 interconnection lines 400 kV with the neighboring countries: to Croatia (two lines), to Serbia (one line) and to Montenegro (one line)
- 10 interconnection lines 220 kV (seven to Croatia, one to Serbia and two to Montenegro), and
- 23 interconnection lines 110 kV (mostly to Croatia).

Existing transmission network in Bosnia and Herzegovina is shown on the Figure 11.

Figure 11 Existing 400 kV and 220 kV transmission network in Bosnia and Herzegovina

In Bosnia and Herzegovina, the transmission system there are:

- 10 SS 400/x kV with total transformer capacity of 6087,5 MVA
- 8 SS 220/x kV with capacity of 1423 MVA + 4 (MV)
- 132 SS 110/x kV with capacity of 5126 MVA + 122,5 (MV), and
- 4 SS (MV)/(MV) with capacity of 42,5 (MV).

Transmission network development plan in Bosnia and Herzegovina has not been updated since February 2021. In addition, some of the investments were not realized as planned.

One of the most important regional 400 kV projects in observed timeframe is Trans-Balkan Electricity Corridor project and it includes Serbian - Bosnia and Herzegovina – Montenegrin power systems on the routes Obrenovac (RS) – B.Bašta (RS) – Višegrad (Bosnia and Herzegovina) and B.Bašta (RS) – Pljevlja (ME).

RES potential as well as investors' interest in new generation capacities in Bosnia and Herzegovina in the last few years is very high. Currently, there are more than 2500 MW of new generation capacities that have been issued grid connection approval by the TSO (Elektroprijenos BiH). However, most of these projects still have several important development steps to take, to obtain all approvals for their construction. The Indicative Generation Expansion Plan is revised frequently, however it is currently out of date because new grid connection requests are practically made every day.

5.3 Kosovo*

Total transmission lines length in Kosovo* (2021) consists of 1430 km. It includes interconnection lines to 4 neighboring systems as follows:

- 4 interconnection lines 400 kV to the neighboring countries: Albania (one line), Serbia (one line), Montenegro (one line), North Macedonia (one line)
- 2 interconnection lines 220 kV to Albania and Serbia and
- 2 interconnection lines 110 kV to Serbia.

In 16 auto transformers (ATR) with total installed transformer capacity of 3750 MVA, including:

- 1200 MVA at voltage levels 400/220 kV (3 ATR)
- 1200 MVA at voltage levels 400/110 kV (4 ATR), and
- 1350 MVA at voltage levels 220/110 kV (9 ATR).

There are also 65 transformers with a combined capacity of about 2320 MVA on the boundary with the distribution network.

The transmission network of Kosovo* operates with 37 substations of different voltage levels and that:

- 1 400/220 kV substation
- 2 400/110 kV substations
- 3 220/110 kV substations
- 1 substation 220/35/10(20) kV and 1 substation 220/10(20) kV
- 7 110/35/10(20) kV substations
- 6 substations 110/35 kV and
- 16 110/10(20) kV substations.

There are three substations connected to the transmission network, owned by the industry customers, such as: Ferroniceli (220/35 kV), Trepça (110/35/6,3 kV) and Sharr-Cemi (110/6,3 kV).

The following two figures show the map and single-phase diagram of the existing transmission system of Kosovo*.

According to KOSTT, in 2022 there were 20 power plants (2500 MW, or 2 times the capacity of the existing power plants) preparing to connect to the transmission network.

The latest publicly available version of Kosovo* Transmission Network Development Plan [28] is published in October 2022.

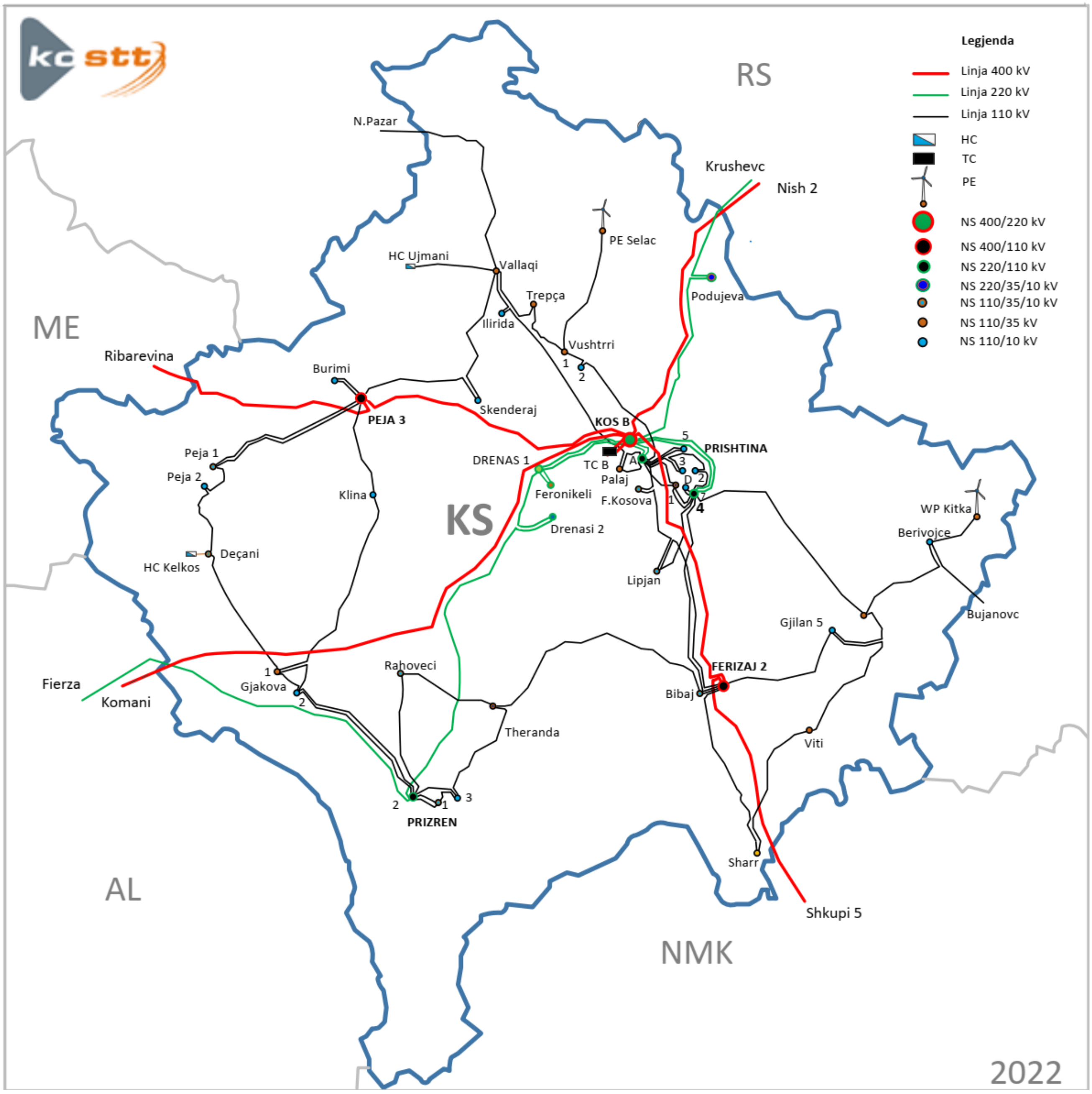


Figure 12 Kosovo* transmission network map in 2022

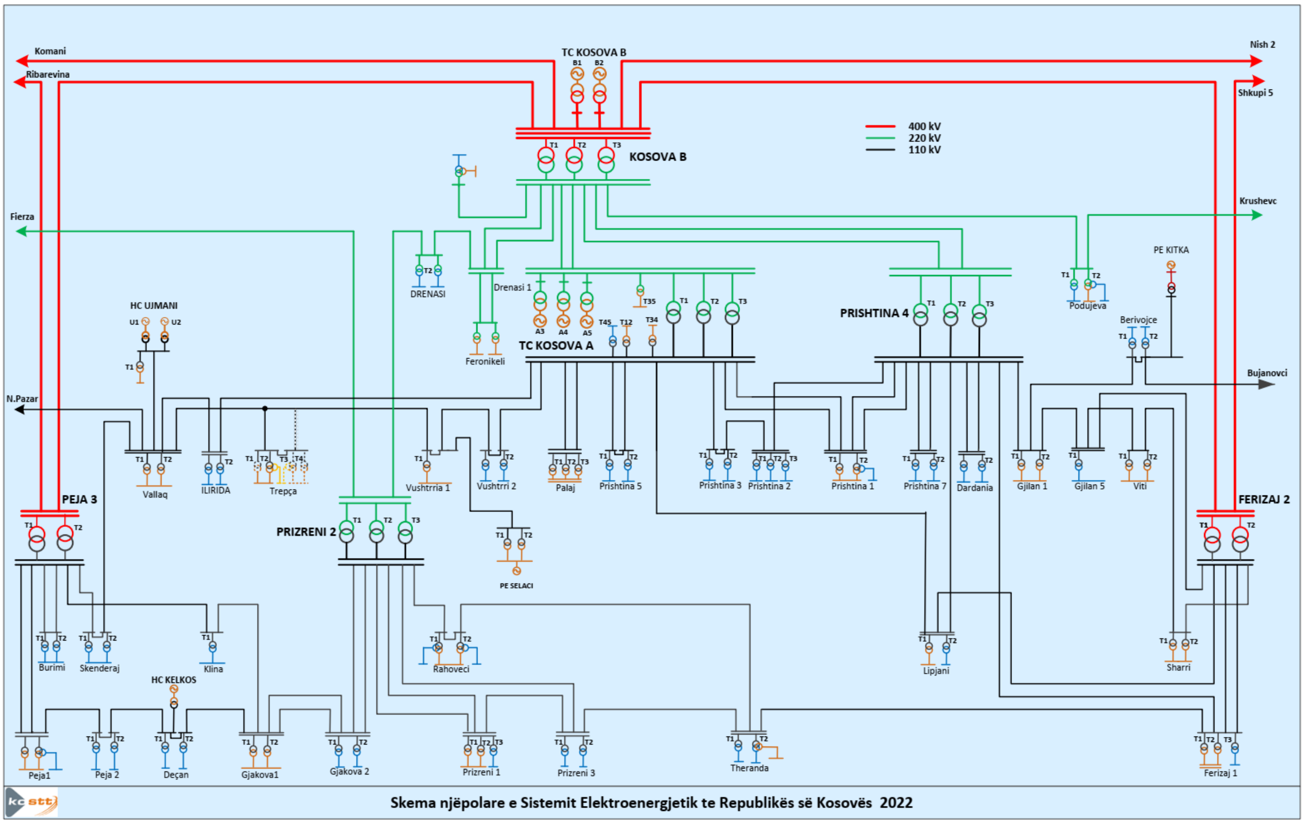


Figure 13 Single-phase scheme of Kosovo* power system in 2022

5.4 Montenegro

As in the other Contracting Parties in WB6, electricity transmission system in Montenegro covers 400, 220 and 110 kV elements, including switchgears, transformers, and lines, up to the network users' connection point and relevant telecommunication and information equipment and facilities.

110 kV network in Montenegro is heavily loaded as a result of significant consumption centers and power plant injections, particularly in the coastal area. 400 and 220 kV networks are primarily characterized by relatively lower levels of element loadings.

With commissioning of SS Lastva along with HVDC link to Italy (600 MW) in late 2019 the power flows and cross-border exchanges of Montenegrin transmission system considerably changed.

CGES has a transmission network consisting of 48 lines with a length of about 1416 km. It includes interconnection lines to 5 neighboring systems as follows:

- 4 interconnection lines 400 kV to the neighboring countries: Albania (one line), Bosnia and Herzegovina (one line), Kosovo* (one line), Italy (one HVDC submarine cable)
- 5 interconnection lines 220 kV to Bosnia and Herzegovina (two lines), Serbia (two lines) and Albania (one line) and
- 4 interconnection lines 110 kV to Serbia (one lines) and to Bosnia and Herzegovina (two lines).

In total, Montenegrin transmission system consists of:

- 6 OHLs on 400 kV
- 8 OHLs on 220 kV
- 31 OHLs on 110 kV, where 3 OHLs are double-circiut lines (2x110 kV), while 4 lines are in operation under 35 kV
- 2 cables on 110 kV and
- 1 combined cable-overhead line.

In 24 transmission substations there are 55 transformers with total installed transformer capacity of around 4200 MVA, including:

- 1 SS 400/220/110 kV (SS Pljevlja 2)
- 1 SS 400/110/35 kV (SS Ribarevine)
- 1 SS 400/110 kV (SS Podgorica 2)
- 2 SS 220/110/35 kV (SS Podgorica 1 and SS Mojkovac)
- 15 SS 110/35 kV (SS H. Novi, SS Tivat, SS Budva, SS Bar, SS Ulcinj, SS Virpazar, SS Nikšić, SS Vilusi, SS Danilovgrad, SS Pljevlja 1, SS Cetinje, SS Berane, SS Andrijevica, SS Kotor, SS Brezna)
- 4 SS 110/10 kV: SS Kličevo, SS Podgorica 3, SS Podgorica 4, and SS Podgorica 5.

Existing transmission network map of Montenegro is given on the following Figure.

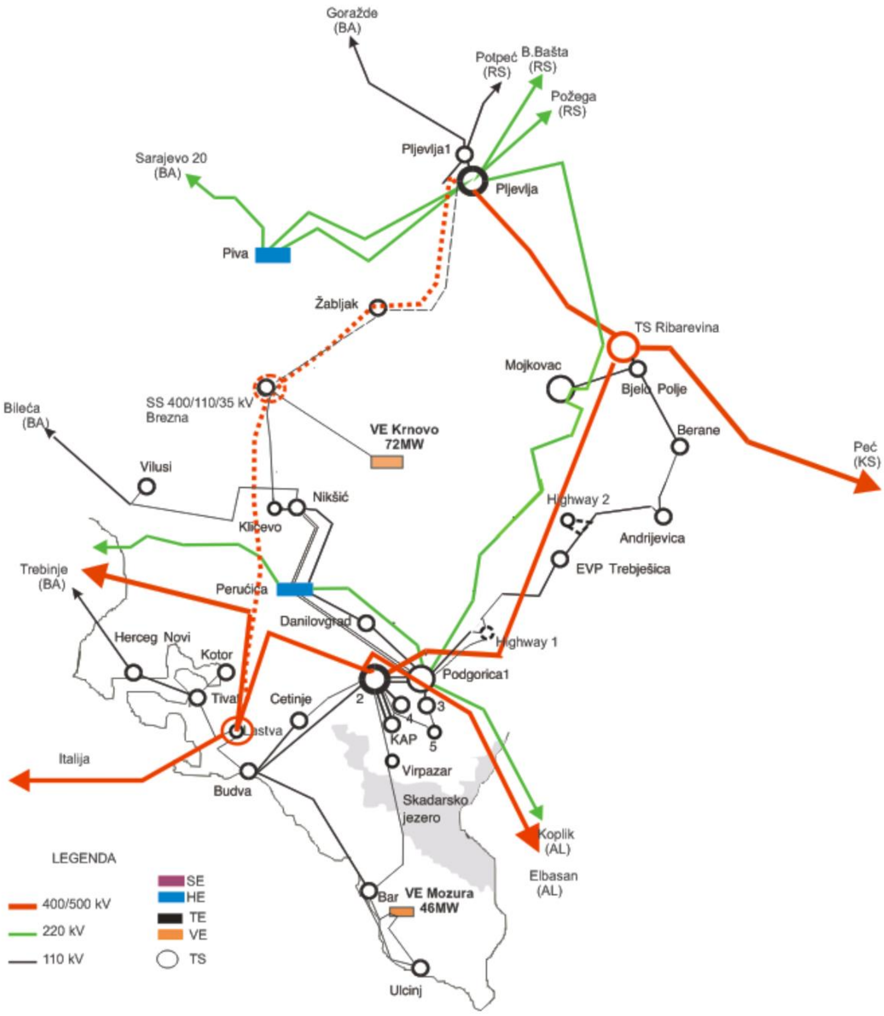


Figure 14 Existing 400 kV, 220 kV and 110 kV transmission network in Montenegro

In March 2022, Montenegrin TSO delivered transmission network development plan 2023-2032 to the regulatory authority for approval [29].

The construction of new transmission substations and lines will strongly depend on the connection needs of new RES projects and consumption centres. According to CGES, in 2020 and 2022 there were 5 power plants (767 MW, or 0.73 times the capacity of the existing power plants) preparing to connect to the transmission network.

It is also important to note that HVDC link to Italy is planned to be upgraded from the existing capacity of 600 MW to 1200 MW. Commissioning date of the second HVDC pole depends on the realization of necessary 400 kV lines to Bosnia and Herzegovina and Serbia, as well on market coupling between Montenegro and at least one neighbouring country.

5.5 North Macedonia

Transmission network in North Macedonia consists of 400 and 110 kV elements. Total transmission lines length in North Macedonia is around 2000 km. It includes interconnection lines to 4 neighboring systems as follows:

- 5 interconnection lines 400 kV to the neighboring countries: to Greece (two lines), to Kosovo* (one line), to Serbia (one line) and to Bulgaria (one line)
- 2 interconnection lines 110 kV to Bulgaria.

In 78 transmission substations total installed transformer capacity is around 4500 MVA, including:

- 5 SS 400/110 kV
- 73 SS 110/x kV.

Topology of the transmission network of North Macedonia in 2020 is shown on the following Figure.

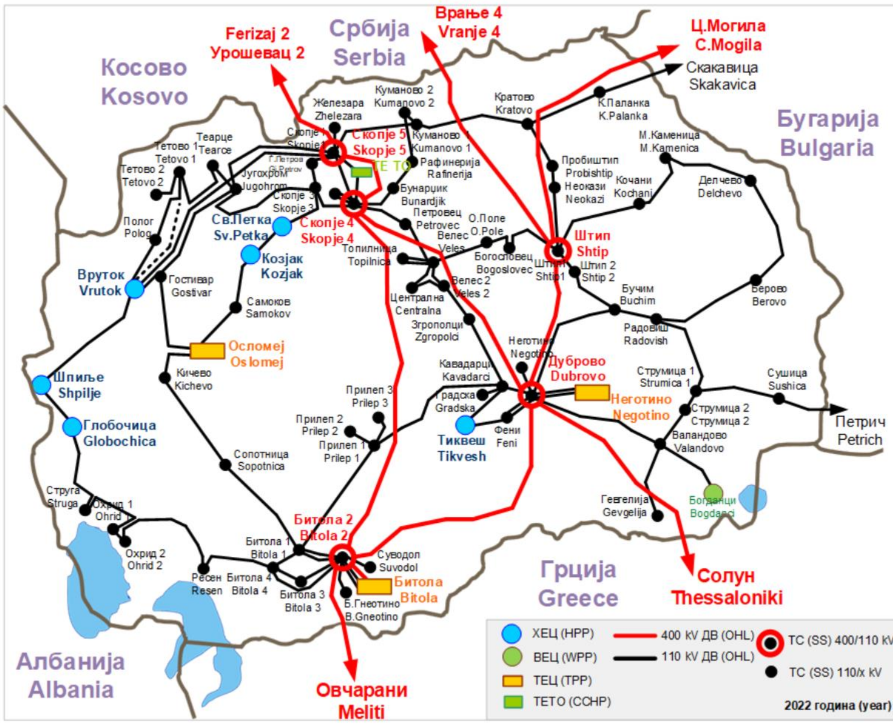


Figure 15 Topology of the transmission network of North Macedonia in 2020

According to MEPSO, in 2022 there were 41 power plants (4900 MW, or 2.2 times the capacity of the existing power plants) preparing to connect to the transmission network.

The latest version of Transmission Network Development Plan 2023 – 2032 of North Macedonia [30] is published in October 2022.

5.6 Serbia

Transmission network in Serbia consists of 400, 220 and 110 kV elements. Total transmission lines length in Serbia is around 9800 km. Serbian power system is the most connected system in the region. It includes interconnection lines to 8 neighboring systems as follows:

- 7 interconnection lines 400 kV to the neighboring countries: to Croatia (one line), to Bosnia and Herzegovina (one line), to Hungary (one line), to Romania (one line), to Bulgaria (one line), to Kosovo* (one line) and to North Macedonia (one line),
- 4 interconnection lines 220 kV to Bosnia and Herzegovina (one line), to Montenegro (two lines), to Kosovo* (one line).

According to the latest version of Serbian Transmission Network Development Plan 2023 – 2032 [31] published for public discussion in August 2023 (still not approved by NRA as of September 2023), there are forty-two main transmission substations in Serbian transmission network operated by EMS with total transformer capacity of 16041 MVA, including:

- 20 SS 400/x kV with total transformer capacity of 9750 MVA
- 14 SS 220/110 kV with capacity of 5482 MVA, and
- 9 SS 110/x kV with capacity of 750 MVA, owned by EMS.

The topology of the existing Serbian extra high voltage transmission network is shown in the following figure.

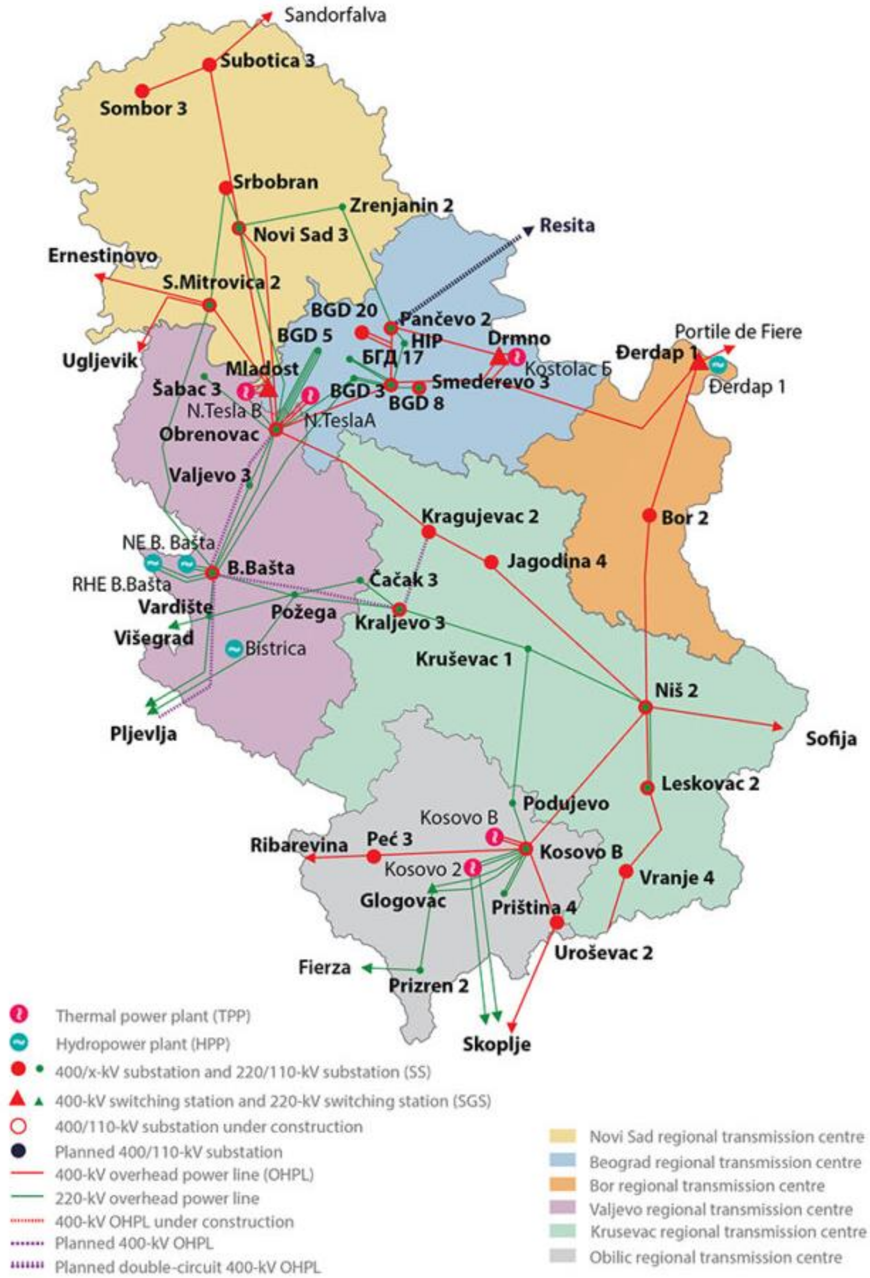


Figure 16 400 and 220 kV transmission network in Serbia (and Kosovo*) in 2022

5.7 Moldova

Transmission network in Moldova consists of 400, 330, 110 and 35 kV elements. Total transmission lines length in Moldova is around 4725 km. It includes interconnection lines to 2 neighboring systems:

- 1 interconnection line 400 kV to Romania
- 7 interconnection lines 330 kV to Ukraine,
- 11 interconnection lines 110 kV to Ukraine and
- 4 interconnection lines 110 kV to Romania but operating in isolated mode.

There are 183 transmission substations with 649 transformers in operation in Moldovan transmission network with total installed transformer capacities of 5072 MVA.

The following figure shows existing transmission network map in Moldova.

Figure 17 Existing transmission network of Republic of Moldova

The latest version of Moldovan Transmission Network Development Plan 2018 – 2027 [32] is published in January 2018 (almost 6 years ago). The Moldovan electricity system has undergone numerous structural and operational changes since then, including synchronization with the ENTSO-E network in 2022. As agreed in the Inception Report, 1 new element is assumed in Moldovan transmission network in 2028 that is relevant for this study – OHL 400 kV Vulcănești – Chisinau.

5.8 Ukraine

Transmission network in Ukraine is the largest among the EnC Contracting Parties and consists of 750, 500, 400, 330, 220, 150 and 110-135 kV elements. The total transmission lines length in Ukraine is around 23000 km. It includes 13 interconnection lines to 4 neighboring ENTSO-E systems (Poland, Hungary, Slovakia and Romania) and 7 lines 330 kV and 11 lines 110 kV to Moldova.

In Ukraine there are 137 transmission substations of 220-750 kV. Map of the existing transmission network in Ukraine is shown on the following Figure, without showing elements which are damaged or destroyed because of the war.

Figure 18 Pre-war transmission network in Ukraine

According to the Transmission System Development Plan of Ukraine for 2021– 2030, it was planned to rehabilitate 61 substations, 1,537 km of 330 kV lines, 10 km of 220 kV lines and replace 860 towers for 110–330 kV, to build new substations with the transformer capacity increased by 12,451 MVA, install new lines for 750 kV voltage – 611 km, 500 kV – 61 km, 400 kV – 55 km, 330 kV – 2,390 km, 220 kV – 90 km. The invasion by Russia has rendered this plan obsolete, and the current system has sustained significant war damage.

No changes to the transmission topology are anticipated until 2028 (pre-war topology is assumed), as agreed with the EnCS for this assignment, with the exception of one interconnection line, the OHL 400 kV Khmelnytskyi (UA) - Rzeszów (PL).

6 CALCULATION METHODOLOGY

MACZT calculation methodology is quite complex, both in its mathematical background, as well as in its implementation. In this study, ACER Recommendation 01/2019 [11] is used for calculation as it is described in detail later in this chapter. The discussions about the methodology around Europe are still underway, primarily about the market time units and CNE(C)s on which the methodology has to be applied. Some TSOs argue that it is not possible nor needed to fulfil 70% target on all CNE(C)s in every single market time unit. For example, as given in Chapter 3, in France 70% target is considered only in time units when price convergence is not reached. The Italian TSO on the North Italian border use cNTC and just one CNEC in one market time unit, while, for example in Croatia FB approach is used on all CNE(C)s. Some TSOs claim that due to different works in the system (maintenance, constructions etc.) 70% target cannot be reached and it is simply not needed in these periods and that 70% target fulfilment in these periods would result in network overbuilding. In the next period, it is necessary to make additional efforts to standardize the approach to calculations, and additional documents with explanations or changes can be expected. EnC Contracting Parties should follow the recommendations of ACER and implement the relevant decisions.

Therefore**, to avoid any confusion or misunderstanding, during the first study workshop discussions (including ACER), and Inception Report approved by the EnC Secretariat, the calculation methodology was clarified, agreed, and used in this study. It is applied on all CNE(C)s in all market time units, as requested by ACER methodology and agreed by EnCS.**

The calculation methodology used in this study is additionally verified. Basic numerical indicators (PTDFs, RAM, MCCC, MNCC that will be clarified later) calculated with this methodology were double-checked and compared with corresponding values published on the Joint Allocation Office (JAO) platform [33]. The comparison proves that calculated values were the same as the official values from JAO platform. It proves that **calculation methodology is reliable**.

6.1 Calculation methodology

In general, 70% target compliance may assume significant additional investment needs in the transmission network, especially in small systems such as in the WB6 countries. Therefore, it is of utmost importance to be precise and clear in MACZT calculation approach and methodology. The main steps in the MACZT calculation are given as follows:

- The **first step** in the MACZT calculation is the definition of the coordination area of bidding zones borders (BZBs) for capacity calculation. BZBs are combined in so-called CCR. ENTSO-E publishes the BZ Technical Report as a regular reporting on BZ configurations and this is a basis for the ACER to assess the efficiency of current BZs. The biggest region in Europe is the Core CCR, consisting of the Central West (CWE) and Central East Europe (CEE). WB6, Ukraine and Moldova are not included in the ACER's decision on CCR determination and are established by Decision 2022/03/MC-EnC (Figure 2) [3]. The calculation approach in EnC CCRs is the same like in EU.
- The **second step** is a confirmation of the network model for a certain MTU (t). The network model is built upon individual grid models which represent the bidding zones in each scenario. The bidding zones are defined as the largest geographical areas within which market

participants can exchange energy without capacity allocation. IGMs are prepared by the responsible TSOs upon assumptions and forecasts of future system. Network data, forecasting tools and reasonably certain data on planned/forced outages and grid topology are used to create IGMs. The CGM is developed for each MTU by RCC using the individual IGMs [34].

- The **third step** is the definition of CNE(C) list for the analyzed bidding zones (BZs). The basic rule for defining the CNE(C) list is to include on the list all tie lines (high impact on cross-border exchange), and all internal lines or transformers that are significantly impacted by cross-border exchanges in a certain operational situation (normal state or with one or more contingencies, depending on the TSO's risk policy).
- In the **fourth step** the calculation and collection of all the parameters needed for MACZT calculation is performed. These parameters are dependent on the type of approach (NTC or FB). For the NTC approach these parameters include maximum admissible power flow per CNE(C), GSK list[8], zone-to-hub PTDFs, zone-to-zone PTDFs, exchanges and net positions in the network model and NTC values on the BZBs. On the other hand, for the FB approach the parameters include maximum power flow and reference flow per CNE(C), GSK list, zone-to-hub PTDFs, zone-to-zone PTDFs, and exchanges and net positions in the network model.
- In the **fifth step** the calculation of margin from coordinated capacity calculation (MCCC) and margin from non-coordinated capacity calculation (MNCC) per each CNE(C) is performed. MCCC is the portion of capacity of a CNEC available for cross-zonal trade on bidding-zone borders within the considered coordination area or coordinated BZB, while MNCC is the portion of capacity of a CNEC available for cross-zonal trade on bidding-zone borders outside the considered coordination area.
- Finally, MACZT for each CNE(C) is determined in absolute and percentage value (regarding the maximum power flow). The MACZT percentage value is checked with the limit value of 70% (or higher) for the fulfilment of the regulation.

As defined in the latest EnC MC decision [35] and agreed in the Inception report:

1. CCR **Shadow South-East Europe** (Shadow SEE CCR), shall include the bidding zone borders between Contracting Parties within the WB6 area, as well as borders to the neighboring EU countries
2. CCR **Eastern Europe** (EE CCR) shall include the bidding zone border between Ukraine and Moldova (UA - MD) as well as borders to the neighboring EU countries and
3. CCR **Italy-Montenegro** (IT-ME CCR) shall include the bidding zone border between Italy and Montenegro (IT-ME).

This CCR set-up for the EnC is shown in the Figure 2.

[8] ENTSO-E defined different options for GSK list definition. It is available on the following link. The most common proportional to base case approach was used in this study.

The starting point in this analysis is the calculation of the PTDFs. This calculation is done using an adequate transmission network model. PTDFs indicate an incremental change in active power that occurs on transmission lines due to active power transfers between two regions. These regions can be defined by areas, zones, single buses, injection groups or the system slack. These values provide a linearized approximation of how the flow on the transmission lines and interfaces change in response to a power exchange increment.

PTDFs should be calculated per each critical network element (CNE) or critical network element with contingency (CNEC), both hereafters mentioned as CNE(C). Cross-zonal sensitivity is the criterion for selecting the CNE(C)s that are significantly impacted by cross-zonal trade. By definition, **cross-zonal network elements are considered to be significantly impacted. Other network elements shall be considered as CNE(C)s if their cross-zonal sensitivity exceeds a threshold of 5%** (i.e., if they have zone-to-zone $PTDF$ higher than 5% between any bidding zones). The details on this threshold will be given later in Chapter 9.

As explained earlier, nodal PTDFs are calculated by subsequent variation of the injections in each node of the network model. For every single nodal variation, the effect on every CNE(C)'s loading is monitored and calculated as a percentage of the element loading change over nodal injection change. Then the generation shift key (GSK) translates the nodal PTDFs into zonal PTDFs (or zone-to-hub PTDFs) as it converts the zonal variation into an increase of generation in specific nodes.

The GSK defines how net position change is mapped to the generating units in a bidding zone. Therefore, it contains the relation between the change in a net position of the bidding zone and the change in output of every generating unit inside the same bidding zone. The GSK values are given in dimensionless units. For instance, a value of 0,05 for one unit means that 5% of the change of the net position of the bidding zone will be realized by this unit. Technically, the GSK values are allocated to units in the network model. In cases where a generation unit contained in the GSK is not directly connected to a node of the network model (e.g., because it is connected to a voltage level not contained in the network model), its share of the GSK can be allocated to one or more nodes of the network model in order to appropriately model its technical impact on the transmission system. Those nodes are usually associated to generation on dominantly demand side (distributed sources), so they are listed on load shift key. There are many ways (so-called strategies) to generate GSKs. Each of them has different implications for the market and are used very differently across TSOs.

Using all assumptions listed above, the calculation of MACZT will be performed using the principles of the methodological paper for estimating MACZT pursuant to ACER Recommendation 01/2019 [11]. Generally, in the process of MACZT calculation there are two possible approaches, depending on capacity calculation methodology (CCM) used in the given CCR:

- NTC-based approach
- FB approach.

The existing situation in Shadow SEE CCR is estimated using NTC approach, as this approach is still in use in this region. However, it is compared with the expected future application of the FB approach in this CCR. A methodology for the calculation of MACZT for both approaches is given in ACER *Recommendation No 01/2019* [11]. Additional recommendations for long-term MACZT calculation (planning purposes) are given in ACER *Long-term capacity calculation methodology of the Core CCR* [7].

6.1.1 Calculation methodology with NTC approach

The block structure for the NTC approach methodology for each defined CNE(C) *ij* and MTU *t* is given in the following figure. It consists of the following seven steps:

1. Development of the network model for given MTU (t)
2. Nodal PTDF calculation
3. zone-to-hub and zone-to-zone PTDF calculation
4. CNE(C)s selection process
5. Calculation of margin from coordinated capacity calculation (MCCC)
6. Calculation of margin from non-coordinated capacity calculation (MNCC)
7. Calculation of MACZT.

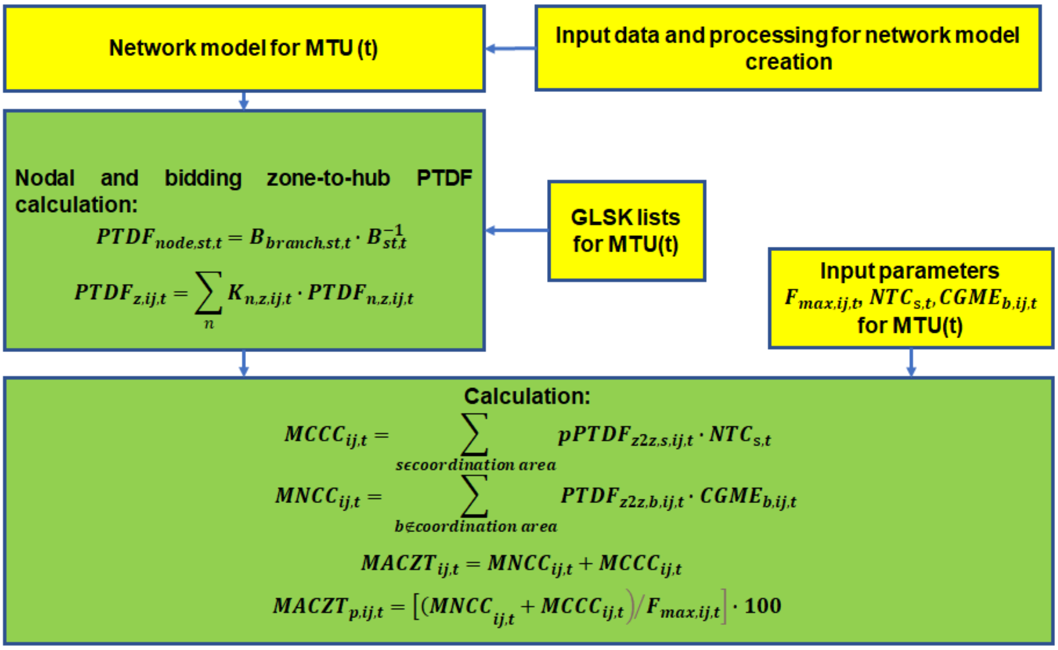


Figure 19 MACZT calculation process (mathematical representation) for NTC approach

The steps presented on the previous Figure are further explained as follows:

1) Development of the network model for given MTU (t)

The network model (including the network topology, operational data, and nodal generation/load injections) was built upon the data provided by the TSOs and available on the ENTSO-e transparency platform [2]. The existing situation was analyzed for the following two regimes: **20 January 2021 at 19:30 h** (3rd Wednesday in January at 19:30 h) and **21 July 2021 at 19:30 h** (3rd Wednesday in July at 19:30 h). Using the NTC approach only the mentioned existing regimes were analyzed. For regimes in future (with 2028 as reference year per TOR) MACZT was calculated only with the FB approach. Moreover, in the existing regimes only the WB6 Contracting Parties were analyzed.

2) Nodal PTDF calculation

The nodal PTDFs are calculated from the network model. This calculation could be performed in two different ways. The first method is based on the branch and node susceptance matrix. The second one is based on the application of the direct current (DC) load flow analysis.

a) Susceptance matrix method

The susceptance matrix method has the basis in the DC load flow analysis. The basic equations of DC flow analysis are the following:

$$\boldsymbol{P_{inj}} = \boldsymbol{B} \cdot \boldsymbol{\delta} \tag{1}$$

$$\boldsymbol{P_{branch}} = \boldsymbol{B_{branch}} \cdot \boldsymbol{\delta} \tag{2}$$

where are:

$\mathbf{P_{inj}}$ – matrix of injections in nodes (difference between generation and load),

B – node susceptance matrix,

δ - node angle matrix,

$\mathbf{P_{branch}}$ **–** branch load flow matrix,

$\mathbf{B_{branch}}$ **–** branch susceptance matrix.

As is known from the DC load flow theory Eq. (1) is used for all nodes except the reference (swing) bus node, because the angle of the reference node is not calculated but it is assumed (usually as 0 degree). The main assumptions of the DC flow analysis are:

- The line losses are neglected
- The absolute value of node voltages is considered as 1 p.u., (per unit) and thus voltage regulation in the systems and voltage drops are neglected
- The angle differences between the node branches are small, and thus the sine function of the node angle may be approximated as the value of the angle (sin(δ) ≈ δ).

Substituting **δ** from Eq. (1) in Eq. (2) the change of the $\mathbf{P_{branch}}$ in respect to $\mathbf{P_{inj}}$, and thus the nodal PTDFs are defined as follows:

$$\boldsymbol{PTDF_{node}} = \boldsymbol{B_{branch}} \cdot \boldsymbol{B^{-1}} \tag{3}$$

In MACZT calculations a certain CNE(C) define the state of the system (normal state or with contingencies), while the model is valid for a certain MTU t and thus Eq. (3) is translated to:

$$PTDF_{node,st,t} = B_{branch,st,t} \cdot B_{st,t}^{-1} \qquad (4)$$

where:

$B_{branch,st,t}$ – branch susceptance matrix (p.u.) for network state *st* and MTU *t* with size *L* x *N-1*,

$B_{st,t}$ – node susceptance matrix (p.u.) for network state *st* and MTU *t* with size *N-1* x *N-1*.

The branch susceptance matrix is built for all branches (lines or transformers) in the network model for which MACZT is calculated. This minimally includes all elements on the defined CNE(C) list (but it may also include all elements in the model for checking purposes or criteria-checking of the CNE(C) list). The node susceptance matrix includes all nodes from the model except the swing bus node (the matrix dimensions are the number of nodes in model *N* minus one). The branch and node susceptance matrix are dependent on the state of the network model (topology). Thus, the nodal PTDFs are different in normal state and for states of contingencies. It is worth emphasizing that the nodal PTDFs are independent of nodes injections (defined node generations and load in the model) but are dependent on the choice of the swing node.

An illustrative example on using Eq. (3) will be performed for a small network model shown on the following Figure.

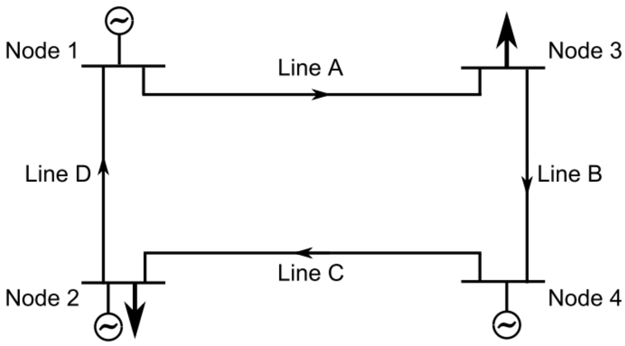


Figure 20 Illustrative example on the application of susceptance matrix method

The full susceptance node and branch matrix (for lines A, B, C, D with the assumed directions) have the following form:

$$B = \begin{bmatrix} B_{12}+B_{13} & -B_{12} & -B_{13} & 0 \\ -B_{12} & B_{12}+B_{24} & 0 & -B_{24} \\ -B_{13} & 0 & B_{13}+B_{34} & -B_{34} \\ 0 & -B_{24} & -B_{34} & B_{24}+B_{34} \end{bmatrix}$$

$$B_{branch} = \begin{bmatrix} B_{13} & 0 & -B_{13} & 0 \\ 0 & 0 & B_{34} & -B_{34} \\ 0 & -B_{24} & 0 & B_{24} \\ -B_{12} & B_{12} & 0 & 0 \end{bmatrix}$$

Assuming that the reference node is Node 1 (from **B** first row and column are removed, while from $\mathbf{B_{branch}}$ just the first column) and that all lines have the same susceptance of 0.1 p.u., the node PTDF are calculated as follows:

$$\boldsymbol{PTDF_{node}} = \begin{bmatrix} \mathbf{0} & -\boldsymbol{B_{13}} & \mathbf{0} \\ \mathbf{0} & \boldsymbol{B_{34}} & -\boldsymbol{B_{34}} \\ -\boldsymbol{B_{24}} & \mathbf{0} & \boldsymbol{B_{24}} \\ \boldsymbol{B_{12}} & \mathbf{0} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \boldsymbol{B_{12}} + \boldsymbol{B_{24}} & \mathbf{0} & -\boldsymbol{B_{24}} \\ \mathbf{0} & \boldsymbol{B_{13}} + \boldsymbol{B_{34}} & -\boldsymbol{B_{34}} \\ -\boldsymbol{B_{24}} & -\boldsymbol{B_{34}} & \boldsymbol{B_{24}} + \boldsymbol{B_{34}} \end{bmatrix}^{-1}$$

$$\boldsymbol{PTDF_{node}} = \begin{bmatrix} \mathbf{0} & -\mathbf{0.25} & -\mathbf{0.75} & -\mathbf{0.5} \\ \mathbf{0} & -\mathbf{0.25} & \mathbf{0.25} & -\mathbf{0.5} \\ \mathbf{0} & -\mathbf{0.25} & \mathbf{0.25} & \mathbf{0.5} \\ \mathbf{0} & \mathbf{0.75} & \mathbf{0.25} & \mathbf{0.5} \end{bmatrix}$$

As given in the example, usually for the reference node an extra column with zeros is added. In the case of line B (represented with the second row) it can be concluded:

- The change of injection in node 2 for +1 MW reduces the flow of line B by 0,25 MW
- The change of injection in node 3 for +1 MW increases the flow of line B by 0,25 MW
- The change of injection in node 4 for +1 MW reduces the flow of line B by 0,5 MW.

In a full network model covering the whole ENTSO-e area, the number of nodes is quite high (up to around 20000). It leads to high dimensions of the node susceptance matrix. The dimensions of the $\mathbf{B_{branch}}$ depends on the monitored CNE(C)s. The number of CNE(C)s is defined separately for each bidding zone.

b) DC load flow method

Alternative to using Eq. (4) is to directly use the DC load flow analysis. For each node PTDF for a CNE(C) *ij* and MTU *t* is calculated as follows:

$$\boldsymbol{PTDF_{n,ij,t}} = \frac{\boldsymbol{P_{n,ij,t,after}} - \boldsymbol{P_{n,ij,t,before}}}{\boldsymbol{\Delta P_n}} \tag{5}$$

where:

$\mathbf{P_{n,ij,t,after}}$ – DC flow for CNE(C) *ij* and MTU *t* after the increment of injection in node *n*

$\mathbf{P_{n,ij,t,before}}$ - DC flow for CNE(C) *ij* and MTU *t* before the increment of injection in node *n*

$\mathbf{\Delta P_n}$ – increase of injection in node n (usually +1 MW).

It can be inferred from the analysis of Eq. (2) that a particular nodal PTDF for node n, CNE(C) *ij*, and MTU *t* indicates the change in the DC flow on the studied CNE(C) with regard to the increment of injection in the node *n*.

Any topology change in the network model results in different DC flows, and thus in different nodal PTDFs.

3) Bidding zone-to-hub and zone-to-zone PTDF calculation

After the calculation of nodal PTDFs for each bidding zone the zone-to-hub PTDFs are calculated. The bidding zones considered in the network model for the defined regimes in 2021 are presented in the following table.

Table 1 Bidding zones considered for zone-to-hub PTDF calculation

Bidding zones		
AT - Austria	IT - Italy	ALEGrO - HVDC (BE-DE)
AL - Albania	MK - North Macedonia	Cobra - HVDC (NL - DK)
BE - Belgium	KS – Kosovo*	GrIT - HVDC (GR - IT)
BG - Bulgaria	NL - Netherlands	Monita - HVDC (IT - ME)
BA - Bosnia and Herzegovina	PT - Portugal	LitPol - HVDC (PL - LT)
CH - Switzerland	PL - Poland	NorNed - HVDC (NO - NL)
CZ - Czech Republic	RO - Romania	NorLink - HVDC (DE - NO)
DE - Deutschland	SK - Slovakia	SwePol - HVDC (SE - PL)
ES - Spain	SI - Slovenia	Baltic - HVDC (DE - SE)
FR - France	TR - Turkey	BritNed - HVDC (GB - NL)
GR - Greece	UA - Ukraine	IFA200 - HVDC (GB- FR)
HU - Hungary	ME - Montenegro	IFA-2 - HVDC (GB - FR)
HR - Croatia	RS - Serbia	Nemo link - HVDC (GB - BE)

Zone-to-hub PTDFs are calculated based on GSK lists. The GSK lists are formed by responsible TSOs and define the nodes in the network model which contribute to the shift reflecting the change in the bidding zone net position. These lists generally include generator nodes in the network model but may also include load nodes which represent the generators on lower voltage levels not initially included in the transmission network model. Different strategies are applicable in generating GSK list [36]. A list of common strategies is given in the following table. Apart from the strategies given in the table, some other possible strategies are also given in *Supporting document for the Nordic CCR's proposal for capacity calculation methodology* [37].

Table 2 GSK definition strategies

Type of strategy	Description
Proportional to the base case of generation or load	In this strategy the node share is proportional to the base case generation or load within the bidding zone. Thus, the share of a node in the zone-to-hub PTDF is calculated as the value of the base case generator/load divided by the total generation/load in the bidding zone.
Proportional to the participation factors	In this strategy individual participation factors for each node are defined. Thus, the share of a node in the zone-to-hub PTDF is defined by the participation factors.
Proportional to the remaining available capacity	In this strategy the node share is proportional to the remaining available generation margin (only generators are considered). Thus, the share of a node in the zone-to-hub PTDFs depends on the calculated remaining available generation margin.
Depending on the merit list	In this strategy the generation nodes shift up or down according to the defined merit order. The merit list is separately defined for the bidding zone positive or negative shift.
Interconnection shift key	In this strategy the shift is performed through a change of pattern on the interconnection flows from external bidding zones to the reference bidding zone.

A general formula for the zone-to-hub PTDFs is given as follows:

$$\boldsymbol{PTDF_{z,ij,t}} = \sum_{n} \boldsymbol{K_{n,z,ij,t}} \cdot \boldsymbol{PTDF_{n,z,ij,t}} \tag{6}$$

where:

$K_{n,z,ij,t}$ – share in the shift of node *n* in bidding zone *z* for CNE(C) *ij* an MTU *t* according to the given GSK list,

$PTDF_{n,z,ij,t}$ – nodal PTDF of node *n* in bidding zone *z* for CNE(C) *ij* an MTU *t*.

In this study for all WB6 Contracting Parties the GSK list was formed using proportional strategy to the base case generation sample. As a result, the shift share ($K_{n,z,ij,t}$) was determined as the ratio of the generation in a given node divided by the actual production of the full bidding zone for each node in the network model where a generator is present.

This approach was chosen because it is frequently employed in the EU when no particular approach has been established for a given bidding zone.

For the CORE region (bidding zones AT, BE, DE, CZ, FR, HR, HU, NL, PL, RO, SI, SK) the actual GSK list for the selected MTU (3rd Wednesday in Jan and July 2021 at 19:30) was used. It is worth emphasizing that the zone-to-hub PTDFs are dependent on the choice of the slack bus node in the network model. Thus, for a different choice of the slack bus node the results of the zone-to-hub PTDFs are different.

From the zone-to-hub PTDFs the zone-to-zone PTDFs are calculated as follows:

$$\boldsymbol{PTDF_{z2z,ij,t}} = \boldsymbol{PTDF_{z1,ij,t}} - \boldsymbol{PTDF_{z2,ij,t}} \tag{7}$$

where:

$PTDF_{z1,ij,t}$ – zone to hub PTDF of first bidding zone for CNEC *ij* and MTU *t*,

$PTDF_{z2,ij,t}$ – zone to hub PTDF of second bidding zone for CNEC *ij* and MTU *t*.

Zone-to-zone PTDFs are independent on the choice of the slack bus node in the network model and have the same value but opposite sign for different zone-to-zone direction (for example the zone-to-zone PTDF of HR-SI has the same value but opposite sign from the PTDF of SI-HR).

4) CNE(C)s selection process

The process of the CNE(C) selection can be divided into three phases which are further explained as follows:

1. The list of BASECASE CNE is formed with the modeled elements fulfilling the following 4 requirements:
    a) Element is a part of the transmission network
    b) Element is in operation
    c) Element has a reactance greater than zero (in order to avoid busbar couplers)
    d) Nominal voltage of the element is equal or greater than 220 kV.
2. The list of elements with contingency CNEC(s) is formed applying the following 2 criteria:
    a) Element is already listed above as a BASECASE CNE
    b) Given element is combined with all single contingencies in the same TSO network, including cross-border elements.
3. Final CNE(C) list is filtered:
    a) After running the calculation on the CNE(C)s list, only CNE(C)s with at least one zone-to-zone PTDF (representing a real bidding zone border) higher than **5%** remain on the final CNE(C) list
    b) Additionally, both directions are used, meaning that CNE(C) with OPPOSITE direction is also added to the CNE(C)s list.

As mentioned above, the threshold of 5% of the zone-to-zone PTDFs is used according to Article 15 of the ACER *Long-term capacity calculation methodology of the Core CCR* [7]. In this process of CNE(C) selection a vast number of CNE(C)s per each WB6 Contracting Parties was selected. However, for the NTC approach only limiting CNE(C)s should be monitored, and thus filtered results are also generated.

In parallel, within this study a **questionnaire for the participating TSOs** was organized to collect their operational experience in characteristic regimes and with limiting elements for each BZBs. The questionnaire responses are given in Appendix 2 and were included in the study analysis with NTC approach.

5) Margin from coordinated capacity calculation (MCCC)

MCCC represents the portion of capacity of a CNE(C) available for cross-zonal trade on bidding-zone borders within the considered coordination area. The WB6 coordination area included the BZBs presented in the following table. The coordination area includes all BZBs among the WB6 Contracting Parties and between the WB6 Contracting Parties and neighboring EU Member States.

Table 3 Bidding zones borders included in the WB6 coordination area

Bidding zones borders of WB6 coordination area	
AL-ME/ ME-AL	RS-KS/ KS-RS
AL-RS/ RS-AL	RS-HR/ HR-RS
AL-KS/ KS-AL	RS-RO/ RO-RS
AL-GR/ GR-AL	RS-BG/ BG-RS
BA-ME/ ME-BA	RS-HU/ HU-RS
BA-RS/ RS-BA	ME-KS/ KS-ME
BA-HR/HR-BA	MK-KS/ KS-MK
RS-ME/ ME-RS	MK-GR/ GR-MK
RS-MK/ MK-RS	MK-BG/ BG-MK

In the NTC approach the MCCC is calculated as follows:

$$\boldsymbol{MCCC_{ij,t}} = \sum_{\boldsymbol{s\epsilon coordination\ area}} \boldsymbol{pPTDF_{z2z,s,ij,t} \cdot NTC_{s,t}} \tag{8}$$

where:

$pPTDF_{z2z,s,ij,t}$ – positive zone-to-zone PTDF on coordinated BZB s for CNE(C) *ij* and MTU *t*,

$NTC_{s,t}$ – value of NTC on coordinated BZB *s* and MTU *t*.

In Eq. (8) only positive zone-to-zone PTDFs are considered. In the calculation a coordination border is considered only once (for different BZBs directions zone-to-zone PTDFs have the same value but opposite sign).

It is important to note that relevant $NTC_{s,t}$ values on the coordinated BZBs are defined by each participating TSO and given in the questionnaire responses.

6) Margin from non-coordinated capacity calculation (MNCC)

MNCC represents the portion of capacity of a CNE(C) available for cross-zonal trade on bidding-zone borders outside the considered coordination area. In the NTC approach this element is calculated as follows:

$$\boldsymbol{MNCC_{ij,t}} = \sum_{\boldsymbol{b\notin coordination\ area}} \boldsymbol{PTDF_{z2z,b,ij,t} \cdot CGME_{b,ij,t}} \tag{9}$$

where:

$PTDF_{z2z,s,ij,t}$ –zone-to-zone PTDF on the oriented non-coordinated BZB *b* for CNE(C) *ij* and MTU *t*,

$CGME_{b,ij,t}$ – value of scheduled exchanges (or network model forecast of the net exchange) on the oriented non-coordinated BZB *b* for CNE(C) *ij* and MTU *t*.

The oriented non-coordinated BZBs include all the BZBs in the network model not included in the previously mentioned coordination area of WB6. In the calculation of MNCC each non-coordinated BZB is considered only in one direction. An overview of the non-coordinated BZBs used in the calculations is shown in the following table.

Table 4 Non-coordinated BZBs for WB6 Contracting Parties

Non-coordinated bidding zones borders		
AT-CH or CH-AT	CZ-DE or DE-CZ	HU-SI or SI-HU
AT-CZ or CZ-AT	CZ-PL or PL-CZ	HU-SK or SK-HU
AT-DE or DE-AT	CZ-SK or SK-CZ	PL-SK or SK-PL
AT-HU or HU-AT	FR-DE or DE-FR	PT-ES or ES-PT
AT-IT or IT-AT	FR-CH or CH-FR	RO-UA or UA-RO
AT-SI or SI-AT	FR-ES or ES-FR	SK-UA or UA-SK
BE-FR or FR-BE	FR-IT or IT-FR	SI-IT or IT-SI
BE-NL or NL-BE	DE-CH or CH-DE	CH-IT or IT-CH
BG-GR or GR-BG	DE-NL or NL-DE	ALEGrO - HVDC (BE-DE)
BG-RO or RO-BG	DE-PL or PL-DE	Cobra - HVDC (NL - DK)
BG-TR or TR-BG	GR-TR or TR-GR	Monita - HVDC (IT - ME)
HR-HU or HU-HR	HU-UA or UA-HU	GrIT - HVDC (GR - IT)
HR-SI or SI-HR	HU-RO or RO-HU	

The values of the scheduled exchanges ($CGME_{b,ij,t}$) were not calculated for the two regimes in 2021. These values were taken from the tab “Total Commercial Schedules [12.1.F]” on the ENTSO-e transparency platform [2]. For a certain BZB direction the adequate difference of two totals was used for each non-coordinated BZB.

7) Margin available for cross-zonal trade (MACZT)

MACZT represents the portion of capacity of a CNE(C) available for cross-zonal trade. The value of MACZT in MW (MACZT) and % (MACZT_p) is calculated according to the following equations:

$$\boldsymbol{MACZT_{ij,t} = MCCC_{ij,t} + MNCC_{ij,t}} \tag{10}$$

$$\boldsymbol{MACZT_{p,ij,t} = \left[\frac{MCCC_{ij,t} + MNCC_{ij,t}}{F_{max,ij,t}}\right] \cdot 100} \tag{11}$$

where:

$\mathbf{MCCC_{ij,t}}$ – margin from coordinated capacity calculation for CNE(C) *ij* and MTU *t*,

$\mathbf{MNCC_{ij,t}}$ – margin from non-coordinated capacity calculation for CNE(C) *ij* and MTU *t*,

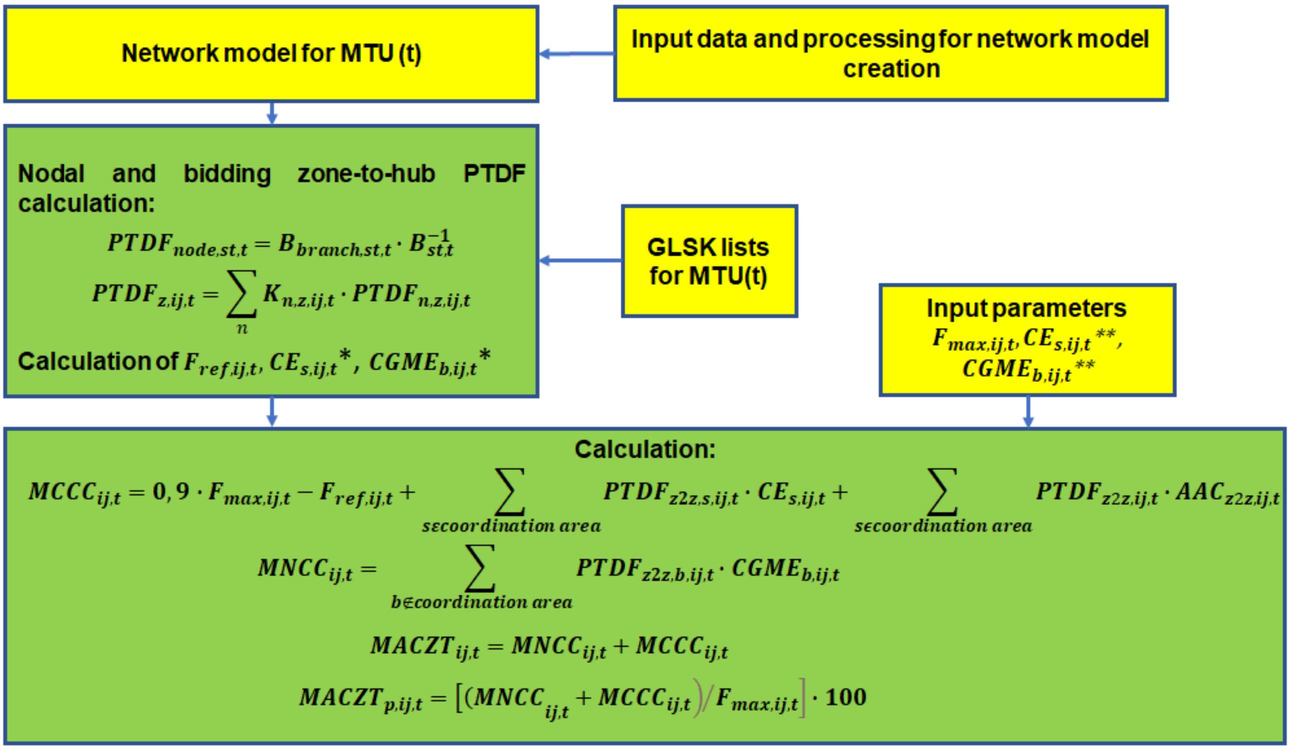
$\mathbf{F_{max,ij,t}}$ - maximum power flow (MW) for CNE(C) *ij* and MTU *t*.

The value of $F_{max,ij,t}$ for a CNE(C) *ij* in MTU *t* was taken from the network model. This limit typically represents thermal rating of the relevant CNE(C), although other limitations may apply (stability, operational, etc.). Usually $F_{max,ij,t}$ is defined by the responsible TSO in the network modeling phase.

To recap, this methodology is related to **NTC approach only**. In the following subchapter the **FB** approach methodology will also be explained in detail.

6.1.2 Calculation methodology with FB approach

Block diagram for the FB approach for each defined CNE(C) and MTU is given in the following figure.



*only regimes for 3rd Wednesday 2028 at 19:30
**only regimes for 3rd Wednesday 2021 at 19:30

Figure 21 MACZT calculation process (mathematical representation) for FB approach

It consists of the same seven basic steps, but with different calculation background:

1. Creation of the network model for given MTU (t)
2. Nodal PTDF calculation
3. Zone-to-hub and zone-to-zone PTDF calculation
4. CNE(C)s selection process
5. Calculation of margin from coordinated capacity calculation (MCCC)
6. Calculation of margin from non-coordinated capacity calculation (MNCC)
7. Calculation of MACZT.

Each step details are given as follows:

1) Development of the network model for a certain MTU (t)

For FB approach, the future network model was also created for two power system regimes in 2028: 19 January 2028 at 19:30 h (3rd Wednesday in January at 19:30 h) and 19 July 2028 at 19:30 h (3rd Wednesday in July at 19:30 h). The network model (including network topology, operational data, and nodal generation/load injections) was built by upgrading the network models of the existing power system regimes. Power system balances in WB6 were defined as given in the regional SECI transmission system models. In 2028 new bidding zone was built – Moldova, while the bidding zone of Ukraine was extended (modeled as equivalent network in 2021 models). As agreed with the EnCS, in 2028 in Moldova only one new internal network element was added to the current topology - OHL 400 kV Vulcănești – Chisinau.

In Ukraine pre-war network topology is assumed for 2028, except for one interconnection line, the OHL 400 kV Khmelnytskyi (UA) - Rzeszów (PL).

2) Nodal PTDF calculation

The process of nodal PTDF computation for the 2021 and 2028 regimes is the same in the FB approach as it is in the NTC approach. For the calculation of zone-to-hub PTDFs in 2028 for the CORE region (bidding zones AT, BE, DE, CZ, FR, HR, HU, NL, PL, RO, SI, SK) the proportional principle was used (node generation divided by total bidding zone generation) as in rest of the bidding zones (the GSK list for the regimes in 2028 was not available as it is for selected historical regimes in 2021).

3) Zone-to-hub and zone-to-zone PTDF calculation

The zone-to-hub and zone-to-zone PTDF calculation process for the 2021 and 2028 regimes is the same in the FB approach as it was previously described using the NTC approach. The bidding zone of Moldova and Ukraine was included for 2028 regimes, and PTDFs were computed for this zone.

4) CNE(C)s selection process

The CNE(C)s selection process is the same as explained before for the NTC approach. As for the WB6 Contracting Parties, the bidding zones of Ukraine and Moldova are subject to the same principle.

5) Margin from coordinated capacity calculation (MCCC)

In the FB approach the MCCC is calculated according to the following equation:

$$\begin{aligned} \boldsymbol{MCCC_{ij,t}} = \mathbf{0,9} \cdot \boldsymbol{F_{max,ij,t}} - \boldsymbol{F_{ref,ij,t}} + \sum_{s\epsilon coordination\ area} \boldsymbol{PTDF_{z2z,s,ij,t}} \cdot \boldsymbol{CE_{s,ij,t}} \\ + \sum_{s\epsilon coordination\ area} \boldsymbol{PTDF_{z2z,s,ij,t}} \cdot \boldsymbol{AAC_{z2z,s,ij,t}} \end{aligned} \tag{12}$$

where:

$\mathbf{F_{max,ij,t}}$ - maximum power flow (MW) for CNE(C) *ij* and MTU *t*,

$\mathbf{F_{ref,ij,t}}$ - reference flow for CNE(C) *ij* and MTU *t*,

$\mathbf{PTDF_{z2z,s,ij,t}}$ –zone-to-zone PTDF on coordinated BZB *s* for CNE(C) *ij* and MTU *t*,

$\mathbf{CE_{s,ij,t}}$ - commercial cross-border exchanges among the coordinated BZBs,

$\mathbf{AAC_{z2z,s,ij,t}}$ - already allocated capacities on coordinated BZBs.

In Eq (12) only 90% of $F_{max,ij,t}$ is used for the calculation of the MCCC, because it is as assumed that the flow reliability margin (FRM) of each CNE(C) is 10%, as recommended by ACER if the CNE(C) is not already used in FB calculation initiatives[9].

The following Table shows the BZBs for the WB6 coordination area in the FB method for 2021 power system regimes.

Table 5 Bidding zones borders included in the WB6 coordination area and FB approach

Bidding zones borders of WB6 coordination area	
AL-ME or ME-AL	RS-KS or KS-RS
AL-RS or RS-AL	RS-HR or HR-RS
AL-KS or KS-AL	RS-RO or RO-RS
AL-GR or GR-AL	RS-BG or BG-RS
BA-ME or ME-BA	RS-HU or HU-RS
BA-RS or RS-BA	ME-KS or KS-ME
BA-HR or HR-BA	MK-KS or KS-MK
RS-ME or ME-RS	MK-GR or GR-MK
RS-MK or MK-RS	MK-BG or BG-MK

For the future regimes **in 2028 two coordination areas (CCRs)** are analyzed:

1. WB6 coordination area including BZBs between WB6 Contracting Parties and EU Member States and
2. UA-MD coordination including BZBs between UA/MD and EU Member States area.

For the WB6 coordination area the BZBs are practically the same as in 2021, with the addition of the BZB AL-MK or MK-AL due to the construction of new OHL 400 kV Bitola (MK) - Elbasan 2 (AL). UA-MD coordination area has the BZBs given in the following table.

Table 6 Bidding zones borders in UA-MD coordination area

Bidding zones borders of UA - MD coordination area	
UA-MD or MD-UA	UA-SK or SK-UA
UA-PL or PL-UA	UA-RO or RO-UA
UA-HU or HU-UA	MD-RO or RO-MD

[9]ACER: Intrady capacity calculation methodology in Core CCR, 2019

It is important to note that in calculation according to Eq. (12) each BZB is considered only in one direction.

As previously mentioned in the NTC approach $F_{max,ij,t}$ for a CNE(C) *ij* and MTU *t* typically represents the thermal rating of the relevant CNE(C), although other limitations may apply (stability, operational, etc.). This value is taken from the network model.

The reference flow for CNE(C) *ij* and MTU *t* ($Fref_{ij,t}$) is obtained from the DC load flow analysis. The reference flow is calculated separately for each power system regime (due to the changes in the reference flow for normal and contingency conditions). In the FB approach the reference flow is calculated for each CNE(C) in the same manner for current and future regimes.

In the FB approach for the current regimes commercial cross-border exchanges among the coordinated BZBs ($CE_{s,ij,t}$) were approximated with the “Total Commercial Schedules [12.1.F]” given on the ENTSO-e transparency platform [2] as the difference of two totals for each coordinated BZB.

For future regimes in 2028 $CE_{s,ij,t}$ was calculated according to the following methodology[10]:

1. For each cross-border element the loop flow is calculated as follows:

$$\boldsymbol{LF_{l,t} = F_{ref,l,t} - \sum_{g \varepsilon All} PTDF_{z2h,g,l,t} \cdot NP_{g,t}} \quad (13)$$

where:

$F_{ref,l,t}$ - reference flow for cross-border element *l* and MTU *t*,

$PTDF_{z2h,g,l,t}$ –zone-to-hub PTDF of bidding zone g, cross-border element *l* and MTU *t*,

$NP_{g,t}$ - neto position of bidding zone g for MTU (*t*).

For calculating the loop-flow (zero-balanced flow) all biding zones in the network model are considered in the summation term of Eq. (13).

2. For each cross-border the market flow is calculated as follows:

$$\boldsymbol{MF_{l,t} = F_{ref,l,t} - LF_{l,t} = \sum_{g \varepsilon All} PTDF_{z2h,g,l,t} \cdot NP_{g,t}} \quad (14)$$

where:

$PTDF_{z2h,g,l,t}$ –zone-to-hub PTDF of bidding zone *g,* cross-border element *l* and MTU *t*,

$NP_{g,t}$ - neto position of bidding zone *g* for MTU (*t*).

3. The scheduled flows ($CE_{s,\,ij}$, and *t*) on each BZB were determined by adding the market flows of all cross-border components that make up the BZB.

---

[10] Explanatory document to the common methodology for redispatching and countertrading cost-sharing for single day-ahead and intraday coupling for Capacity Calculation Region Core in accordance with Article 74 of the Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a Guideline on Capacity Allocation and Congestion Management, 22 February 2019

This process took into account cross-border elements at all voltage levels (including the 110 kV voltage level). Thus, the formula for scheduled flows ($CE_{s,ij,t}$) is the following:

$$\boldsymbol{CE_{s,ij,t}} = \sum_{l} \boldsymbol{MF_{l,t}} \tag{15}$$

where:

$MF_{l,t}$ - market flow of cross-border element *l* which is part of the coordinated BZB for CNE(C) *ij* and MTU *t*.

This process of scheduled flow calculation is an approximation in which unscheduled flows are ignored.

As the long-term capacity calculation is performed, the term

$$\sum_{s\epsilon coordination\ area} \boldsymbol{PTDF_{z2z,s,ij,t}} \cdot \boldsymbol{CE_{s,ij,t}} \text{ of Eq. (12)}$$

was also taken into consideration. In principle, this term removes the effect of scheduled flows within the coordination area.

For intraday and day-ahead calculation of MACZT this term is omitted.

Already allocated capacities and the term $\sum_{s\epsilon coordination\ area} \boldsymbol{PTDF_{z2z,s,ij,t}} \cdot \boldsymbol{AAC_{z2z,s,ij,t}}$ for long-term capacity calculation is omitted and it is assumed to be equal to zero. This value was not available for 2028, so with this approach the calculation is on the safe side.

For intraday and day-ahead MACZT calculation this term should be considered (outside the scope of this study).

6) Margin from non-coordinated capacity calculation (MNCC)

In NTC and FB approach the MNCC part of MACZT is calculated as defined in Eq. (9). Thus, for the regimes in 2021 the results of MNCC per each CNE(C) are the same in the FB and in the NTC approach (the same calculation methodology).

For future regimes two coordination areas are distinguished, so MNCC part includes different BZBs. For the WB6 Contracting Parties the BZBs are the same as above. For UA-MD Contracting Parties the BZBs included in the non-coordinated part the BZBs are given in the following table.

Table 7 Non-coordinated BZBs for UA-MD Contracting Parties

Non-coordinated bidding zones borders		
AT-CH or CH-AT	CZ-DE or DE-CZ	HU-SK or SK-HU
AT-CZ or CZ-AT	CZ-PL or PL-CZ	PL-SK or SK-PL
AT-DE or DE-AT	CZ-SK or SK-CZ	PT-ES or ES-PT
AT-HU or HU-AT	FR-DE or DE-FR	SI-IT or IT-SI
AT-IT or IT-AT	FR-CH or CH-FR	CH-IT or IT-CH
AT-SI or SI-AT	FR-ES or ES-FR	ALEGrO - HVDC (BE-DE)
BE-FR or FR-BE	FR-IT or IT-FR	Cobra - HVDC (NL - DK)
BE-NL or NL-BE	DE-CH or CH-DE	Monita - HVDC (IT - ME)
BG-GR or GR-BG	DE-NL or NL-DE	GrIT - HVDC (GR - IT)
BG-RO or RO-BG	DE-PL or PL-DE	AL-ME or ME-AL
BG-TR or TR-BG	GR-TR or TR-GR	AL-RS or RS-AL
HR-HU or HU-HR	HU-SI or SI-HU	AL-KS or KS-AL
HR-SI or SI-HR	HU-RO or RO-HU	AL-GR or GR-AL
BA-ME or ME-BA	BA-HR or HR-BA	RS-MK or MK-RS
BA-RS or RS-BA	RS-ME or ME-RS	RS-KS or KS-RS
RS-HR or HR-RS	RS-BG or BG-RS	ME-KS or KS-ME
RS-RO or RO-RS	RS-HU or HU-RS	MK-KS or KS-MK
MK-GR or GR-MK	MK-BG or BG-MK	

For the future regimes in 2028 the calculation methodology for $CGME_{b,ij,t}$ is similar to the calculation methodology for ($CE_{s,ij,t}$). The following formula is applied:

$$\boldsymbol{CGME_{b,ij,t}} = \sum_{f} \boldsymbol{MF_{f,t}} \tag{16}$$

where:

$MF_{f,t}$ - market flow of cross-border element *f* which is part of the non-coordinated BZB for CNE(C) *ij* and MTU *t*.

7) Margin available for cross-zonal trade (MACZT)

In FB approach the MACZT value is calculated in the same way as in the NTC approach - according to Eq. (10) and (11).

6.2 Calculation example

In what follows it is decided to use the power systems of Montenegro and North Macedonia as an illustrative example to make the use of the NTC and FB method easier to understand.

Graphical presentation of the analyzed CNE(C) is presented in the following figure.

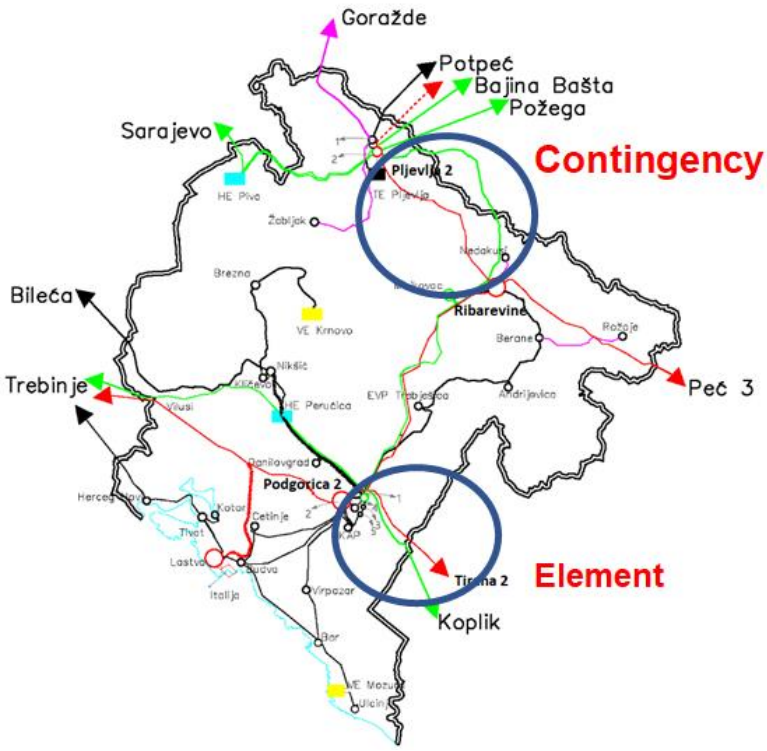


Figure 22 Graphical representation of analyzed CNE(C)

The input data for the selected example are:

- Selected time snapshot: **20 January 2021 at 19:30 h.**
- Selected CNE(C): **OHL 400 kV Podgorica 2 - Tirana 2** with contingency **OHL 400 kV Ribarevine - Pljevlja 2** in the **direct** direction.
- Analyzed methodology: **NTC** and **FB** approach.

6.2.1 NTC approach results

As a first step, the nodal PTDFs and bidding zone-to-hub PTDFs for the analyzed CNE(C) are calculated. The following Table shows zone-to-hub PTDF calculation results from the nodal PTDFs, for the bidding zone of North Macedonia (MK) and given CNE(C).

Table 8 North Macedonia zone-to-hub PTDF calculation results for the analyzed CNE(C)

Node name	Share in GSK list	Value of nodal PTDF	Contribution to zone-to-hub PTDF
YBITOL1	0,16431	0,11755	0,019315
YBITOL52	0,16406	0,115498	0,018949
YGLOBO5	0,02153	0,105932	0,002281
YKOZJA5	0,06562	0,101967	0,006691
YOSLOM5	0,07178	0,103879	0,007456
YSPILJ5	0,01846	0,105012	0,001939
YSVPET5	0,03691	0,101497	0,003746
YTE-TO5	0,21226	0,100168	0,021262
YTIKVE5	0,04102	0,105198	0,004315
YTPPNE5	0,08203	0,105051	0,008617
YVBOGD5	0,0041	0,103838	0,000426
YVRUTO5	0,11792	0,101903	0,012016
Total zone-to-hub PTDF MK			0,107013

With the 12 nodes on the GSK list (generator nodes in the network model), bidding zone North Macedonia obviously has 12 generator nodes with the share proportional to the power generation in each node regarding total generation in the entire bidding zone.

Table 9 NTC approach MCCC calculation for the example

BZB	NTC value (MW)	$PTDF_{z2z}$	$pPTDF_{z2z}$ * NTC (MW)
AL-ME	300	-0,2497355	0
ME-AL	300	0,2497355	74,920644
AL-RS	0	0,1864995	0
RS-AL	0	-0,1864995	0
AL-KS	250	0,1398062	34,9515525
KS-AL	250	-0,1398062	0
AL-GR	400	0,075515	30,205988
GR-AL	400	-0,075515	0
BA-ME	500	-0,0039068	0
ME-BA	450	0,0039068	1,758042
BA-RS	500	-0,0671427	0
RS-BA	600	0,0671427	40,28562
BA-HR	1000	-0,0097469	0
HR-BA	1000	0,0097469	9,74694
RS-ME	300	0,0632359	18,970782
ME-RS	200	-0,0632359	0
RS-MK	300	-0,0780982	0
MK-RS	250	0,0780982	19,524545
RS-KS	0	-0,0466933	0
KS-RS	0	0,0466933	0
RS-HR	600	0,0573958	34,437456
HR-RS	500	-0,0573958	0
RS-RO	800	-0,0249288	0
RO-RS	800	0,0249288	19,943056
RS-BG	300	-0,0509381	0
BG-RS	350	0,0509381	17,8283385
RS-HU	800	0,0245111	19,608912
HU-RS	700	-0,0245111	0
ME-KS	300	-0,1099293	0
KS-ME	300	0,1099293	32,978781
MK-KS	250	0,0314049	7,8512125
KS-MK	400	-0,0314049	0
MK-GR	400	-0,0328864	0
GR-MK	400	0,0328864	13,154556
MK-BG	250	0,0271601	6,7900175
BG-MK	300	-0,0271601	0
MCCC (MW)			**382.96**

The final value of the zone-to-hub PTDF of North Macedonia is obtained by summing all contributions to the zone-to-hub PTDF (Eq. (6)).

After calculation of zone-to-hub and zone-to-zone PTDFs, the MCCC is calculated according to Eq. (8). The results are given in the following table, while NTC values are given in the following figure.

The majority of the WB6 Contracting Parties have well-connected power systems, but they also have very low NTC values on the borders of the bidding zones, which is crucial to notice.

Therefore, an important task for the TSOs in Contracting Parties is to increase capacity usage and efficiency not only on the cross-border, but also on the internal network elements.

Figure 23 NTC values for the given example graphically represented in the coordination area

MNCC values (Eq. (9) are shown in the following table, while scheduled commercial exchanges are shown in the following figure.

Table 10 NTC approach MNCC calculation for the example

BZB	$CGME_b$ (MW)	$PTDF_{z2z}$ (MW)	$PTDF_{z2z}$ * $CGME_b$ (MW)
AT-CH	0,008228	0,008228	0,008228
AT-CZ	1,496904	1,496904	1,496904
AT-DE	4,182095	4,182095	4,182095
AT-HU	-1,72074	-1,72074	-1,72074
AT-IT	0,487812	0,487812	0,487812
AT-SI	2,268818	2,268818	2,268818
BE-FR	0,965809	0,965809	0,965809
BE-NL	0,286461	0,286461	0,286461
BG-GR	-33,0856	-33,0856	-33,0856
BG-RO	3,147124	3,147124	3,147124
BG-TR	1,591498	1,591498	1,591498
HR-HU	-19,6321	-19,6321	-19,6321
HR-SI	2,997124	2,997124	2,997124
CZ-DE	-1,14061	-1,14061	-1,14061
CZ-PL	0,690603	0,690603	0,690603
CZ-SK	-4,36977	-4,36977	-4,36977
FR-DE	2,197632	2,197632	2,197632
FR-CH	0,867058	0,867058	0,867058
FR-ES	0,414444	0,414444	0,414444
FR-IT	5,090367	5,090367	5,090367
DE-CH	0,666602	0,666602	0,666602
DE-NL	0,069228	0,069228	0,069228
DE-PL	0,831085	0,831085	0,831085
GR-TR	-2,20657	-2,20657	-2,20657
HU-UA	0,085043	0,085043	0,085043
HU-RO	-16,7601	-16,7601	-16,7601
HU-SI	0	0	0
HU-SK	2,123199	2,123199	2,123199
PL-SK	-0,07844	-0,07844	-0,07844
PT-ES	-0,00419	-0,00419	-0,00419
RO-UA	-0,19995	-0,19995	-0,19995
SK-UA	-1,56319	-1,56319	-1,56319
SI-IT	-1,00708	-1,00708	-1,00708
CH-IT	5,908683	5,908683	5,908683
ALEGrO	0,18431	0,18431	0,18431
Cobra	-0,9757	-0,9757	-0,9757
Monita	86,74475	86,74475	86,74475
GrIT	1,386933	1,386933	1,386933
MNCC (MW)			**41,95**

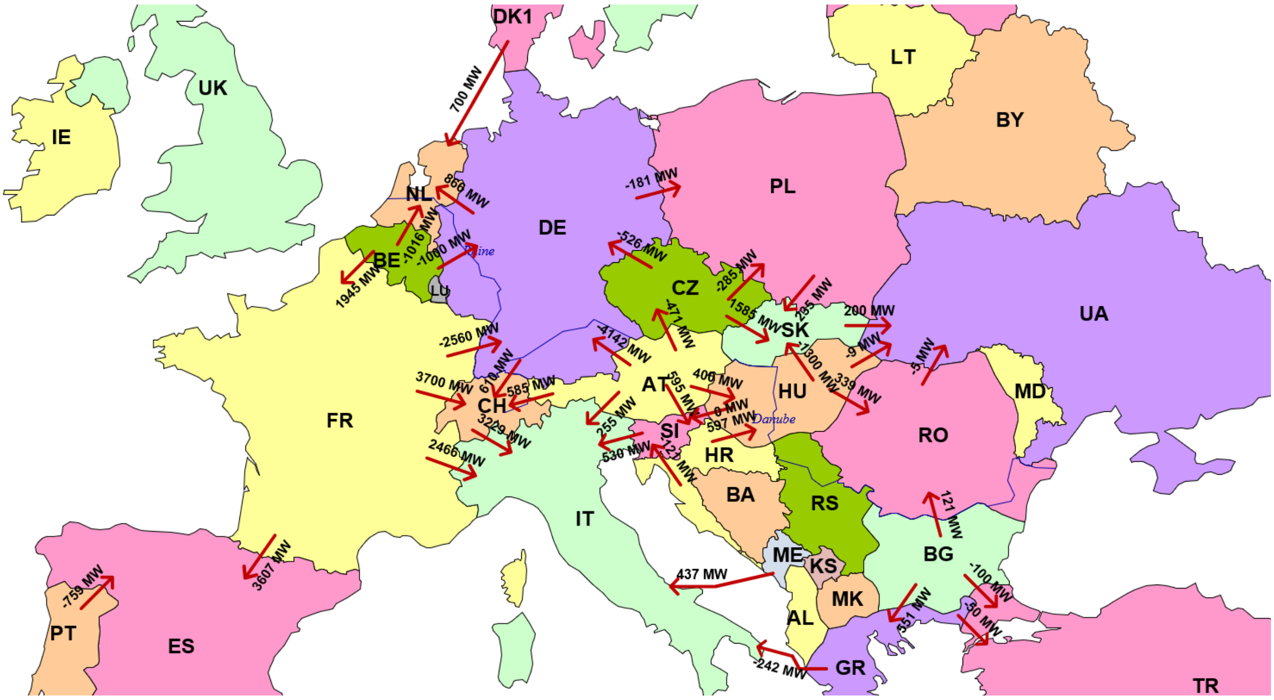


Figure 24 Graphical representation of CGM_b in the non-coordination area for the analyzed example

In this example, using the NTC method, the resulting MACZT value is:

$$\boldsymbol{MACZT_{ij,t} = MCCC_{ij,t} + MNCC_{ij,t} = 382,96 + 41,95 = 424,91\ MW}$$

$$\boldsymbol{MACZT_{p,ij,t} = \left[\frac{MCCC_{ij,t} + MNCC_{ij,t}}{F_{max,ij,t}}\right] \cdot 100 = \left[\frac{424,91}{1316}\right] \cdot 100 = 32,29\%}$$

Clearly, with the NTC approach the final MACZT value is **32,29%, which is far below the 70% target**.

6.2.2 FB approach results

In the FB approach the calculations of the zone-to-hub and zone-to-zone PTDFs are the same as in the NTC approach.

The MCCC is calculated according to Eq. (12). Initially, the contribution to the MCCC from the commercial cross-border exchanges among the coordinated BZBs (CE_s) is calculated. This is presented in the following table. Cross-border exchanges are graphically shown in the following map.

Table 11 FB approach contribution of CE_s for the example

BZB	CE_s (MW)	$PTDF_{z2z}$	$PTDF_{z2z}$ * CE_s (MW)
AL-GR	150	0,075515	11,32725
AL-ME	29	0,249735	7,242329
AL-RS	0	0,1865	0
AL-KS	0	0,139806	0
BA-HR	585	-0,00975	-5,70196
BA-ME	194	-0,00391	-0,75791
BA-RS	364	-0,06714	-24,4399
BG-MK	263	-0,02716	-7,1431
BG-RS	-75	0,050938	-3,82036
HR-RS	-47	-0,0574	2,697601
GR-MK	-14	0,032886	-0,46041
HU-RS	-247	-0,02451	6,054252
KS-ME	0	0,109929	0
KS-MK	0	-0,0314	0
KS-RS	0	0,046693	0
ME-RS	-135	-0,06324	8,536852
MK-RS	-218	0,078098	-17,0254
RO-RS	-351	0,024929	-8,75002
Total (MW)			-32,24

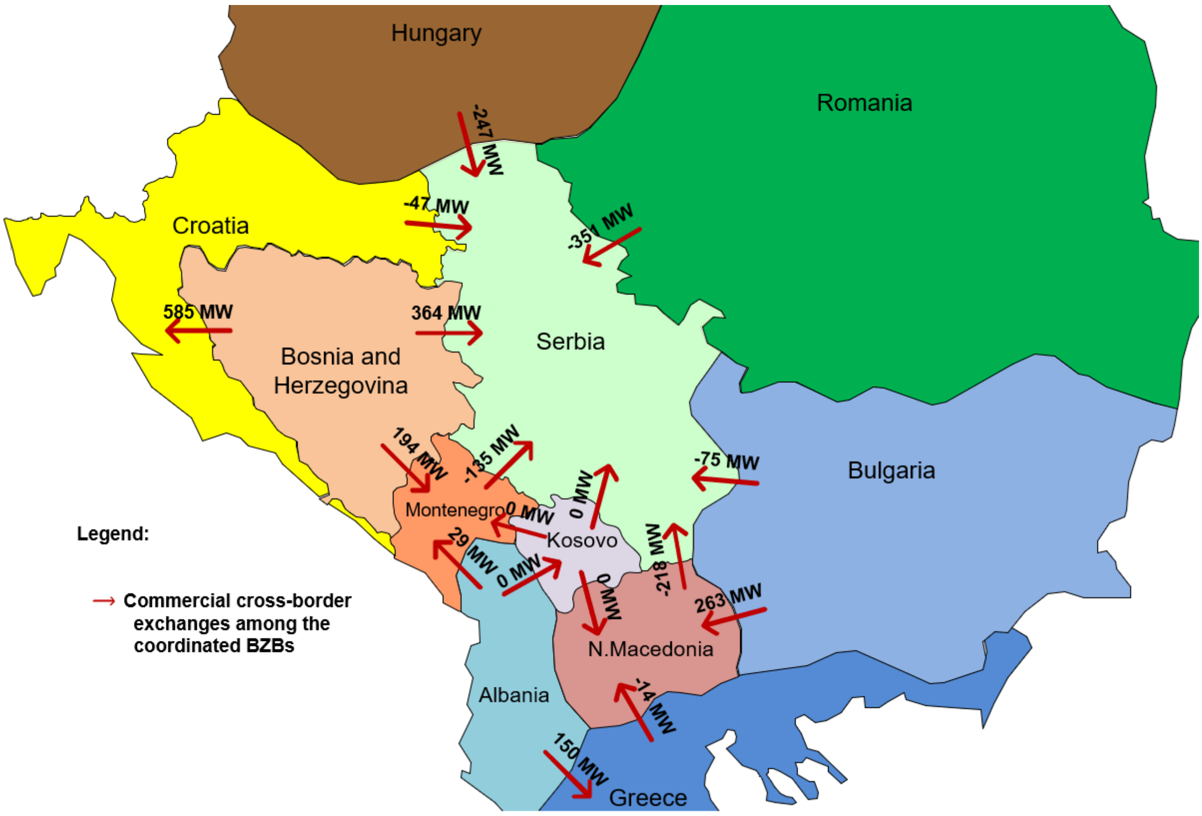


Figure 25 Graphical representation of the CE_s in the coordination area for analyzed example

The reference flow for analyzed case was -247,71 MW, thus the application of Eq. (12) omitting the term related to already allocated capacity (value 0 MW) yields to:

$$
\begin{aligned}
MCCC_{ij,t} &= 0,9 \cdot F_{max,ij,t} - F_{ref,ij,t} + \sum_{s\epsilon coordination\ area} PTDF_{z2z,s,ij,t} \cdot CE_{s,ij,t} \\
&+ \sum_{s\epsilon coordination\ area} PTDF_{z2z,s,ij,t} \cdot AAC_{z2z,s,ij,t} \\
&= 0,9 * 1316 - (-247,71) - 32,4 + 0 = 1400\ MW
\end{aligned}
$$

The value of MNCC is identical to the one calculated for the NTC approach and equals to 41,95 MW.

In this example, using the FB method, the resulting MACZT value is:

$$MACZT_{ij,t} = MCCC_{ij,t} + MNCC_{ij,t} = 1400,193 + 41,95 = 1442,14\ MW$$

$$MACZT_{p,ij,t} = \left[\frac{MCCC_{ij,t} + MNCC_{ij,t}}{F_{max,ij,t}}\right] \cdot 100 = \left[\frac{1442,14}{1316}\right] \cdot 100 = 109,55\%$$

With the FB approach the final MACZT value is equal to 109,55%, which is above the 70% target value, and far above NTC approach result of 32,29%.

7 ESTIMATION OF THE 70% TARGET FULFILLMENT IN THE EXISTING NETWORK IN WB6 AND COMPARISON OF NTC AND FLOW-BASED APPROACH

In this chapter the existing transmission network is analyzed based on 3rd Wednesday 19:30 in January and July 2021 equivalent model. Estimation of the actual level of 70% target fulfillment is provided for each WB6 Contracting Party, both with NTC and FB approach.

The chapter is conceptually divided into two main parts. The first part gives overall recapitulation of obtained results on the regional level, while second part gives more detailed results for each Contracting Party.

The input data from the TSOs had to be gathered in order to execute the computations using the NTC approach. A survey was created and sent to the regional TSOs. All TSOs gave prompt responses. The survey results are included in Appendix 2 and used in full for the purpose of this study.

It is important to note that according to ACER in the NTC approach only one limiting element (one selected CNE(C)) has to be observed (as selected by the relevant TSO) in given regime, while in the FB approach all CNE(C)s have to fulfill 70% target. At the 1st workshop in May 2023 it was agreed for the NTC approach to use limiting elements per each TSO as input data. However, limiting elements were not provided by all TSOs in the questionnaire, therefore in the NTC approach all CNE(C)s were observed as in the FB approach. In this way both approaches can be consistently compared and the TSOs have a possibility to select and further analyze the most limiting element from their operational practice and fully check 70% target compliance.

Moreover, in the NTC approach one CNE(C) is critical (mostly limiting) in one power system regime and 70% target has to be fulfilled with respect to this element. However, there are different worst-case CNE(C)s depending on the observed regime (MTU). Since in this study only two selected regimes were analyzed for each year, all CNE(C) results are listed.

It is important to note that there is a large difference between unilateral NTC approach (the lowest of two distinct NTC values, as is the case on the Croatia-Bosnia and Herzegovina and Croatia-Serbia borders at the moment) and coordinated NTC (cNTC). Only unilateral NTC data were available for this study and were utilized, as agreed upon in the Inception report and TSO questionnaire. In 2021 and still now (2023) TSOs use unilateral/bilateral approach, not coordinated NTC.

The cNTC technique, which would likely produce higher MACZT values, is a possible way to follow up this study. It would require a new set of input data on coordinated (and most likely higher) NTC values that have been accepted by all TSOs.

7.1 High-level recap on the regional level

This study covered 176 network elements on 400 and 220 kV voltage levels, with more than 20000 CNE(C)s for each investigated scenario. Before moving on to the exact calculation findings, it is crucial to keep in mind that this caused extraordinarily huge calculation output lists. In total, 16 large excel files were generated for each Contracting Party for each scenario, based on the detailed data filtering and processing, while total number of generated figures is about 1500. Analysis was done for each Contracting Party, per each internal network element and per each border (cross-zonal line) using criteria explained in previous chapter.

Therefore, the figures and tables given in the following subchapters show results covering both directions of the power flows through considered CNE(C)s. The following link provides more thorough results for each and every CNE(C)s, including:

- PTDFs for each bidding zone
- F_{ref} (MW)
- MCCC (MW)
- MNCC (MW)
- F_{max} (MW)
- MACZT (MW)
- MACZT_p (%)
- MACZT_p graphics.

In addition, these results are further processed to obtain relevant statistics and graphics for all network elements:

- Minimum MACZT [%]
- Maximum MACZT [%]
- Mean MACZT [%]
- Contingency (system state) resulting with maximum MACZT
- Contingency (system state) resulting with minimum MACZT.

Statistics is also provided for both directions simultaneously, as well as separately for each direction.

7.2 Albania

7.2.1 Calculation results with NTC approach

The following figures show MACZT calculation results for Albania, with NTC approach on 20 Jan 2021 at 19:30 h and 21 July 2021 at 19:30 h. There are 24 elements analyzed in Albania, including both internal and cross-zonal. Albanian power system includes 5 cross-zonal lines (400 and 220 kV) on 3 borders (with Greece, Kosovo*, and Montenegro). In total 2502 CNE(C)s were analyzed in Albania. Minimum, maximum, and mean MACZT values are shown for each element, and both directions. There are only 3 elements that fulfill 70% target.

As mentioned above, a large number of calculation results were obtained. For illustration, MACZT levels (%) for OHL 400 kV Tirana 2 – Elbasan 2 are given in the following two Figures. For this specific line, in both the direct and opposite directions of the power flow, 118 contingencies (CNE(C)s) were examined. Clearly, none of these cases fulfills 70% requirement.

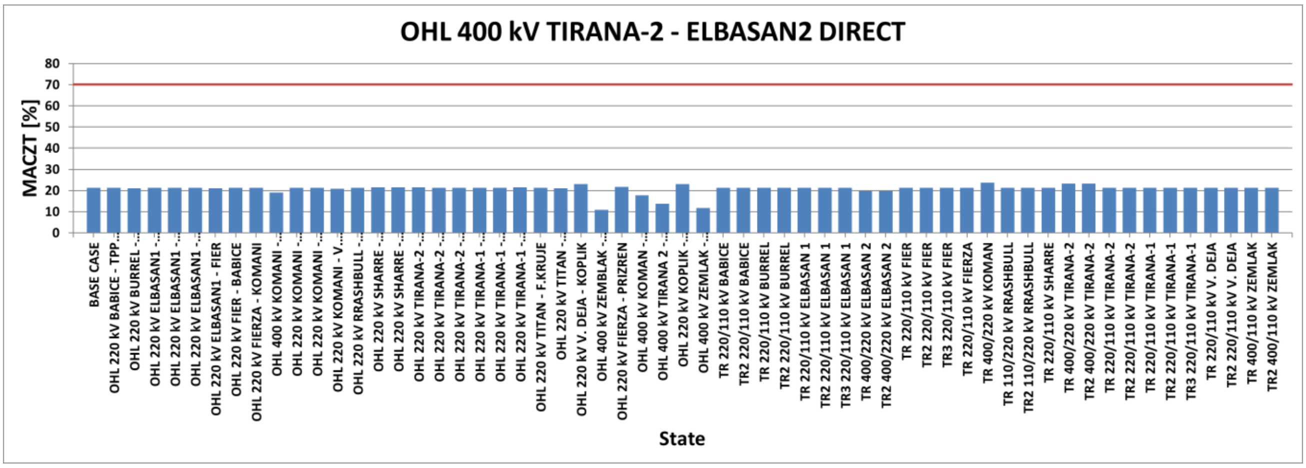


Figure 26 Illustrative example of MACZT calculation results for OHL 400 kV Tirana 2 – Elbasan 2 direct flow in Albania with NTC approach

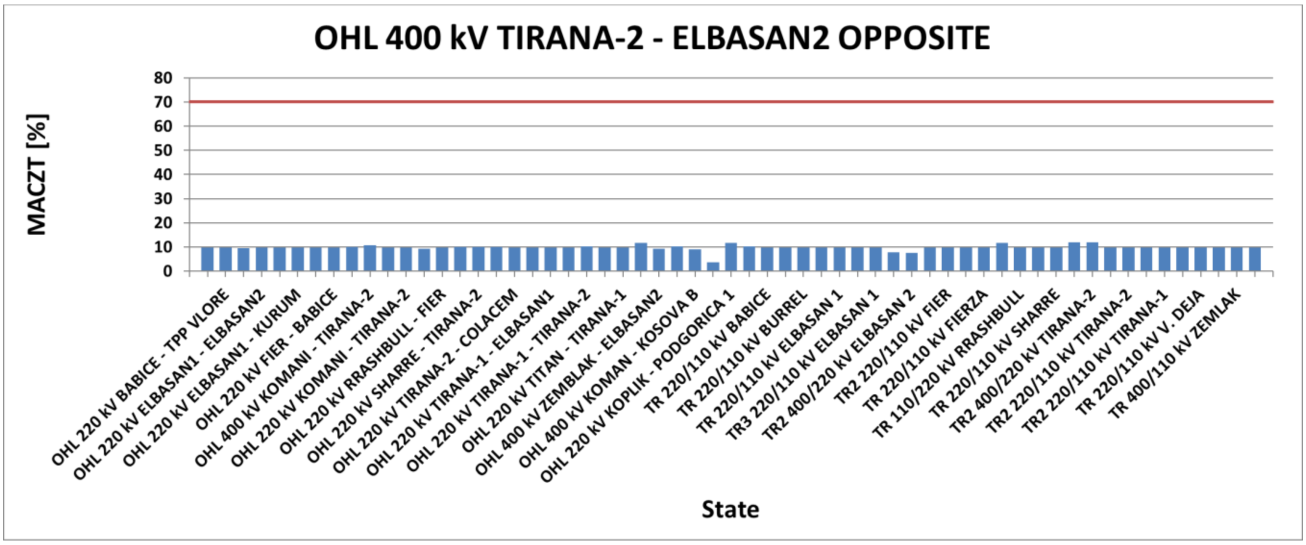


Figure 27 Illustrative example of MACZT calculation results for OHL 400 kV Tirana 2 – Elbasan 2 opposite flow in Albania with NTC approach

The same results were prepared for all considered elements in the region. For easier following in the following figures only the worst-case CNEC(C)s with minimum MACZT value were selected and presented graphically, since these cases are the most relevant for the 70% target fulfillment. Maximum MACZT value represents the scenario with the highest value, while mean MACZT value represents average value of all MACZT outputs for considered element. On 20 Jan 2021 at 19:30 h there are no elements fulfilling 70% target (minimum MACZT value (**blue bar**) higher than 70%).

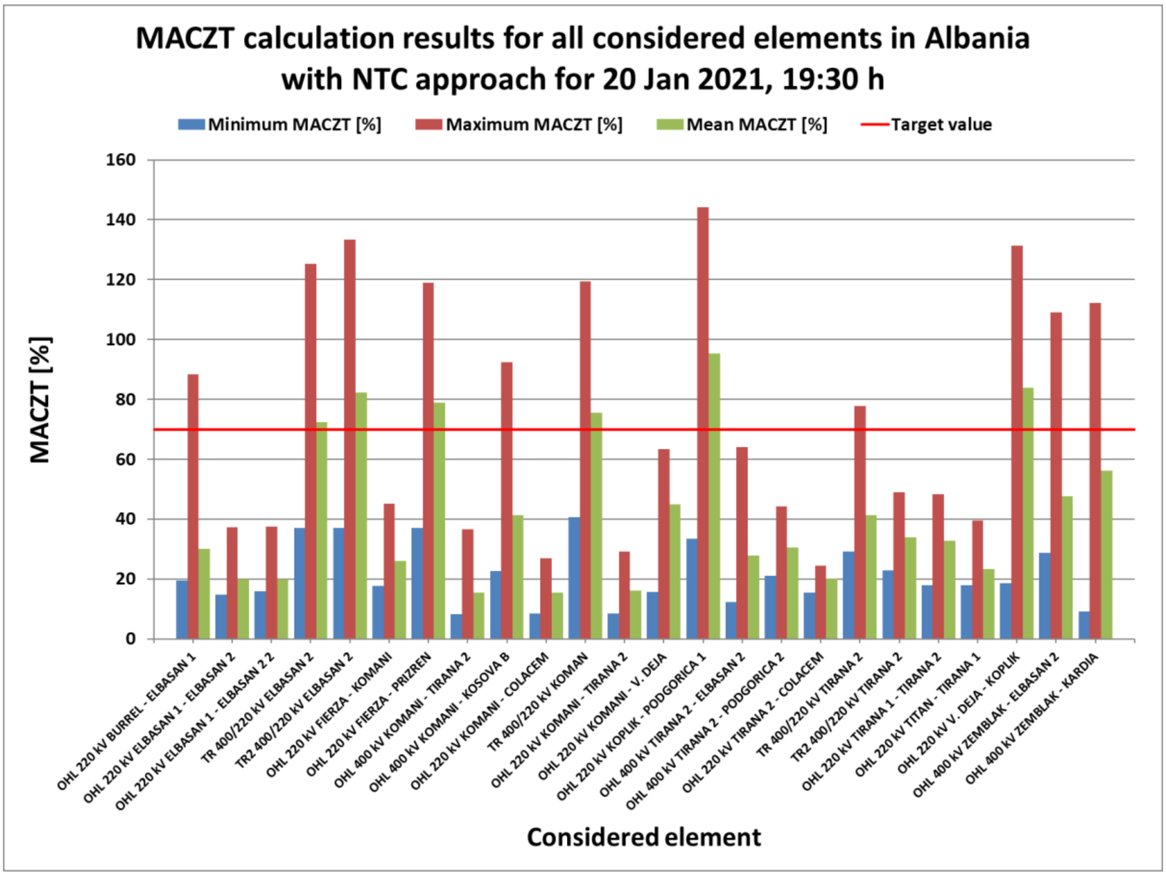


Figure 28 MACZT calculation results for Albania, NTC approach on 20 January 2021 at 19:30 h

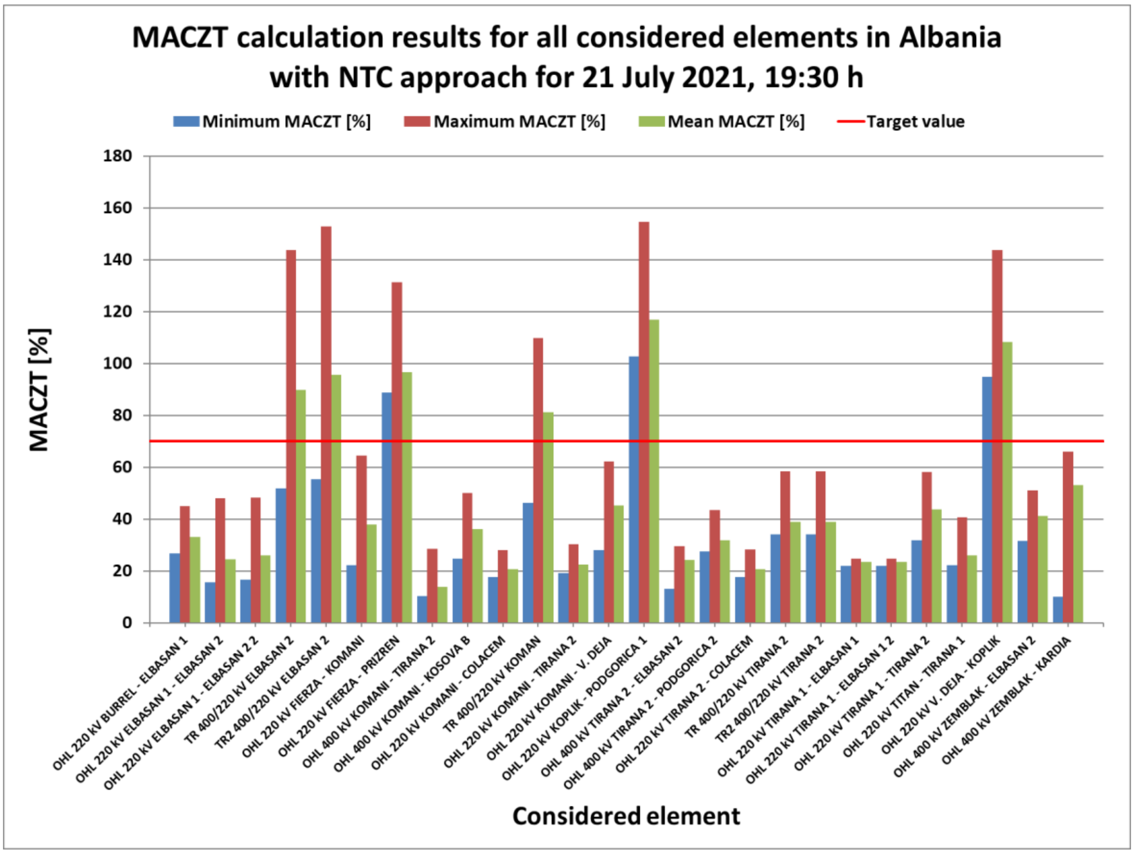


Figure 29 MACZT calculation results for Albania, NTC approach on 21 July 2021 at 19:30 h

In July 2021 scenario 3 lines fulfilled 70% target (OHL 220 kV Fierza – Prizren (KS), OHL 220 kV Koplik – Podgorica 1 (ME) and OHL 220 kV V.Deja - Koplik).

The elements depicted in the next two tables have minimum calculated MACZT values below 20% in the given January and July 2021 scenarios with NTC method. Values under 20% are chosen as the most crucial and pertinent for the future Action Plan and enforcing measures.

Table 12 List of calculated minimum MACZT values below 20% for considered element on 20 January 2021 at 19:30 h with **NTC approach in Albania**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV KOMANI - TIRANA 2	OPPOSITE OHL 400 kV TIRANA 2 - PODGORICA 2	8,2
OHL 220 kV KOMANI - TIRANA 2	OPPOSITE OHL 220 kV V. DEJA - KOPLIK	8,5
OHL 220 kV KOMANI - COLACEM	OPPOSITE OHL 220 kV KOPLIK - PODGORICA 1	8,5
OHL 400 kV ZEMBLAK - KARDIA	DIRECT OHL 400 kV ZEMBLAK - ELBASAN 2	9,2
OHL 400 kV TIRANA 2 - ELBASAN 2	DIRECT OHL 400 kV ZEMBLAK - ELBASAN 2	12,2
OHL 220 kV ELBASAN 1 - ELBASAN 2	OPPOSITE TR 220/110 kV FIERZA	14,8
OHL 220 kV TIRANA 2 - COLACEM	DIRECT OHL 400 kV KOMAN - KOSOVA B	15,4
OHL 220 kV KOMANI - V. DEJA	OPPOSITE OHL 220 kV FIER - BABICE	15,6
OHL 220 kV ELBASAN 1 - ELBASAN 2 2	OPPOSITE TR 220/110 kV FIERZA	15,8
OHL 220 kV FIERZA - KOMANI	OPPOSITE OHL 220 kV BABICE - TPP VLORE	17,8
OHL 220 kV TIRANA 1 - TIRANA 2	OPPOSITE OHL 220 kV TIRANA 2 - COLACEM	17,8
OHL 220 kV TITAN - TIRANA 1	OPPOSITE TR 220/110 kV TIRANA 2	17,8
OHL 220 kV V. DEJA - KOPLIK	OPPOSITE OHL 220 kV KOMANI - COLACEM	18,6
OHL 220 kV BURREL - ELBASAN 1	OPPOSITE TR2 110/220 kV RRASHBULL	19,6

There were 14 CNE(C)s in the Albanian 400 and 220 kV network on 20 January 2021, at 19:30 h, with a minimum MACZT value below 20%.

Table 13 List of calculated minimum MACZT values below 20% for considered element on 21 July 2021 at 19:30 h with **NTC approach in Albania**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
OHL 400 kV ZEMBLAK – KARDIA (GR)	DIRECT OHL 400 kV ZEMBLAK - ELBASAN 2	10,0
OHL 400 kV KOMANI - TIRANA 2	OPPOSITE TR 400/220 kV ELBASAN 2	10,4
OHL 400 kV TIRANA 2 - ELBASAN 2	OPPOSITE OHL 400.0 kV TIRANA 2 - PODGORICA 2 (ME)	13,0
OHL 220 kV ELBASAN 1 - ELBASAN 2	DIRECT OHL 400.0 kV ZEMLAK – KARDIA (GR)	15,5
OHL 220 kV ELBASAN 1 - ELBASAN 2 2	DIRECT OHL 400.0 kV ZEMLAK – KARDIA (GR)	16,6
OHL 220 kV TIRANA 2 - COLACEM	DIRECT OHL 220 kV BURREL - ELBASAN 1	17,6
OHL 220 kV KOMANI - COLACEM	OPPOSITE OHL 220 kV BURREL - ELBASAN 1	17,7
OHL 220 kV KOMANI - TIRANA 2	OPPOSITE OHL 220 kV BURREL - ELBASAN 1	19,0

There were eight CNE(C)s with a minimum MACZT value below 20% in the Albanian 400 and 220 kV network on 21 July 2021 at 19:30 h, which is comparable to the January scenario.

7.2.2 Calculation results with FB approach

This subchapter uses FB technique and the same result presentation approach. As shown on the following two tables, in given scenarios in January and July 2021 with **FB approach** there are no calculated minimum MACZT values below 20%. Moreover, the lowest level of MACZT in January scenario is 42,9%.

With FB approach in January scenario in Albania 4 elements (out of 24 in total) fulfilled 70% target, while in July scenario 11 elements fulfilled 70% target, as given on the following two figures. Having in mind that with NTC approach 0 and 3 elements fulfilled 70% target in these scenarios respectively, it clearly proves that FB approach would noticeably improve the level of 70% target fulfillment in Albania.

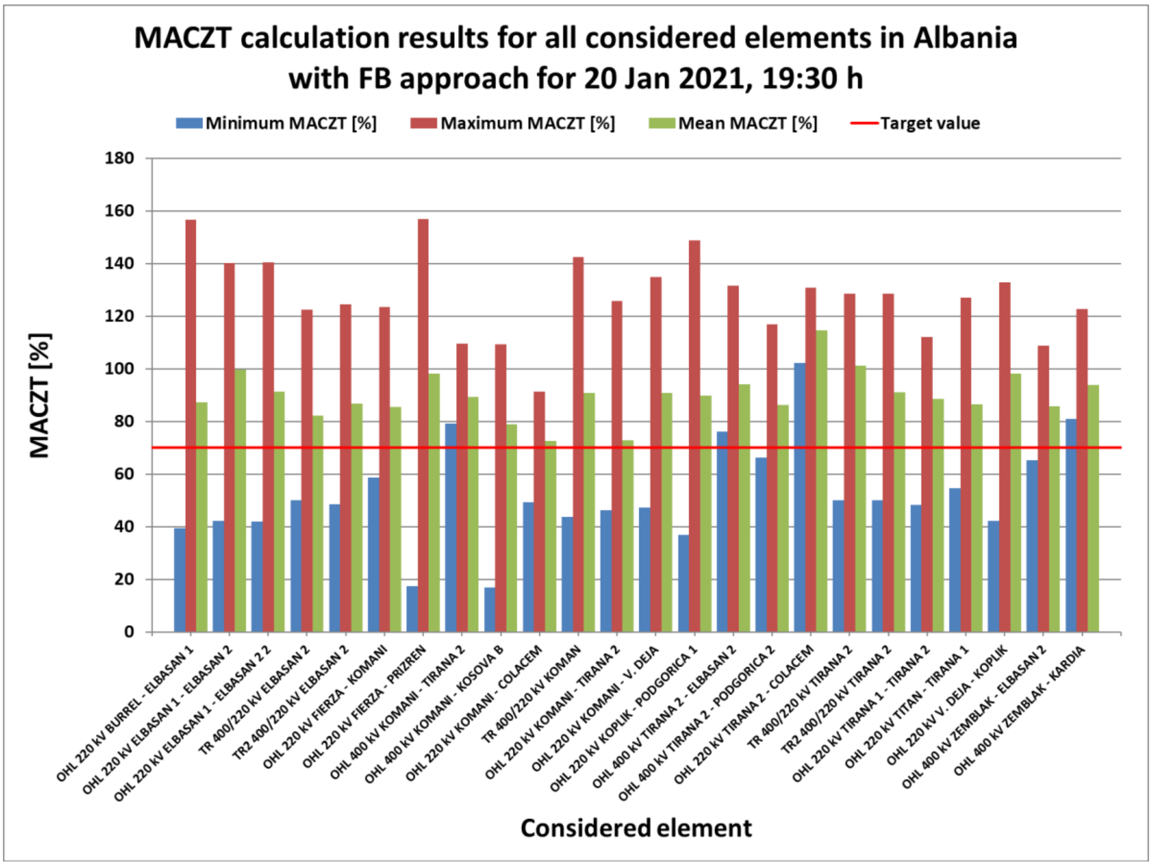


Figure 30 MACZT calculation results for Albania, FB approach on 20 January 2021 at 19:30 h

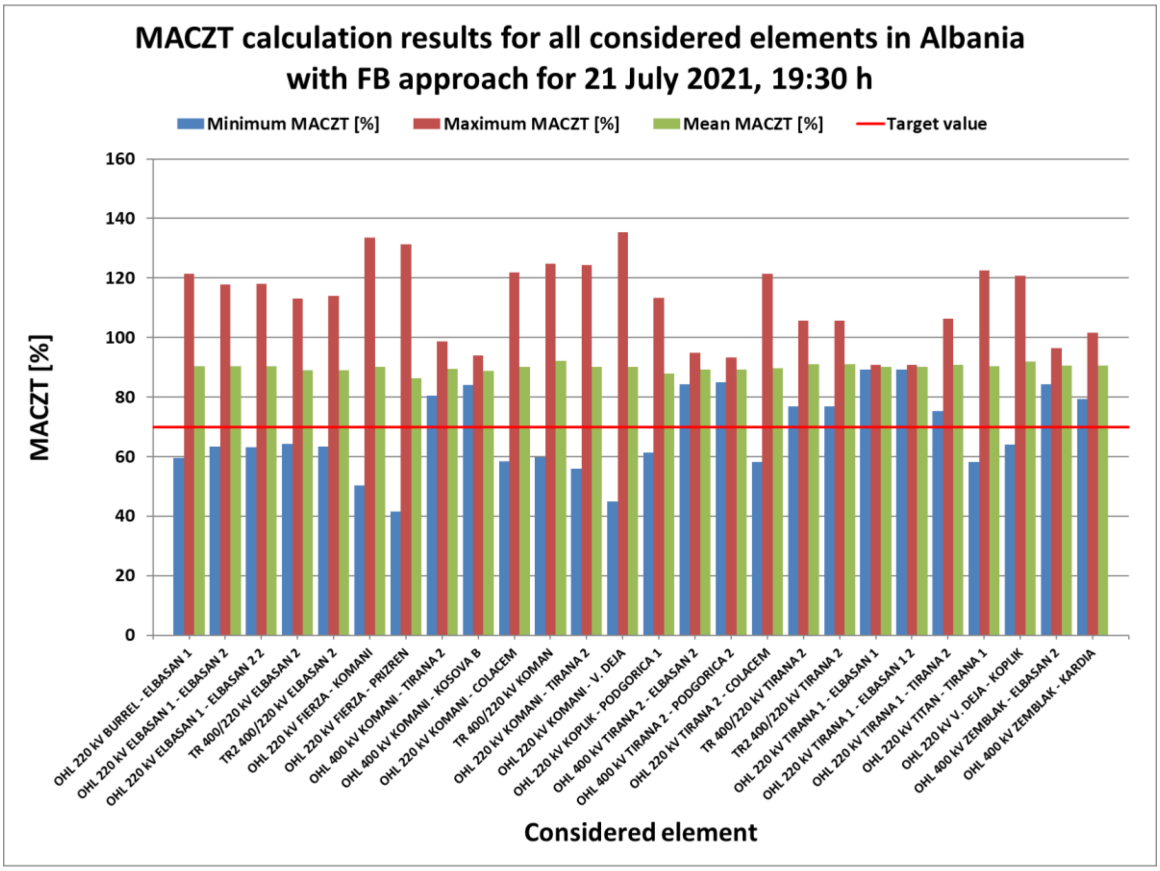


Figure 31 MACZT calculation results for Albania, FB approach on 21 July 2021 at 19:30 h

In the following tables calculated minimum MACZT values below 70% are shown.

With the FB method, there are 13 branches in the January scenario with a minimum MACZT value below 50%, whereas there are just 2 elements in the July scenario.

The worst-case CNE(C)s in the FB approach differ from the worst-case CNE(C)s in the NTC approach.

Table 14 List of calculated minimum MACZT values below 70% on 20 January 2021 at 19:30 h with **FB approach in Albania**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV KOMANI - KOSOVA B	OPPOSITE OHL 220 kV ELBASAN 1 - FIER	17,0
OHL 220 kV FIERZA - PRIZREN	OPPOSITE TR 220/110 kV SHARRE	17,4
OHL 220 kV KOPLIK - PODGORICA 1	DIRECT OHL 400 kV TIRANA 2 - PODGORICA 2	36,9
OHL 220 kV BURREL - ELBASAN 1	OPPOSITE OHL 220 kV TIRANA 2 - COLACEM	39,5
OHL 220 kV ELBASAN 1 - ELBASAN 2 2	OPPOSITE OHL 220 kV TITAN - TIRANA 1	41,9
OHL 220 kV V. DEJA - KOPLIK	OPPOSITE TR2 400/220 kV TIRANA 2	42,1
OHL 220 kV ELBASAN 1 - ELBASAN 2	OPPOSITE OHL 220 kV TITAN - TIRANA 1	42,2
TR 400/220 kV KOMAN	DIRECT OHL 220 kV FIERZA - PRIZREN	43,8
OHL 220 kV KOMANI - TIRANA 2	DIRECT OHL 220 kV KOMANI - COLACEM	46,3
OHL 220 kV KOMANI - V. DEJA	DIRECT OHL 220 kV KOMANI - TIRANA 2	47,2
OHL 220 kV TIRANA 1 - TIRANA 2	OPPOSITE OHL 220 kV KOMANI - V. DEJA	48,1

TR2 400/220 kV ELBASAN 2	DIRECT TR 400/220 kV ELBASAN 2	48,5
OHL 220 kV KOMANI - COLACEM	DIRECT OHL 220 kV KOMANI - TIRANA 2	49,3
TR 400/220 kV ELBASAN 2	DIRECT TR2 400/220 kV ELBASAN 2	50,0
TR 400/220 kV TIRANA 2	OPPOSITE TR 220/110 kV ELBASAN 1	50,1
TR2 400/220 kV TIRANA 2	OPPOSITE TR 220/110 kV ELBASAN 1	50,1
OHL 220 kV TITAN - TIRANA 1	DIRECT OHL 220 kV FIERZA - PRIZREN	54,6
OHL 220 kV FIERZA - KOMANI	DIRECT OHL 220 kV FIERZA - PRIZREN	58,6
OHL 400 kV ZEMBLAK - ELBASAN 2	OPPOSITE OHL 220 kV KOMANI - COLACEM	65,2
OHL 400 kV TIRANA 2 - PODGORICA 2	DIRECT OHL 220 kV KOPLIK - PODGORICA 1	66,3

Table 15 List of calculated minimum MACZT values below 70% on 21 July 2021 at 19:30 h with **FB approach in Albania**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 220 kV FIERZA – PRIZREN (KS)	OPPOSITE OHL 220 kV FIERZA - KOMANI	41,4
OHL 220 kV KOMANI - V. DEJA	DIRECT OHL 220 kV KOMANI - TIRANA 2	45,0
OHL 220 kV FIERZA – KOMANI	DIRECT OHL 220.0 kV FIERZA – PRIZREN (KS)	50,4
OHL 220 kV KOMANI - TIRANA 2	DIRECT OHL 220 kV KOMANI - V. DEJA	56,0
OHL 220 kV TITAN - TIRANA 1	DIRECT OHL 220 kV FIERZA – KOMANI	58,1
OHL 220 kV TIRANA 2 – COLACEM	OPPOSITE OHL 220 kV KOMANI - V. DEJA	58,2
OHL 220 kV KOMANI – COLACEM	DIRECT OHL 220 kV KOMANI - V. DEJA	58,5
OHL 220 kV BURREL - ELBASAN 1	DIRECT OHL 220 kV FIERZA – KOMANI	59,5
TR 400/220 kV KOMAN	DIRECT OHL 220 kV KOMANI - V. DEJA	59,7
OHL 220 kV KOPLIK - PODGORICA 1 (ME)	OPPOSITE OHL 220.0 kV FIERZA – PRIZREN (KS)	61,3
OHL 220 kV ELBASAN 1 - ELBASAN 2 2	OPPOSITE OHL 220 kV ELBASAN 1 - ELBASAN 2	63,1
TR2 400/220 kV ELBASAN 2	DIRECT TR 400/220 kV ELBASAN 2	63,3
OHL 220 kV ELBASAN 1 - ELBASAN 2	OPPOSITE OHL 220 kV ELBASAN 1 - ELBASAN 2 2	63,3
OHL 220 kV V. DEJA - KOPLIK	DIRECT OHL 220.0 kV FIERZA – PRIZREN (KS)	64,1
TR 400/220 kV ELBASAN 2	DIRECT TR2 400/220 kV ELBASAN 2	64,3

7.2.3 Comparison of the NTC and FB approaches' determined minimum MACZT values

For all elements having the lowest MACZT values, the following tables compare the determined minimum MACZT values for the NTC and FB approaches. All three calculated MACZT values are given: minimum, maximum, and mean value. In this way the MACZT value range is given, which is also very indicative information, besides the most critical minimum value.

Table 16 Comparison of calculated minimum MACZT values **in Albania** between NTC and FB approach on 20 January 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 400 kV KOMANI - TIRANA 2	8,2	15,5	36,6	79,2	89,3	109,6
OHL 220 kV KOMANI - TIRANA 2	8,5	16,1	29,1	46,3	72,8	125,7

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 220 kV KOMANI - COLACEM	8,5	15,4	27,0	49,3	72,6	91,4
OHL 400 kV ZEMBLAK - KARDIA	9,2	56,2	112,2	81,0	93,8	122,8
OHL 400 kV TIRANA 2 - ELBASAN 2	12,2	27,9	64,0	76,2	94,1	131,4
OHL 220 kV ELBASAN 1 - ELBASAN 2	14,8	20,0	37,3	42,2	99,7	140,1
OHL 220 kV TIRANA 2 - COLACEM	15,4	20,1	24,4	102,2	114,7	130,7
OHL 220 kV KOMANI - V. DEJA	15,6	44,8	63,5	47,2	90,8	134,9
OHL 220 kV ELBASAN 1 - ELBASAN 2 2	15,8	20,0	37,5	41,9	91,4	140,5
OHL 220 kV FIERZA - KOMANI	17,8	26,1	45,2	58,6	85,4	123,6
OHL 220 kV TIRANA 1 - TIRANA 2	17,8	32,8	48,2	48,1	88,4	112,0
OHL 220 kV TITAN - TIRANA 1	17,8	23,3	39,5	54,6	86,5	127,0
OHL 220 kV V. DEJA - KOPLIK	18,6	84,0	131,3	42,1	98,0	132,9
OHL 220 kV BURREL - ELBASAN 1	19,6	30,0	88,4	39,5	87,3	156,6

Table 17 Comparison of calculated minimum MACZT values **in Albania** between NTC and FB approach on 21 July 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 400 kV ZEMBLAK – KARDIA (GR)	10,0	53,0	66,0	79,4	90,6	101,6
OHL 400 kV KOMANI - TIRANA 2	19,0	22,3	30,2	56,0	90,2	124,3
OHL 400 kV TIRANA 2 - ELBASAN 2	13,0	24,3	29,6	84,3	89,2	94,8
OHL 220 kV ELBASAN 1 - ELBASAN 2	15,5	24,5	48,1	63,3	90,3	117,9
OHL 220 kV ELBASAN 1 - ELBASAN 2 2	16,6	26,1	48,4	63,1	90,3	118,1
OHL 220 kV TIRANA 2 - COLACEM	17,6	20,7	28,2	58,2	89,8	121,5
OHL 220 kV KOMANI - COLACEM	17,7	20,8	28,0	58,5	90,2	121,8
OHL 220 kV KOMANI - TIRANA 2	10,4	13,8	28,5	80,4	89,4	98,8

As expected, the MACZT values are significantly higher with FB than with NTC approach. Additionally, under the January 2021 scenario, all 14 CNE(C)s that had minimum MACZT values below 20% with the NTC approach might increase them to greater than 39,5% with the FB approach.

In the same way, all 8 CNE(C)s in the July 2021 scenario whose minimum MACZT values were below 20% with the NTC approach would increase their MACZT values to over 56% with the FB approach.

7.3 Bosnia and Herzegovina

7.3.1 Calculation results with NTC approach

The following two Figures show MACZT calculation results for Bosnia and Herzegovina, with NTC approach on 20 Jan 2021 at 19:30 h and 21 July 2021 at 19:30 h. There are 34 considered elements in Bosnia and Herzegovina, including both internal and cross-zonal. The power system of Bosnia and Herzegovina includes 7 cross-zonal lines (400 and 220 kV) on 3 borders (with Croatia, Serbia and Montenegro). In total 3492 CNE(C)s were analyzed in Bosnia and Herzegovina.

For each element minimum, maximum and mean MACZT values are presented (for both directions). No element met the 70% target on 20 January 2021, at 19:30.

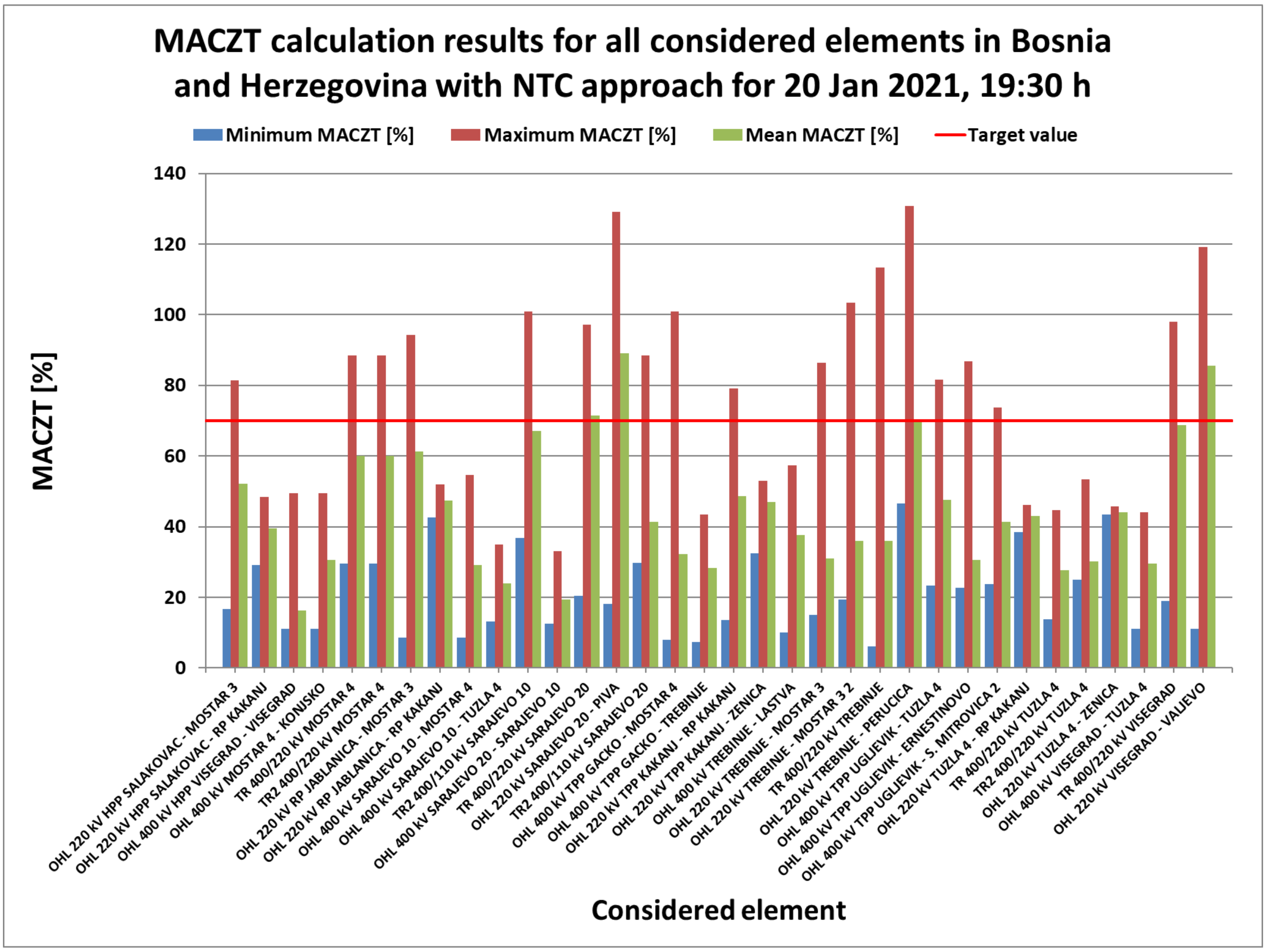


Figure 32 MACZT calculation results for Bosnia and Herzegovina, NTC approach on 20 January 2021 at 19:30 h

In July 2021 scenario only 1 cross-zonal line fulfilled 70% target (OHL 220 kV Višegrad – Valjevo (RS)).

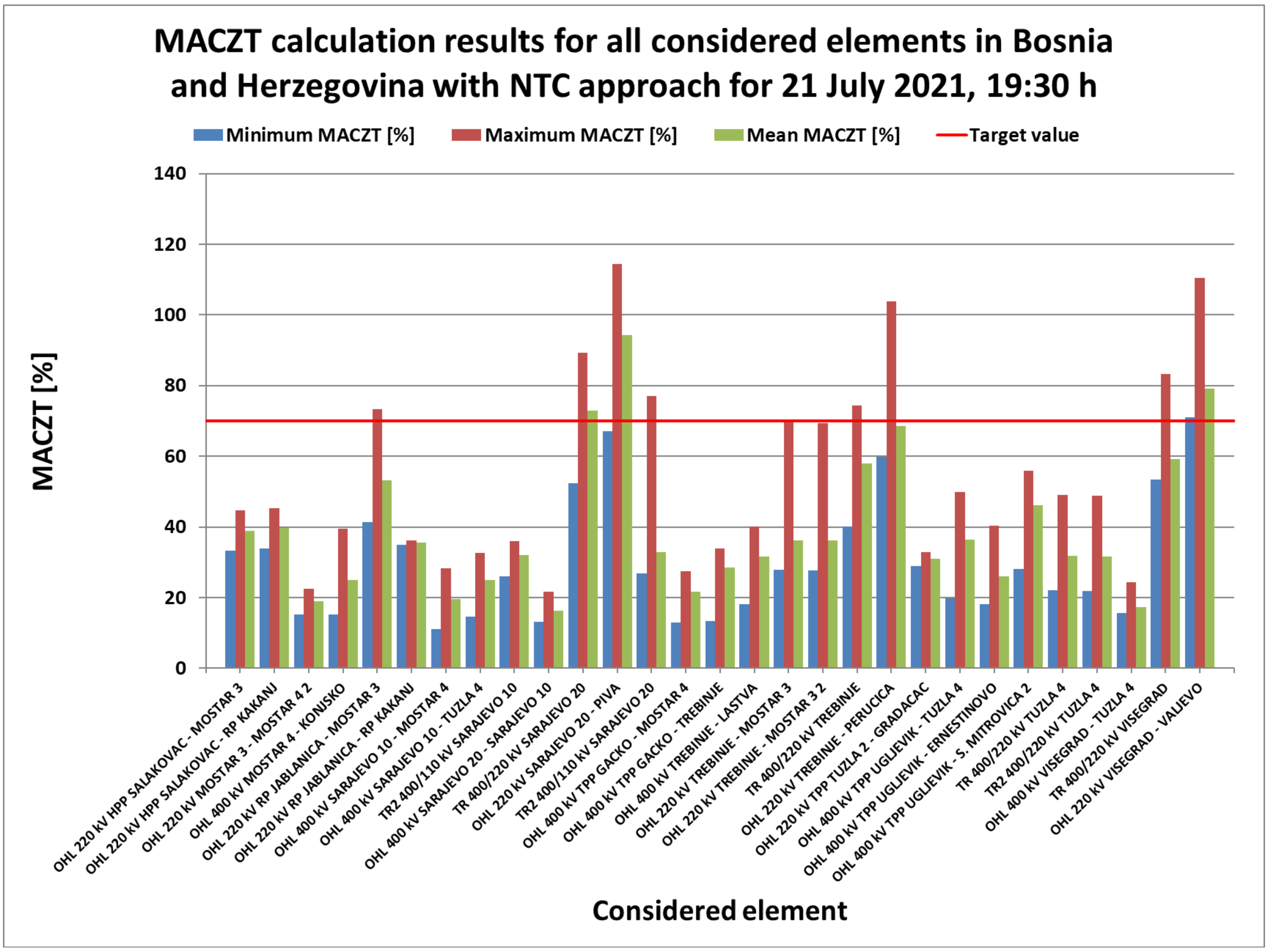


Figure 33 MACZT calculation results for Bosnia and Herzegovina, NTC approach on 21 July 2021 at 19:30 h

The elements depicted in the next two tables have minimum calculated MACZT values below 20% in the given January and July 2021 scenarios with **NTC method**.

Table 18 List of calculated minimum MACZT values below 20% on 20 January 2021 at 19:30 h with **NTC approach in Bosnia and Herzegovina**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
TR 400/220 kV TREBINJE	OPPOSITE TR4 220/110 kV MOSTAR 4	6,0
OHL 400 kV TPP GACKO - TREBINJE	OPPOSITE TR 400/220 kV MOSTAR 4	7,4
OHL 400 kV TPP GACKO - MOSTAR 4	DIRECT OHL 400 kV KONJSKO - MOSTAR 4	8,1
OHL 220 kV RP JABLANICA - MOSTAR 3	OPPOSITE BASE CASE	8,5
OHL 400 kV SARAJEVO 10 - MOSTAR 4	OPPOSITE OHL 220 kV TREBINJE - HPP DUBROVNIK	8,6
OHL 400 kV TREBINJE - LASTVA	OPPOSITE TR 220/110 kV GRADACAC	10,0
OHL 400 kV VISEGRAD - TUZLA 4	DIRECT OHL 220 kV VIŠEGRAD - VALJEVO	11,0
OHL 220 kV VISEGRAD - VALJEVO	OPPOSITE OHL 220 kV RP JABLANICA - JAJCE	11,0
OHL 400 kV HPP VISEGRAD - VISEGRAD	DIRECT BASE CASE	11,1
OHL 400 kV MOSTAR 4 - KONJSKO	OPPOSITE OHL 220 kV DJAKOVO - GRADACAC	11,1
OHL 400 kV SARAJEVO 20 - SARAJEVO 10	DIRECT OHL 400 kV SARAJEVO 10 - MOSTAR 4	12,4

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV SARAJEVO 10 - TUZLA 4	DIRECT OHL 400 kV SARAJEVO 10 - MOSTAR 4	13,2
OHL 220 kV TPP KAKANJ - RP KAKANJ	OPPOSITE OHL 220 kV DJAKOVO - GRADACAC	13,5
TR 400/220 kV TUZLA 4	OPPOSITE OHL 220 kV HPP SALAKOVAC - MOSTAR 3	13,7
OHL 220 kV TREBINJE - MOSTAR 3	OPPOSITE OHL 400 kV KONJSKO - MOSTAR 4	15,1
OHL 220 kV HPP SALAKOVAC - MOSTAR 3	OPPOSITE BASE CASE	16,7
OHL 220 kV SARAJEVO 20 - PIVA	OPPOSITE OHL 220 kV MOSTAR 3 - EAL	18,1
TR 400/220 kV VISEGRAD	OPPOSITE BASE CASE	19,0
OHL 220 kV TREBINJE - MOSTAR 3 2	DIRECT OHL 400 kV HPP VISEGRAD - VISEGRAD	19,5

In total on 20 Jan 2021 at 19:30 h in Bosnia and Herzegovina 400 and 220 kV network there were 19 CNE(C)s with minimum MACZT value below 20%. On 21 July 2021 at 19:30 h there were 11 CNE(C)s with minimum MACZT value below 20%, which is higher than in the January scenario.

Table 19 List of calculated minimum MACZT values below 20% on 21 July 2021 at 19:30 h with **NTC approach in Bosnia and Herzegovina**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV SARAJEVO 10 - MOSTAR 4	OPPOSITE OHL 400 kV SARAJEVO 10 - TUZLA 4	11,0
OHL 400 kV TPP GACKO - MOSTAR 4	OPPOSITE OHL 400.0 kV KONJSKO - MOSTAR 4	12,9
OHL 400 kV SARAJEVO 20 - SARAJEVO 10	OPPOSITE OHL 400 kV SARAJEVO 10 - TUZLA 4	13,1
OHL 400 kV TPP GACKO - TREBINJE	OPPOSITE OHL 400 kV TPP GACKO - MOSTAR 4	13,5
OHL 400 kV SARAJEVO 10 - TUZLA 4	DIRECT OHL 400 kV SARAJEVO 10 - MOSTAR 4	14,5
OHL 400 kV MOSTAR 4 – KONJSKO (HR)	OPPOSITE OHL 400 kV TPP GACKO - TREBINJE	15,1
OHL 220 kV MOSTAR 3 - MOSTAR 4 2	OPPOSITE OHL 400 kV TPP GACKO - TREBINJE	15,3
OHL 400 kV VISEGRAD - TUZLA 4	OPPOSITE TR 400/220 kV TUZLA 4	15,6
OHL 400 kV TREBINJE - LASTVA	DIRECT OHL 400 kV TPP GACKO - TREBINJE	18,1
OHL 400 kV TPP UGLJEVIK – ERNESTINOVO (HR)	OPPOSITE OHL 400 kV TPP UGLJEVIK - TUZLA 4	18,1
OHL 400 kV TPP UGLJEVIK - TUZLA 4	OPPOSITE OHL 400 kV TPP UGLJEVIK - S. MITROVICA 2 (RS)	19,8

7.3.2 Calculation results with FB approach

As shown in the following figures and tables, in given scenarios in January and July 2021 with **FB approach** in Bosnia and Herzegovina there are no calculated minimum MACZT values below 20%. Moreover, the lowest level of MACZT in January scenario is 39%.

With FB approach in January scenario in Bosnia and Herzegovina 18 elements (out of 34 in total) fulfilled 70% target, while in July scenario 23 elements fulfilled 70% target. Having in mind that with NTC approach in both scenarios only one element fulfilled 70% target, it clearly proves that FB approach would improve the level of 70% target fulfillment in Bosnia and Herzegovina.

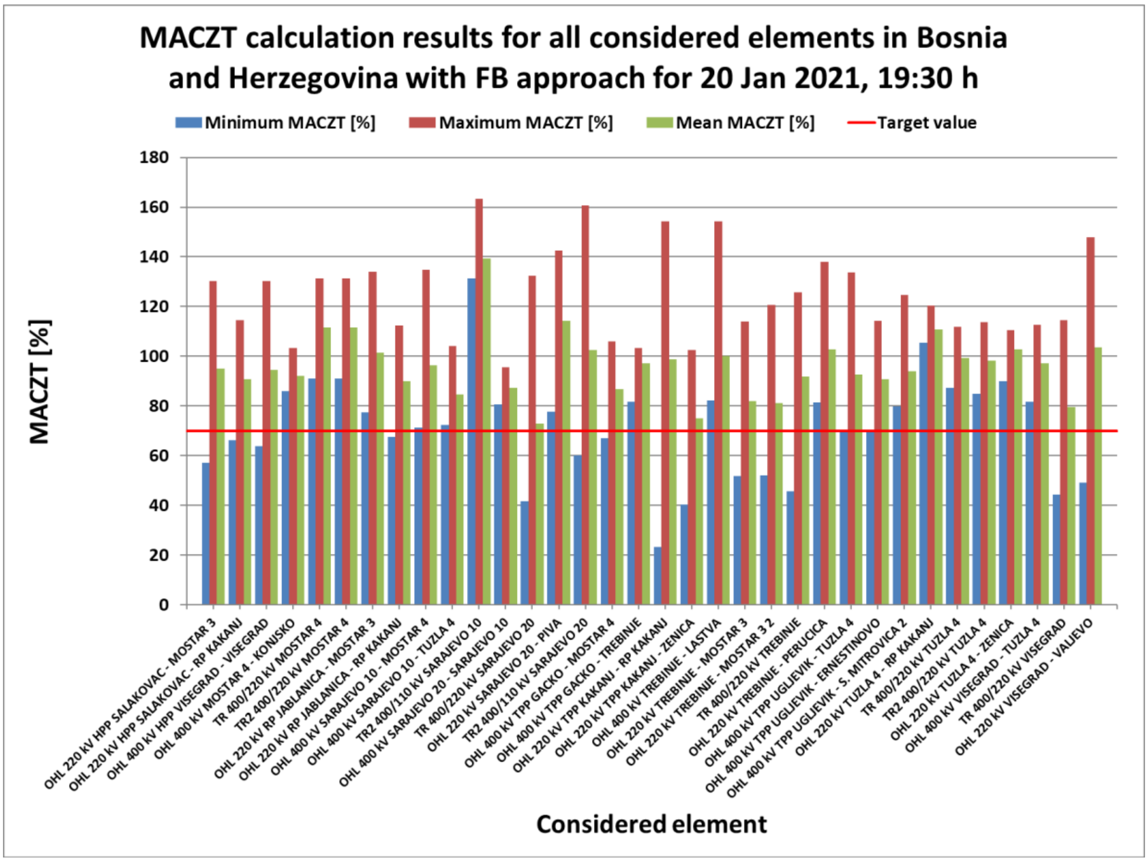


Figure 34 MACZT calculation results for Bosnia and Herzegovina, FB approach on 20 January 2021 at 19:30 h

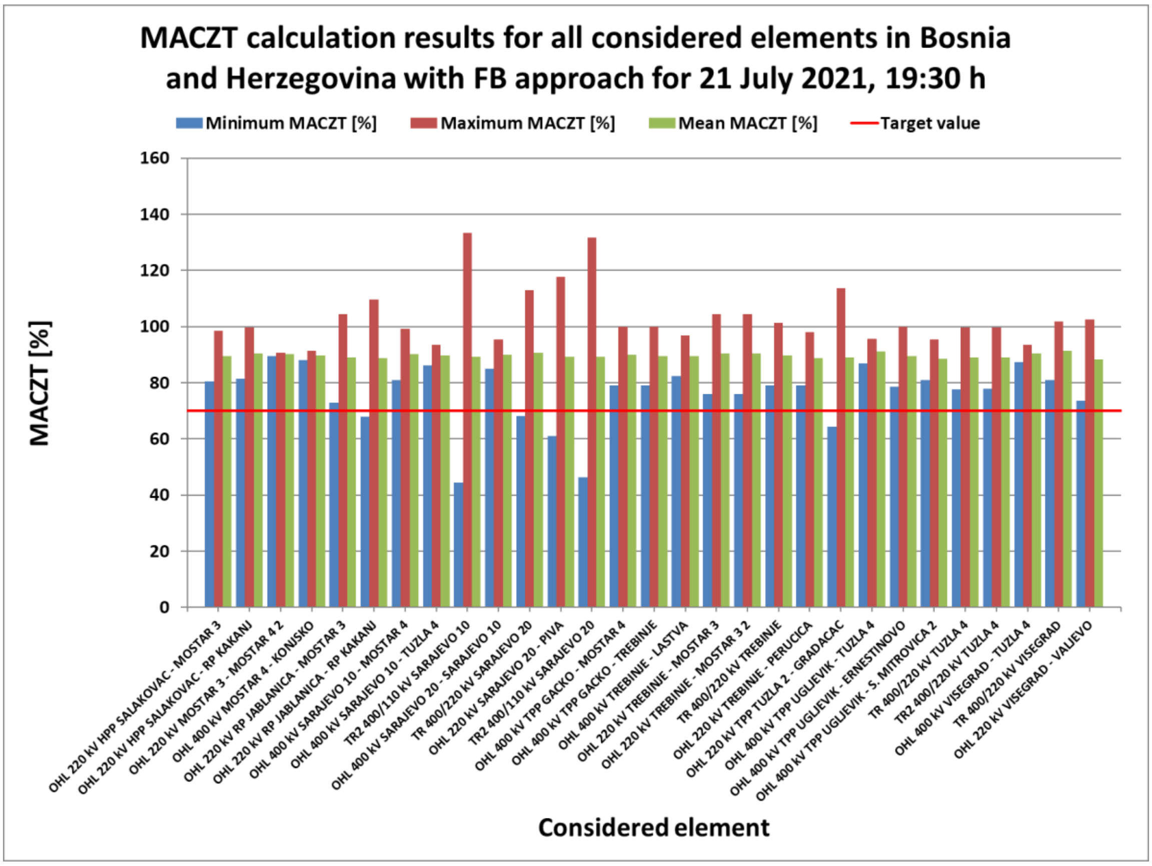


Figure 35 MACZT calculation results for Bosnia and Herzegovina, FB approach on 21 July 2021 at 19:30 h

Since there are no values below 20%, in the next tables calculated minimum MACZT values below 70% are shown. In January scenario there are 16 elements with minimum MACZT value below 70%, while in July scenario there are 6 elements below 70% target. Also, with FB approach in January scenario there are 6 elements with minimum MACZT value below 50%, while in July scenario there are just 2 elements below 50%.

The worst-case CNE(C)s in the FB approach differ from the worst-case CNE(C)s in the NTC approach.

Table 20 List of calculated minimum MACZT values below 70% on 20 January 2021 at 19:30 h with **FB approach in Bosnia and Herzegovina**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
OHL 220 kV TPP KAKANJ - RP KAKANJ	OPPOSITE BASE CASE	23,4
OHL 220 kV TPP KAKANJ - ZENICA	DIRECT OHL 220 kV TUZLA 4 - RP KAKANJ	40,5
TR 400/220 kV SARAJEVO 20	OPPOSITE OHL 220 kV RP JABLANICA - MOSTAR 3	41,7
TR 400/220 kV VISEGRAD	OPPOSITE TR 400/220 kV TUZLA 4	44,3
TR 400/220 kV TREBINJE	OPPOSITE OHL 220 kV MOSTAR 3 - MOSTAR 4	45,8
OHL 220 kV VISEGRAD - VALJEVO	OPPOSITE OHL 220 kV MOSTAR 3 - MOSTAR 4 2	49,1
OHL 220 kV TREBINJE - MOSTAR 3	DIRECT OHL 400 kV TPP GACKO - MOSTAR 4	52,0
OHL 220 kV TREBINJE - MOSTAR 3 2	DIRECT OHL 400 kV TPP GACKO - MOSTAR 4	52,1
OHL 220 kV HPP SALAKOVAC - MOSTAR 3	OPPOSITE OHL 220 kV ZAKUCAC - MOSTAR 4	57,1
TR2 400/110 kV SARAJEVO 20	OPPOSITE OHL 220 kV TUZLA 4 - ZENICA	60,2
OHL 400 kV HPP VISEGRAD - VISEGRAD	OPPOSITE BASE CASE	63,9
OHL 220 kV HPP SALAKOVAC - RP KAKANJ	DIRECT OHL 220 kV RP JABLANICA - MOSTAR 3	66,2
OHL 400 kV TPP GACKO - MOSTAR 4	OPPOSITE BASE CASE	67,1
OHL 220 kV RP JABLANICA - RP KAKANJ	DIRECT OHL 220 kV RP JABLANICA - MOSTAR 3	67,6
OHL 400 kV TPP UGLJEVIK - TUZLA 4	OPPOSITE TR 400/220 kV TUZLA 4	69,7
OHL 400 kV TPP UGLJEVIK - ERNESTINOVO	OPPOSITE OHL 220 kV RP JABLANICA - JAJCE	69,7

Table 21 List of calculated minimum MACZT values below 70% for considered element on 21 July 2021 at 19:30 h with **FB approach in Bosnia and Herzegovina**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
TR2 400/110 kV SARAJEVO 10	OPPOSITE TR2 400/110 kV SARAJEVO 20	44,4
TR2 400/110 kV SARAJEVO 20	OPPOSITE TR2 400/110 kV SARAJEVO 10	46,3
OHL 220 kV SARAJEVO 20 – PIVA (ME)	OPPOSITE OHL 400.0 kV KONJSKO - MOSTAR 4	61,1
OHL 220 kV TPP TUZLA 2 - GRADACAC	DIRECT OHL 400 kV TPP UGLJEVIK - TUZLA 4	64,2
OHL 220 kV RP JABLANICA - RP KAKANJ	DIRECT OHL 220 kV RP JABLANICA - MOSTAR 3	67,9
TR 400/220 kV SARAJEVO 20	DIRECT OHL 400.0 kV KONJSKO - MOSTAR 4	68,0

7.3.3 Comparison of the NTC and FB approaches determined minimum MACZT values

For all elements having the lowest MACZT values, the following tables compare the determined minimum MACZT values for the NTC and FB approaches. All three calculated MACZT values are given: minimum, mean, and maximum value.

Table 22 Comparison of calculated minimum MACZT values **in Bosnia and Herzegovina** between NTC and FB approach on 20 January 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
TR 400/220 kV TREBINJE	13,7	27,7	44,6	45,8	92,0	125,7
OHL 400 kV TPP GACKO - TREBINJE	7,4	28,3	43,3	81,9	97,2	103,4
OHL 400 kV TPP GACKO - MOSTAR 4	8,1	32,3	100,9	67,1	86,7	105,9
OHL 220 kV RP JABLANICA - MOSTAR 3	8,5	61,2	94,3	77,4	101,6	134,0
OHL 400 kV SARAJEVO 10 - MOSTAR 4	13,2	23,9	34,9	71,2	96,4	134,8
OHL 400 kV TREBINJE - LASTVA	10,0	37,6	57,3	82,4	100,2	154,2
OHL 400 kV VISEGRAD - TUZLA 4	11,0	29,6	44,0	81,8	97,3	112,8
OHL 220 kV VISEGRAD - VALJEVO	11,0	85,6	119,2	49,1	103,5	147,8
OHL 400 kV HPP VISEGRAD - VISEGRAD	11,1	16,3	49,5	63,9	94,5	130,2
OHL 400 kV MOSTAR 4 - KONJSKO	11,1	30,5	49,5	86,1	92,1	103,4
OHL 400 kV SARAJEVO 20 - SARAJEVO 10	12,4	19,3	33,0	80,6	87,2	95,5
OHL 400 kV SARAJEVO 10 - TUZLA 4	13,2	23,9	34,9	72,5	84,8	104,0
OHL 220 kV TPP KAKANJ - RP KAKANJ	13,5	48,6	79,0	23,4	98,7	154,2
TR 400/220 kV TUZLA 4	13,7	27,7	44,6	87,4	99,4	111,9
OHL 220 kV TREBINJE - MOSTAR 3	15,1	30,9	86,5	52,0	81,9	114,0
OHL 220 kV HPP SALAKOVAC - MOSTAR 3	16,7	52,1	81,3	52,0	81,9	114,0
OHL 220 kV SARAJEVO 20 - PIVA	18,1	89,1	129,1	77,8	114,2	142,4
TR 400/220 kV VISEGRAD	19,0	68,8	98,0	44,3	79,5	114,7
OHL 220 kV TREBINJE - MOSTAR 3 2	19,5	36,0	103,4	52,1	81,2	120,6

Table 23 Comparison of calculated minimum MACZT values **in Bosnia and Herzegovina** between NTC and FB approach on 21 July 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 400 kV SARAJEVO 10 - MOSTAR 4	11,0	19,6	28,1	81,0	90,1	99,1
OHL 400 kV TPP GACKO - MOSTAR 4	13,0	21,6	27,4	79,0	89,9	99,9
OHL 400 kV SARAJEVO 20 - SARAJEVO 10	13,1	16,3	21,6	84,9	90,0	95,4
OHL 400 kV TPP GACKO - TREBINJE	13,4	28,4	33,9	79,0	89,6	99,9
OHL 400 kV SARAJEVO 10 - TUZLA 4	14,5	25,1	32,6	86,0	89,8	93,6
OHL 400 kV MOSTAR 4 - KONJSKO	14,9	24,9	39,5	88,1	89,8	91,4
OHL 220 kV MOSTAR 3 - MOSTAR 4 2	15,3	18,9	22,5	89,5	90,1	90,6
OHL 400 kV VISEGRAD - TUZLA 4	15,6	17,4	24,4	87,3	90,4	93,4
OHL 400 kV TREBINJE - LASTVA	18,1	31,7	41,9	82,3	89,6	96,7
OHL 400 kV TPP UGLJEVIK – ERNESTINOVO (HR)	18,1	26,0	40,3	78,6	89,4	100,0
OHL 400 kV TPP UGLJEVIK - TUZLA 4	19,8	36,4	49,9	87,0	91,2	95,5

As expected, the MACZT values are significantly higher with FB than with NTC approach. Additionally, under the January 2021 scenario, all 19 CNE(C)s that had minimum MACZT values below 20% with the NTC approach would improve these numbers to greater than 23,4% with the FB approach.

Similar to this, in the July 2021 scenario, all 11 CNE(C)s that had minimum MACZT values below 20% with the NTC approach will improve their MACZT values with the FB approach to more than 89,4%.

7.4 Kosovo*

7.4.1 Calculation results with NTC approach

The following figures show MACZT calculation results for Kosovo*, with NTC approach on 20 Jan 2021 at 19:30 h and 21 July 2021 at 19:30 h. There are 20 considered elements in Kosovo*, including both internal and cross-zonal. Kosovo* power system includes 6 cross-zonal lines (400 and 220 kV) on 4 borders (with Serbia, Montenegro, North Macedonia, and Albania). In total 1198 CNE(C)s were analyzed in Kosovo*.

For each element minimum, maximum and mean MACZT values are presented (for both directions). On 20 Jan 2021 at 19:30 h just 1 considered element (TR 400/110 kV Peja 3) fulfilled 70% target. One element had a minimum MACZT value below 20%, and the rest 19 elements were below 50%.

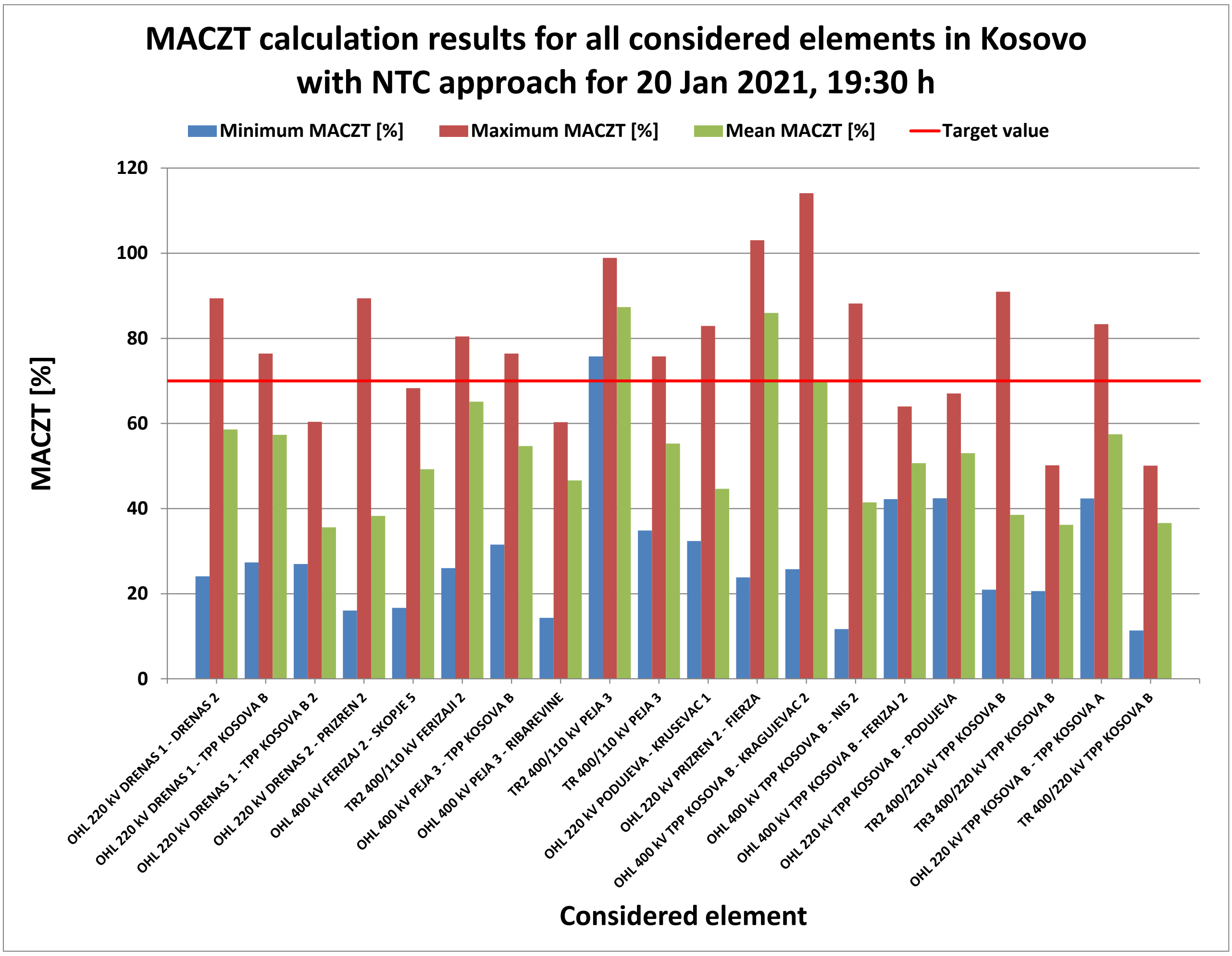


Figure 36 MACZT calculation results for Kosovo*, NTC approach on 20 January 2021 at 19:30 h

In July 2021 scenario only 1 internal line fulfilled 70% target (OHL 400 kV TPP Kosovo A – TPP Kosovo B). Same as in the previous scenario, 16 considered elements were with minimum MACZT value below 50% and just one element below 20%.

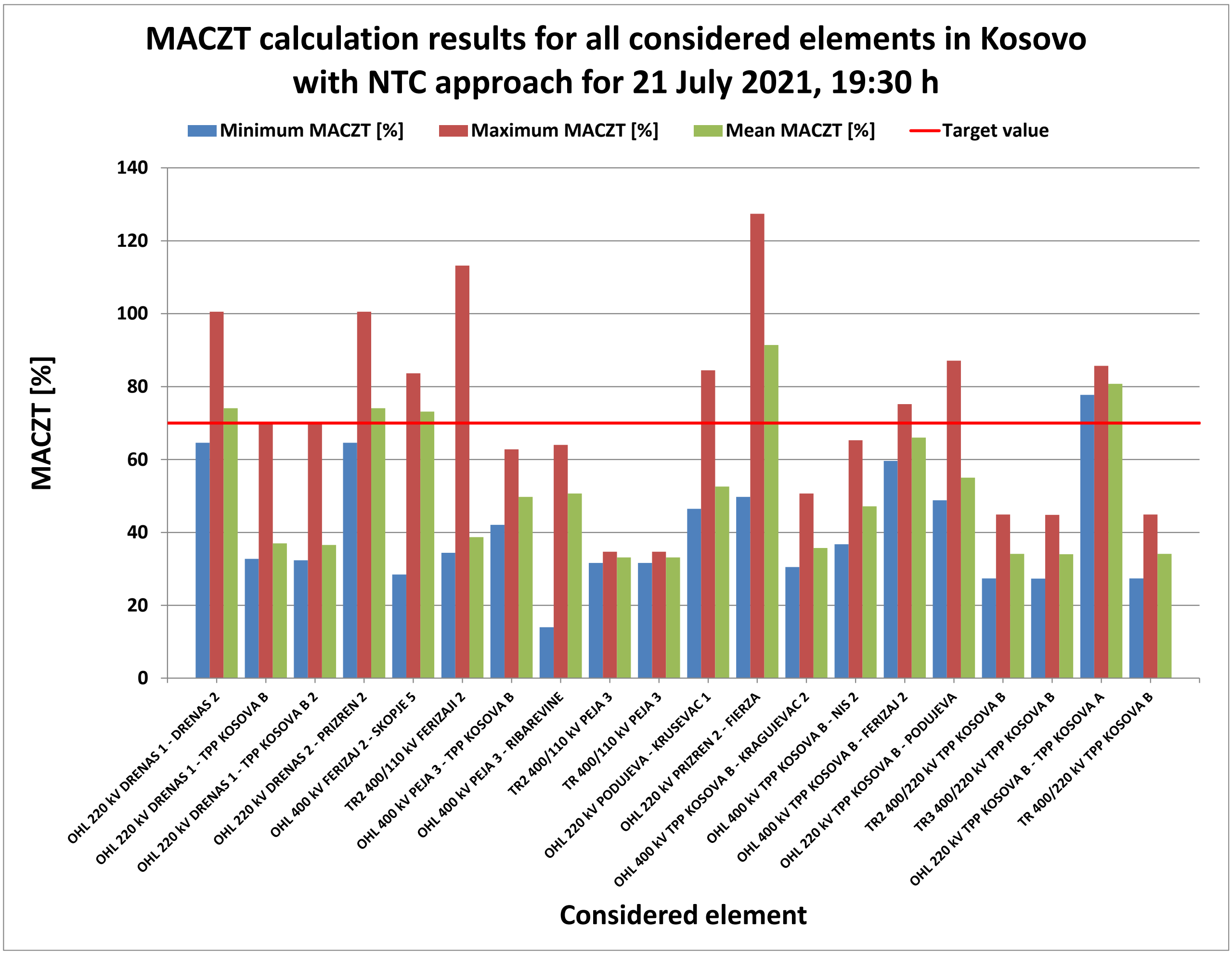


Figure 37 MACZT calculation results for Kosovo*, NTC approach on 21 July 2021 at 19:30 h

In January 2021 scenario with **NTC approach** minimum calculated MACZT value below 20% is detected on 5 elements shown in the following table.

Table 24 List of calculated minimum MACZT values below 20% on 20 January 2021 at 19:30 h with **NTC approach in Kosovo***

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
TR 400/220 kV TPP KOSOVA B	OPPOSITE BASE CASE	11,3
OHL 400 kV TPP KOSOVA B - NIS 2	OPPOSITE BASE CASE	11,7
OHL 400 kV PEJA 3 - RIBAREVINE	DIRECT TR3 400/220 kV TPP KOSOVA B	14,3
OHL 220 kV DRENAS 2 - PRIZREN 2	OPPOSITE BASE CASE	16,0
OHL 400 kV FERIZAJ 2 - SKOPJE 5	OPPOSITE TR 400/110 kV FERIZAJI 2	16,7

The identical CNE(C) was the only one observed with a minimum MACZT value below 20% on July 21, 2021, at 19:30 h.

Table 25 List of calculated minimum MACZT values below 20% on 21 July 2021 at 19:30 h with **NTC approach in Kosovo***

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV PEJA 3 – RIBAREVINE (ME)	DIRECT OHL 400 kV PEJA 3 - TPP KOSOVA B	14,0

7.4.2 Calculation results with FB approach

As shown in the following figures and tables, in given scenarios in January and July 2021 with **FB approach** in Kosovo* there are no calculated minimum MACZT values below 20%. The lowest level of MACZT in January scenario is 22,1%.

With FB approach in January scenario in Kosovo* 6 elements (out of 20 in total) fulfilled 70% target, while in July scenario 17 elements fulfilled 70% target. Having in mind that with NTC approach in both scenarios only 1 element fulfilled 70% target, it clearly proves that FB approach would improve the level of 70% target fulfillment in Kosovo*.

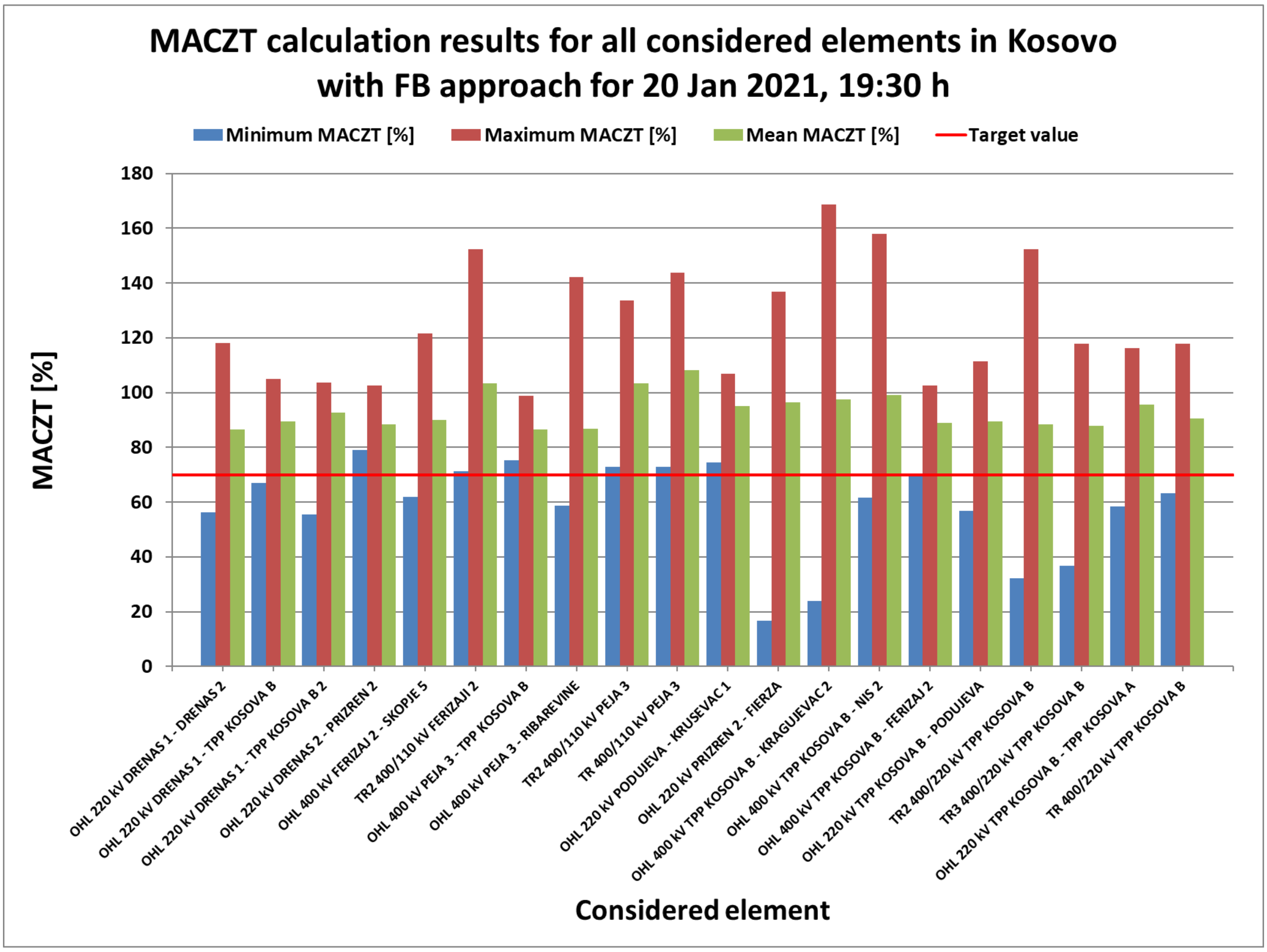


Figure 38 MACZT calculation results for Kosovo*, **FB approach** on 20 January 2021 at 19:30 h

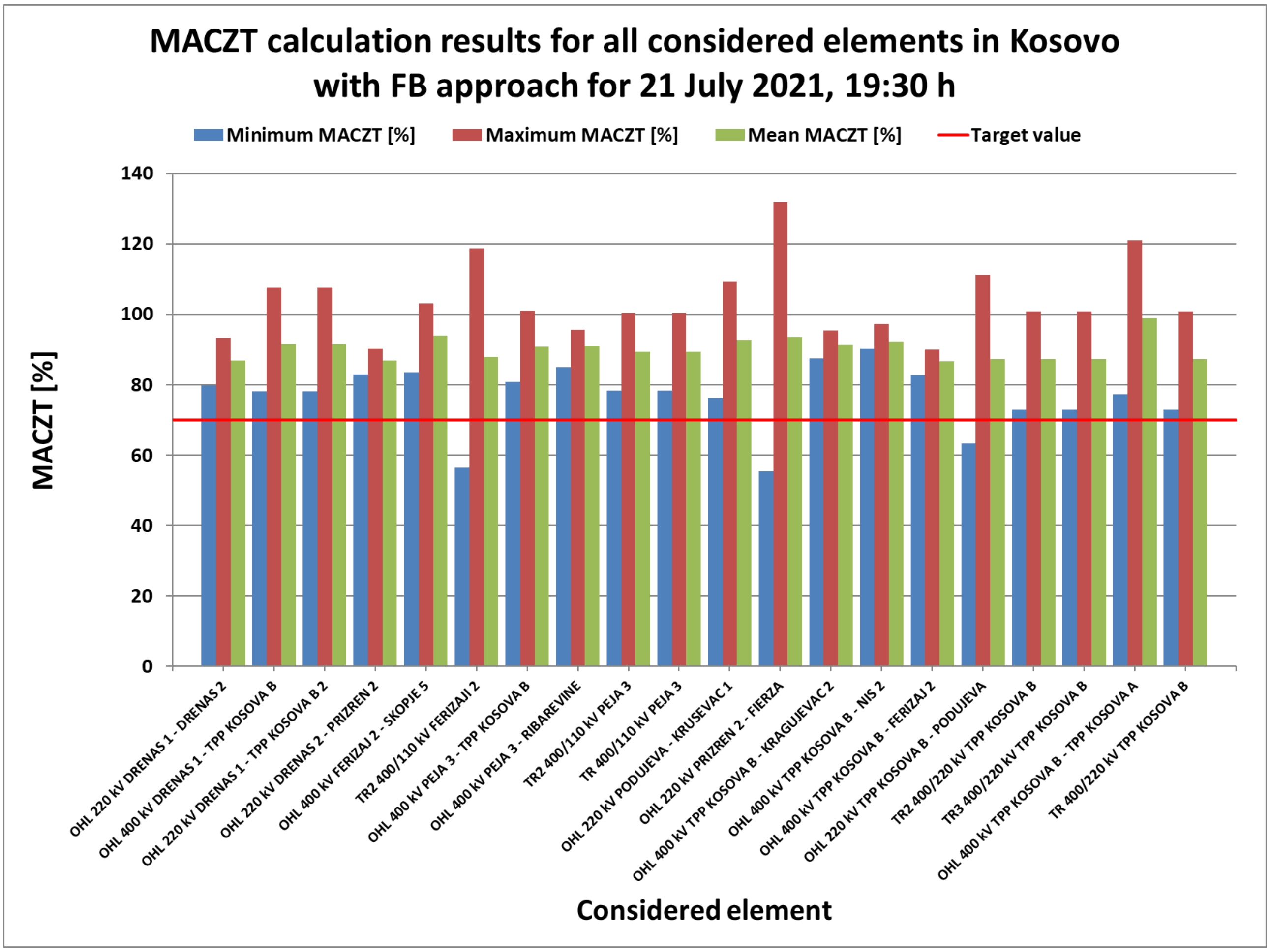


Figure 39 MACZT calculation results for Kosovo*, FB approach on 21 July 2021 at 19:30 h

In the next tables calculated minimum MACZT values below 70% are shown. In January scenario there are 11 elements with minimum MACZT value below 70%, while in July scenario there are 3 elements below 70% target. Also, with FB approach in January scenario there are 4 elements with minimum MACZT value below 50%, while in July scenario there are no elements with minimum MACZT value below 50%.

The worst-case CNE(C)s in the FB approach differ from the worst-case CNE(C)s in the NTC approach. Table 26 List of calculated minimum MACZT values below 70% on 20 January 2021 at 19:30 h with FB approach in Kosovo*

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 220 kV PRIZREN 2 - FIERZA	DIRECT TR3 220/110 kV PRISHTINA 4	16,6
OHL 400 kV TPP KOSOVA B - KRAGUJEVAC 2	DIRECT OHL 400 kV SKOPJE 5 - FERIZAJ 2	24,0
TR2 400/220 kV TPP KOSOVA B	OPPOSITE OHL 220 kV DRENAS 1 - DRENAS 2	32,1
TR3 400/220 kV TPP KOSOVA B	OPPOSITE OHL 220 kV FIERZA - PRIZREN	36,8
OHL 220 kV DRENAS 1 - TPP KOSOVA B 2	OPPOSITE BASE CASE	55,5
OHL 220 kV DRENAS 1 - DRENAS 2	OPPOSITE BASE CASE	56,2
OHL 220 kV TPP KOSOVA B - PODUJEVA	DIRECT TR3 220/110 kV PRISHTINA 4	56,7
OHL 220 kV TPP KOSOVA B - TPP KOSOVA A	DIRECT OHL 220 kV FIERZA - PRIZREN	58,3
OHL 400 kV PEJA 3 - RIBAREVINE	DIRECT TR 400/110 kV PEJA 3	58,6

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV TPP KOSOVA B - NIS 2	OPPOSITE BASE CASE	61,6
OHL 400 kV FERIZAJ 2 - SKOPJE 5	DIRECT OHL 220 kV TPP KOSOVE B - PRODUJEVA	61,9
TR 400/220 kV TPP KOSOVA B	OPPOSITE OHL 220 kV DRENAS 1 - FERONIKEL 2	63,2
OHL 220 kV DRENAS 1 - TPP KOSOVA B	OPPOSITE BASE CASE	67,0
OHL 400 kV TPP KOSOVA B - FERIZAJ 2	OPPOSITE BASE CASE	69,3
OHL 220 kV PRIZREN 2 - FIERZA	DIRECT TR3 220/110 kV PRISHTINA 4	16,6
OHL 400 kV TPP KOSOVA B - KRAGUJEVAC 2	DIRECT OHL 400 kV SKOPJE 5 - FERIZAJ 2	24,0
TR2 400/220 kV TPP KOSOVA B	OPPOSITE OHL 220 kV DRENAS 1 - DRENAS 2	32,1

Table 27 List of calculated minimum MACZT values below 70% on 21 July 2021 at 19:30 h with **FB approach in Kosovo***

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 220 kV PRIZREN 2 – FIERZA (AL)	DIRECT OHL 220 kV DRENAS 1 - DRENAS 2	55,5
TR2 400/110 kV FERIZAJI 2	OPPOSITE OHL 220.0 kV FIERZA - PRIZREN	56,5
OHL 220 kV TPP KOSOVA B - PODUJEVA	DIRECT OHL 400 kV PEJA 3 - TPP KOSOVA B	63,3

7.4.3 Comparison of the NTC and FB approaches determined minimum MACZT

For all elements having the lowest MACZT values, the following tables compare the determined minimum MACZT values for the NTC and FB approaches. All three calculated MACZT values are given: minimum, mean, and maximum value.

Table 28 Comparison of calculated minimum MACZT values **in Kosovo*** between NTC and FB approach on 20 January 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
TR 400/220 kV TPP KOSOVA B	11,3	36,6	50,1	63,2	90,6	117,8
OHL 400 kV TPP KOSOVA B - NIS 2	11,7	41,5	88,2	61,6	99,1	157,9
OHL 400 kV PEJA 3 - RIBAREVINE	14,3	46,6	60,3	58,6	86,7	142,0
OHL 220 kV DRENAS 2 - PRIZREN 2	16,0	38,3	89,4	79,1	88,3	102,6
OHL 400 kV FERIZAJ 2 - SKOPJE 5	16,7	49,2	68,3	61,9	89,9	121,6

Table 29 Comparison of calculated minimum MACZT values **in Kosovo*** between NTC and FB approach on 21 July 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 400 kV PEJA 3 – RIBAREVINE (ME)	14,0	50,7	64,0	85,0	90,9	95,6

MACZT values are significantly higher with FB than with NTC approach. Moreover, in January 2021 scenario all 5 CNE(C) that with NTC approach had minimum MACZT value below 20% would with FB approach increase MACZT values to more than 58,6%.

Similar to this, in the July 2021 scenario, the worst-case CNE(C), which had a minimum MACZT value of 14% with the NTC approach, might increase the MACZT value to 85% with the FB approach.

7.5 Montenegro

7.5.1 Calculation results with NTC approach

The following figures show MACZT calculation results for Montenegro, with NTC approach on 20 Jan 2021 at 19:30 h and 21 July 2021 at 19:30 h. There are 23 considered elements in Montenegro, including both internal and cross-zonal. Montenegrin power system includes 6 cross-zonal lines (400 and 220 kV) on 4 borders (with Serbia, Bosnia and Herzegovina, Albania and Kosovo*). In total 1052 CNE(C)s were analyzed in Montenegro.

For each element minimum, mean and maximum MACZT values are presented (for both directions). On 20 Jan 2021 at 19:30 h 2 considered elements fulfilled 70% target (TR 220/110 kV TPP Pljevlja, TR 220/110 kV Mojkovac). 20 out of 23 considered elements had minimum MACZT value below 50%.

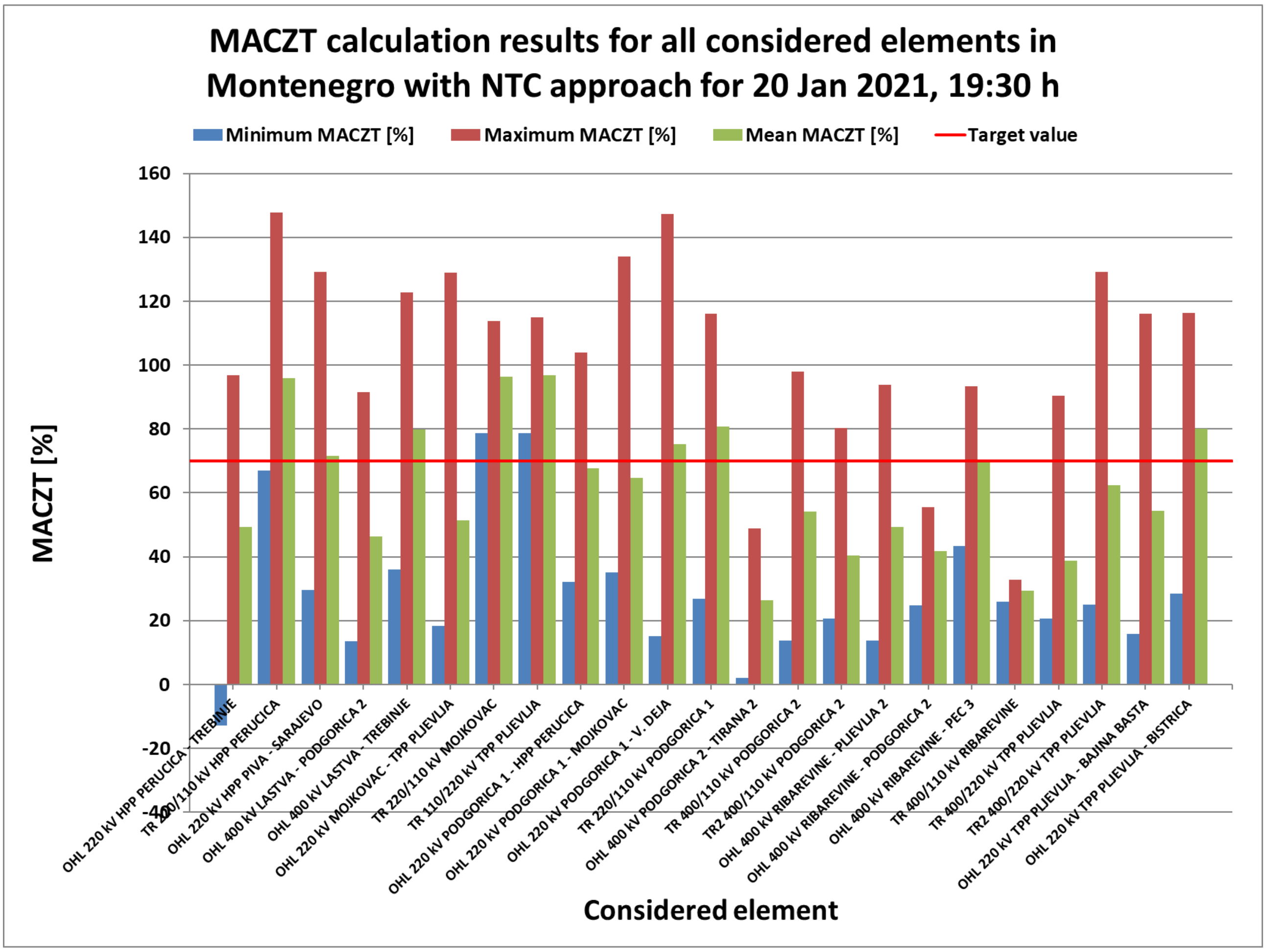


Figure 40 MACZT calculation results for Montenegro, NTC approach on 20 January 2021 at 19:30 h

In July 2021 scenario 5 considered elements fulfilled 70% target.16 considered elements were with minimum MACZT value below 50%.

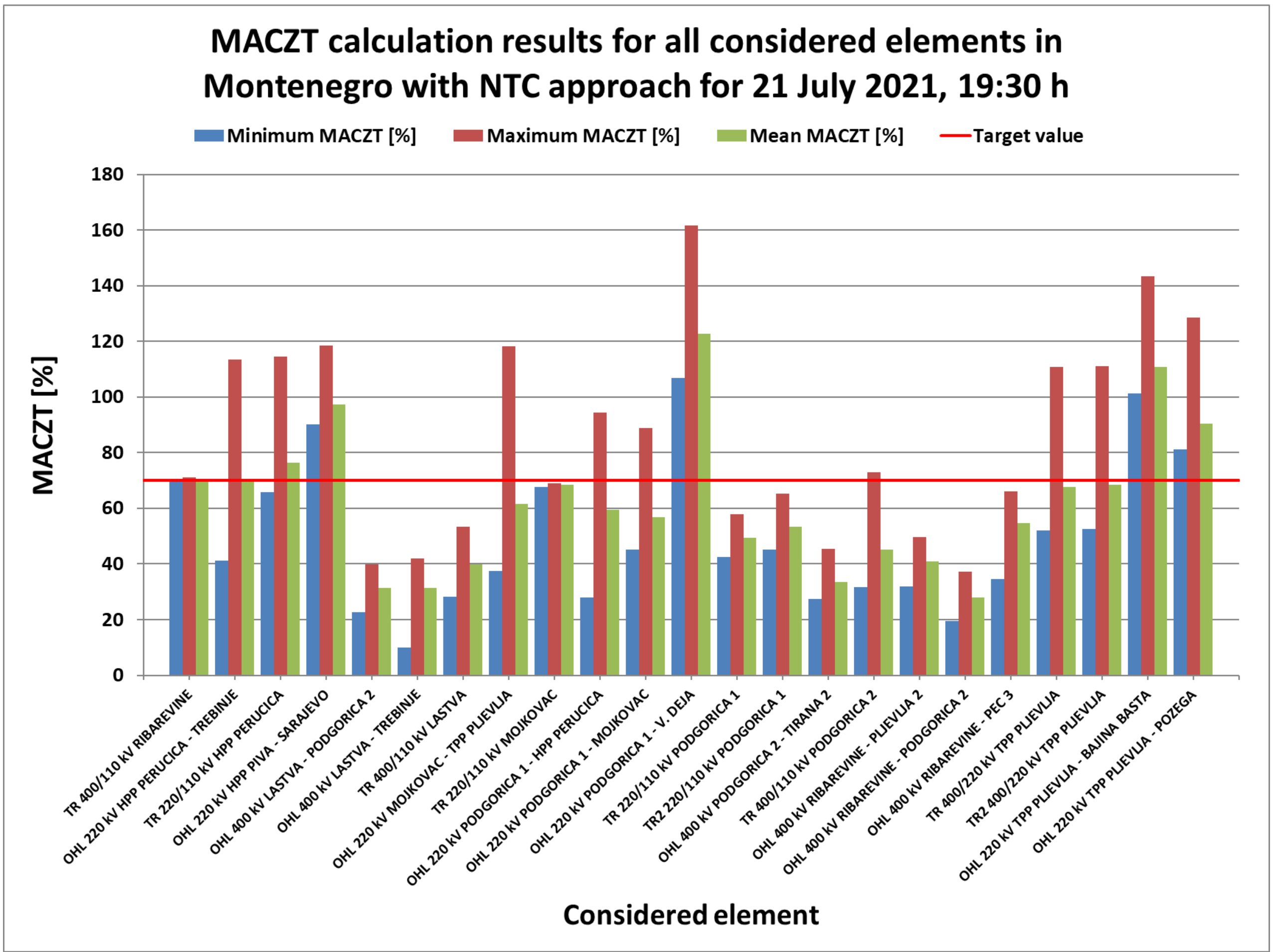


Figure 41 MACZT calculation results for Montenegro, NTC approach on 21 July 2021 at 19:30 h

On 20 Jan 2021 at 19:30 h minimum calculated MACZT value below 20% is detected on 8 elements, as shown in the following table.

Table 30 List of calculated minimum MACZT values below 20% on 20 January 2021 at 19:30 h with **NTC approach in Montenegro**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 220 kV HPP PERUCICA - TREBINJE	OPPOSITE OHL 400 kV TIRANA 2 - PODGORICA 2	-12,8
OHL 400 kV PODGORICA 2 - TIRANA 2	OPPOSITE OHL 220 kV TREBINJE - PERUCICA	2,1
OHL 400 kV LASTVA - PODGORICA 2	DIRECT OHL 400 kV TIRANA 2 - PODGORICA 2	13,6
TR 400/110 kV PODGORICA 2	OPPOSITE BASE CASE	13,8
OHL 400 kV RIBAREVINE - PLJEVLJA 2	OPPOSITE BASE CASE	13,9
OHL 220 kV PODGORICA 1 - V. DEJA	OPPOSITE OHL 220 kV MOJKOVAC - TPP PLJEVLJA	15,0
OHL 220 kV TPP PLJEVLJA - BAJINA BASTA	OPPOSITE OHL 400 kV LASTVA - PODGORICA 2	15,9
OHL 220 kV MOJKOVAC - TPP PLJEVLJA	OPPOSITE BASE CASE	18,5

It is interesting to note negative MACZT value. It appears here due to the negative part of MNCC. In the NTC approach the MCCC is always positive (refer to Eq. 8), while the MNCC can be either positive or negative (refer to Eq. 9).

On 21 July 2021 at 19:30 h the same two CNE(C)s were detected with minimum MACZT value below 20%.

Table 31 List of calculated minimum MACZT values below 20% for considered element on 21 July 2021 at 19:30 h with **NTC approach in Montenegro**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV LASTVA – TREBINJE (BiH)	DIRECT OHL 400 kV LASTVA - PODGORICA 2	10,0
OHL 400 kV RIBAREVINE - PODGORICA 2	OPPOSITE OHL 400.0 kV LASTVA – TREBINJE (BiH)	19,3

7.5.2 Calculation results with FB approach

In January 2021 scenario with **FB approach** in Montenegro there is one case with negative MACZT value (which is possible in the case when MNCC was negative and larger than MCCC). That is detected on the OHL 220 kV Podgorica 1 – HPP Perućica, but besides that the lowest level of MACZT in January scenario is 31,5%, as given in the following table.

With FB approach in January scenario in Montenegro 3 elements (out of 23 in total) fulfilled 70% target, while in July scenario 14 elements fulfilled 70% target. With NTC approach 2 and 5 elements fulfilled 70% target in both scenarios, respectively.

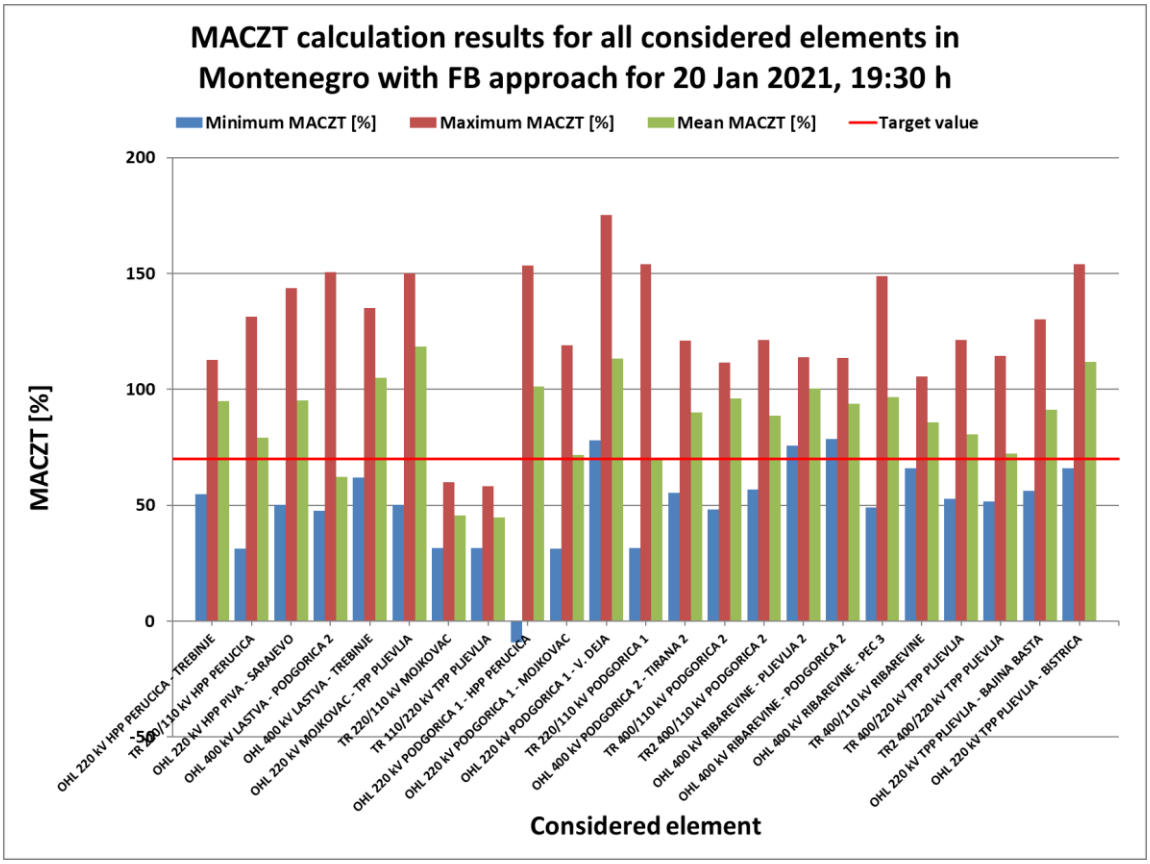


Figure 42 MACZT calculation results for Montenegro, FB approach on 20 January 2021 at 19:30 h

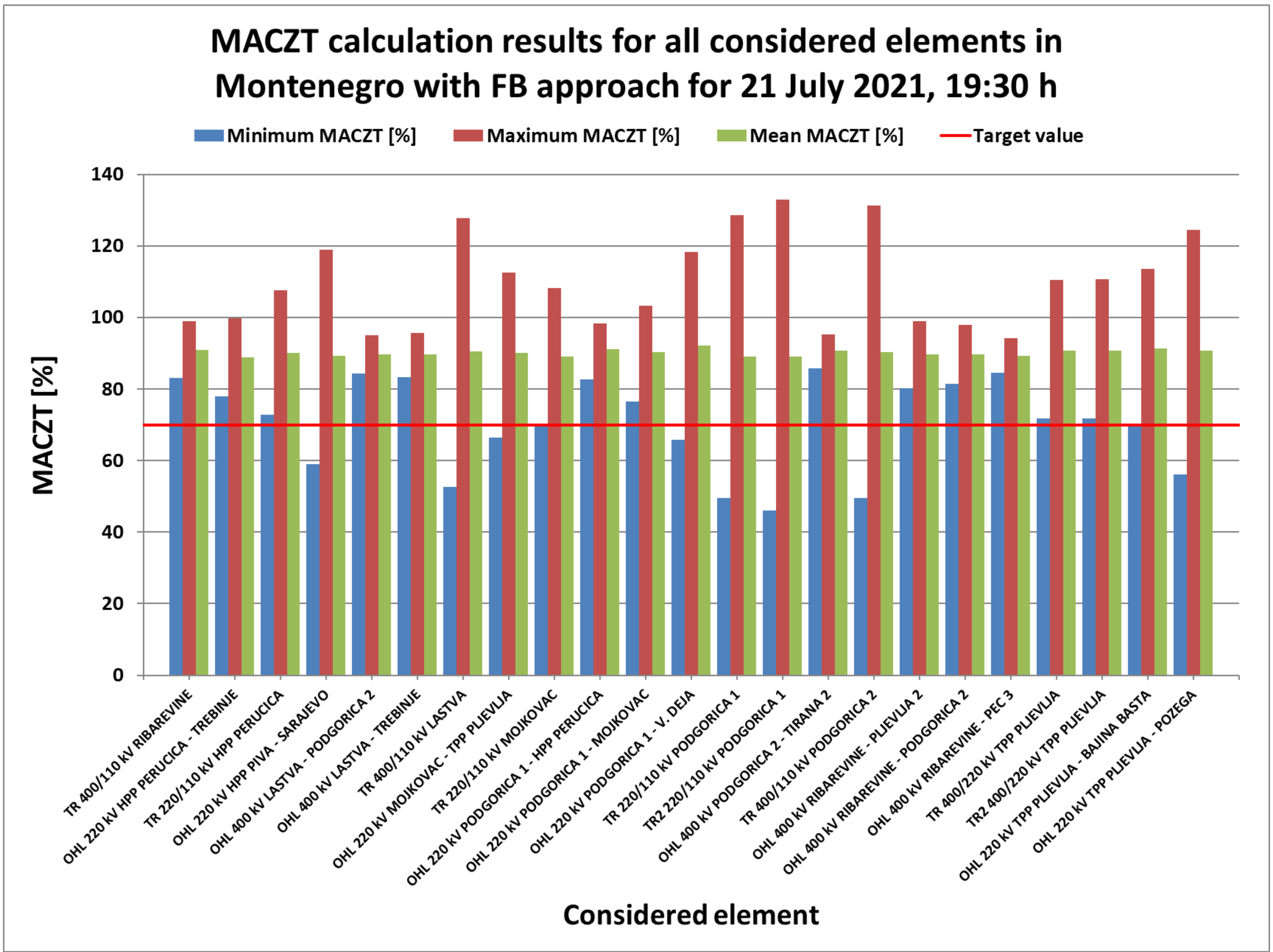


Figure 43 MACZT calculation results for Montenegro, FB approach on 21 July 2021 at 19:30 h

In the next two tables all MACZT values below 70% are shown. In January scenario there are 20 elements with minimum MACZT value below 70%, while in July scenario there are 9 elements below 70% target. Also, with FB approach in January scenario there are 6 elements with minimum MACZT value below 50%, while in July scenario there are 9 elements with minimum MACZT value below 50%.

The worst-case CNE(C)s in the FB approach differ from the worst-case CNE(C)s in the NTC approach.

Table 32 List of calculated minimum MACZT values below 70% on 20 January 2021 at 19:30 h with **FB approach in Montenegro**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 220 kV PODGORICA 1 - HPP PERUCICA	OPPOSITE TR 400/110 kV RIBAREVINE	-9,1
OHL 220 kV PODGORICA 1 - MOJKOVAC	OPPOSITE OHL 400 kV RIBAREVINE - PLJEVLJA 2	31,2
TR 220/110 kV HPP PERUCICA	OPPOSITE OHL 220 kV KOPLIK - PODGORICA 1	31,2
TR 220/110 kV MOJKOVAC	DIRECT OHL 400 kV RIBAREVINE - PLJEVLJA 2	31,5
TR 110/220 kV TPP PLJEVLJA	DIRECT OHL 220 kV TPP PLJEVLJA - BISTIRCA	31,5
TR 220/110 kV PODGORICA 1	DIRECT OHL 220 kV MOJKOVAC - TPP PLJEVLJA	31,5
OHL 400 kV LASTVA - PODGORICA 2	DIRECT OHL 400 kV RIBAREVINE - PLJEVLJA 2	47,5

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
TR 400/110 kV PODGORICA 2	OPPOSITE TR 220/110 kV MOJKOVAC	48,3
OHL 400 kV RIBAREVINE - PEC 3	OPPOSITE OHL 220 kV KOPLIK - PODGORICA 1	48,9
OHL 220 kV HPP PIVA - SARAJEVO	OPPOSITE OHL 400 kV RIBAREVINE - PEC 3	50,1
OHL 220 kV MOJKOVAC - TPP PLJEVLJA	DIRECT OHL 400 kV LASTVA - PODGORICA 2	50,2
TR2 400/220 kV TPP PLJEVLJA	DIRECT TR 110/220 kV TPP PLJEVLJA	51,6
TR 400/220 kV TPP PLJEVLJA	OPPOSITE OHL 400 kV RIBAREVINE - PEC 3	52,7
OHL 220 kV HPP PERUCICA - TREBINJE	DIRECT OHL 400 kV LASTVA - TREBINJE	54,9
OHL 400 kV PODGORICA 2 - TIRANA 2	OPPOSITE OHL 400 kV RIBAREVINE - PODGORICA 2	55,2
OHL 220 kV TPP PLJEVLJA - BAJINA BASTA	OPPOSITE OHL 400 kV TIRANA 2 - PODGORICA 2	56,1
TR2 400/110 kV PODGORICA 2	OPPOSITE TR 220/110 kV PODGORICA 1	56,7
OHL 400 kV LASTVA - TREBINJE	OPPOSITE OHL 220 kV MOJKOVAC - TPP PLJEVLJA	62,0
OHL 220 kV TPP PLJEVLJA - BISTRICA	OPPOSITE OHL 400 kV LASTVA - PODGORICA 2	66,1
TR 400/110 kV RIBAREVINE	OPPOSITE OHL 400 kV RIBAREVINE - PLJEVLJA 2	66,1

Table 33 List of calculated minimum MACZT values below 70% on 21 July 2021 at 19:30 h with **FB approach in Montenegro**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
TR2 220/110 kV PODGORICA 1	OPPOSITE TR 400/110 kV PODGORICA 2	46,0
TR 400/110 kV PODGORICA 2	OPPOSITE TR 400/110 kV LASTVA	49,5
TR 220/110 kV PODGORICA 1	OPPOSITE TR2 220/110 kV PODGORICA 1	49,6
TR 400/110 kV LASTVA	OPPOSITE TR 400/110 kV PODGORICA 2	52,6
OHL 220 kV TPP PLJEVLJA - POZEGA	OPPOSITE OHL 400 kV RIBAREVINE - PLJEVLJA 2	56,2
OHL 220 kV HPP PIVA – SARAJEVO (BIH)	OPPOSITE OHL 400 kV RIBAREVINE - PLJEVLJA 2	59,1
OHL 220 kV PODGORICA 1 - V. DEJA (AL)	DIRECT TR 400/110 kV PODGORICA 2	65,9
OHL 220 kV MOJKOVAC - TPP PLJEVLJA	OPPOSITE OHL 400 kV RIBAREVINE - PLJEVLJA 2	66,3
OHL 220 kV TPP PLJEVLJA - BAJINA BASTA (RS)	OPPOSITE OHL 220.0 kV PLJEVLJA 2 - POZEGA	69,5

7.5.3 Comparison of the NTC and FB approaches determined minimum MACZT

For all elements having the lowest MACZT values, the following tables compare the determined minimum MACZT values for the NTC and FB approaches. All three calculated MACZT values are given: minimum, mean, and maximum value.

Table 34 Comparison of calculated minimum MACZT values **in Montenegro** between NTC and FB approach on 20 January 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 220 kV HPP PERUCICA - TREBINJE	-12,8	49,3	96,8	54,9	94,9	112,7
OHL 400 kV PODGORICA 2 - TIRANA 2	2,1	26,4	48,9	55,2	89,9	120,9
OHL 400 kV LASTVA - PODGORICA 2	13,6	46,4	91,6	47,5	62,4	150,4
TR 400/110 kV PODGORICA 2	13,8	54,1	97,9	48,3	96,2	111,4
OHL 400 kV RIBAREVINE - PLJEVLJA 2	13,9	49,4	93,9	75,7	100,3	113,8
OHL 220 kV PODGORICA 1 - V. DEJA	15,0	75,2	147,4	78,1	113,2	175,1
OHL 220 kV TPP PLJEVLJA - BAJINA BASTA	15,9	54,4	116,0	56,1	91,3	130,3
OHL 220 kV MOJKOVAC - TPP PLJEVLJA	18,5	51,4	128,8	50,2	118,4	149,9

Table 35 Comparison of calculated minimum MACZT values **in Montenegro** between NTC and FB approach on 21 July 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 400 kV LASTVA – TREBINJE (BiH)	10,0	31,4	41,9	83,4	89,6	95,5
OHL 400 kV RIBAREVINE - PODGORICA 2	19,3	28,1	37,1	81,3	89,7	97,9

Clearly, MACZT values are significantly higher with FB than with NTC approach. Moreover, in January 2021 scenario the worst-case CNE(C), that with NTC approach had minimum MACZT value of -12,8%, would with FB approach increase MACZT value to 54,9%.

Similarly, in July 2021 scenario the worst-case CNE(C), that with NTC approach had minimum MACZT value of 10% would with FB approach increase MACZT value to 83,4%.

7.6 North Macedonia

7.6.1 Calculation results with NTC approach

The following figures show MACZT calculation results for North Macedonia, with NTC approach on 20 Jan 2021 at 19:30 h and 21 July 2021 at 19:30 h. There are 19 considered elements in North Macedonia, including both internal and cross-zonal. The power system of North Macedonia includes 5 cross-zonal lines (400 kV) on 4 borders (with Serbia, Kosovo*, Bulgaria and Greece). In total 704 CNE(C)s were analyzed in North Macedonia.

For each element minimum, mean and maximum MACZT values are presented (for both directions). On 20 Jan 2021 at 19:30 h none of considered elements fulfilled 70% target. All 19 considered elements were with minimum MACZT value below 50% and 10 elements below 20%.

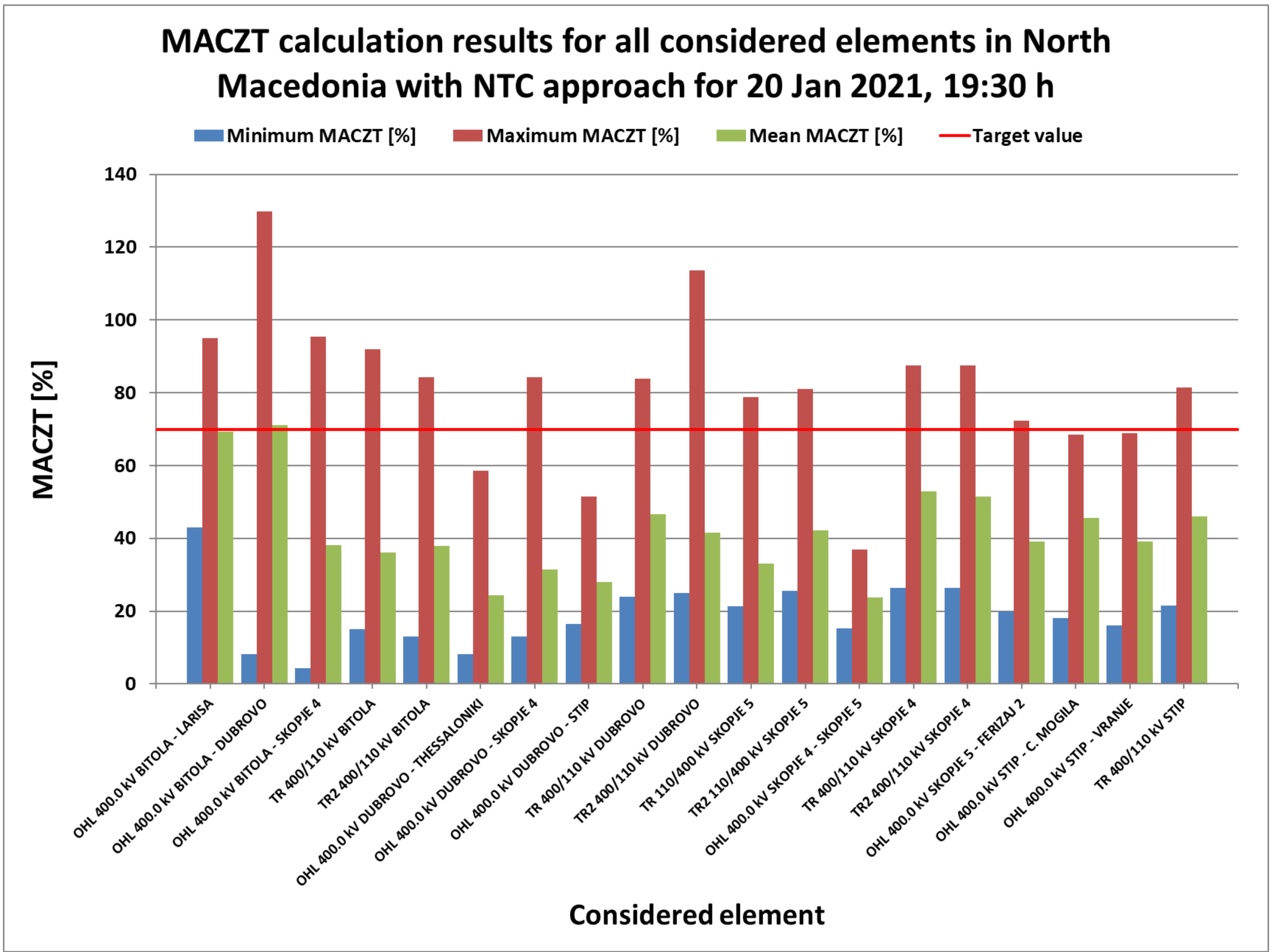


Figure 44 MACZT calculation results for North Macedonia, NTC approach on 20 January 2021 at 19:30 h

In July 2021 scenario 1 considered element fulfilled 70% target. 10 considered elements were with minimum MACZT value below 50%.

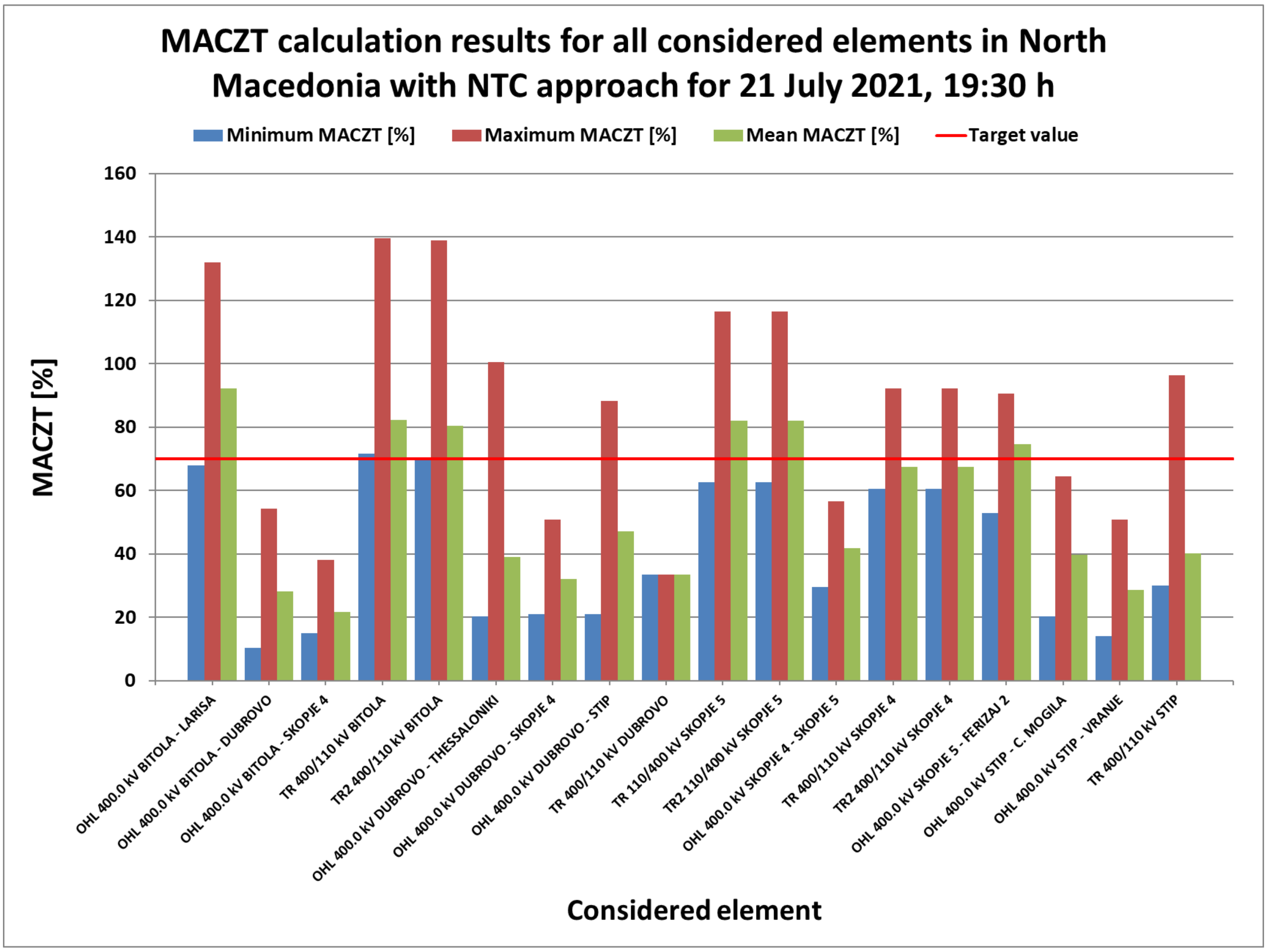


Figure 45 MACZT calculation results for North Macedonia, NTC approach on 21 July 2021 at 19:30 h

For 20 Jan 2021 at 19:30 h minimum calculated MACZT value below 20% is detected on 10 elements, as shown in the following table.

Table 36 List of calculated minimum MACZT values below 20% on 20 January 2021 at 19:30 h with NTC approach in North Macedonia

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
OHL 400.0 kV BITOLA - SKOPJE 4	DIRECT OHL 400 kV STIP - C. MOGILA	4,4
OHL 400.0 kV DUBROVO - THESSALONIKI	DIRECT OHL 400 kV BITOLA - LARISA	8,2
OHL 400.0 kV BITOLA - DUBROVO	DIRECT BASE CASE	8,2
OHL 400.0 kV DUBROVO - SKOPJE 4	DIRECT OHL 400 kV BITOLA - LARISA	13,0
TR2 400/110 kV BITOLA	OPPOSITE OHL 400 kV STIP - VRANJE	13,0
TR 400/110 kV BITOLA	DIRECT OHL 400 kV SKOPJE 5 - FERIZAJ 2	15,0
OHL 400.0 kV SKOPJE 4 - SKOPJE 5	DIRECT TR 400/110 kV BITOLA	15,2
OHL 400.0 kV STIP - VRANJE	DIRECT OHL 400 kV SKOPJE 5 - FERIZAJ 2	16,1
OHL 400.0 kV DUBROVO - STIP	OPPOSITE BASE CASE	16,5
OHL 400.0 kV STIP - C. MOGILA	DIRECT BASE CASE	18,0

For 21 July 2021 at 19:30 h 3 CNE(C)s were detected with minimum MACZT value below 20%.

Table 37 List of calculated minimum MACZT values below 20% on 21 July 2021 at 19:30 h with **NTC approach in North Macedonia**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400.0 kV BITOLA - DUBROVO	DIRECT OHL 400.0 kV DUBROVO - STIP	10,4
OHL 400.0 kV STIP - VRANJE	OPPOSITE OHL 400.0 kV DUBROVO - STIP	14,1
OHL 400.0 kV BITOLA - SKOPJE 4	DIRECT TR2 400/110 kV BITOLA	14,9

7.6.1 Calculation results with FB approach

In the January scenario in North Macedonia, 3 elements (out of 19 total) met the 70% target using the FB approach, but in the July scenario, 14 elements did so. With NTC approach none, and 3 elements fulfilled 70% target in two scenarios, respectively.

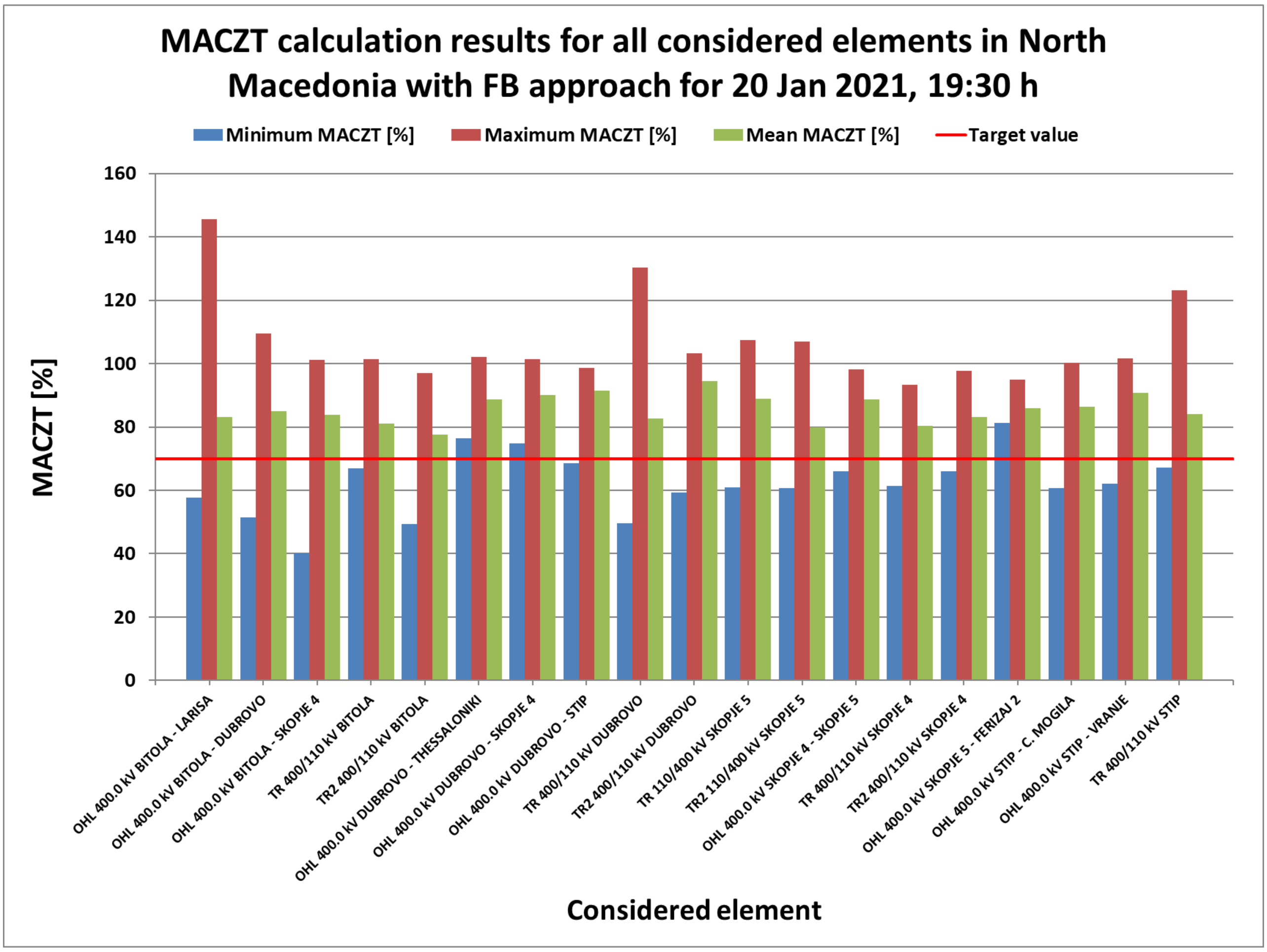


Figure 46 MACZT calculation results for North Macedonia, FB approach on 20 January 2021 at 19:30 h

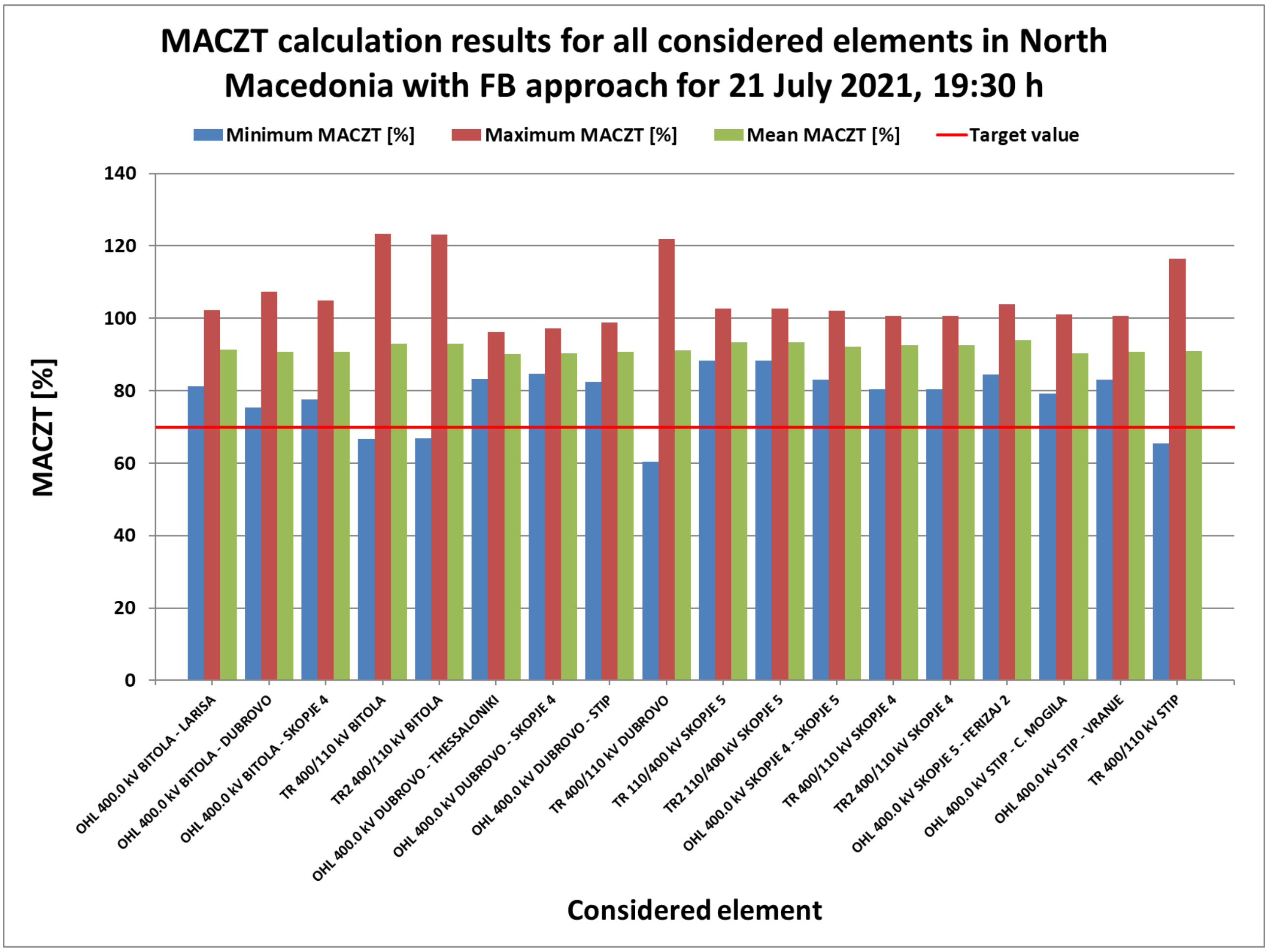


Figure 47 MACZT calculation results for North Macedonia, **FB approach** on 21 July 2021 at 19:30 h

In the next two tables all MACZT values below 70% are shown. In January scenario there are 16 elements with minimum MACZT value below 70%, while in July scenario there are 4 elements below 70% target. Also, with FB approach in January scenario there are 3 elements with minimum MACZT value below 50%, while in July scenario there are no elements with minimum MACZT value below 50%.

Table 38 List of calculated minimum MACZT values below 70% on 20 January 2021 at 19:30 h with **FB approach in North Macedonia**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
OHL 400.0 kV BITOLA - SKOPJE 4	OPPOSITE BASE CASE	40,0
TR2 400/110 kV BITOLA	DIRECT TR2 400/110 kV DUBROVO	49,4
TR 400/110 kV DUBROVO	DIRECT TR2 400/110 kV DUBROVO	49,7
OHL 400.0 kV BITOLA - DUBROVO	DIRECT OHL 400.0 kV BITOLA - SKOPJE 4	51,5
OHL 400.0 kV BITOLA - LARISA	DIRECT OHL 400.0 kV DUBROVO - STIP	57,6
TR2 400/110 kV DUBROVO	OPPOSITE BASE CASE	59,4
TR2 110/400 kV SKOPJE 5	OPPOSITE OHL 400.0 kV DUBROVO - SKOPJE 4	60,7
OHL 400.0 kV STIP - C. MOGILA	OPPOSITE BASE CASE	60,7

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
TR 110/400 kV SKOPJE 5	OPPOSITE TR 400/110 kV STIP	61,0
TR 400/110 kV SKOPJE 4	OPPOSITE OHL 400 kV DUBROVO - THESSALONIKI	61,4
OHL 400.0 kV STIP - VRANJE	OPPOSITE BASE CASE	62,2
TR2 400/110 kV SKOPJE 4	OPPOSITE BASE CASE	66,0
OHL 400.0 kV SKOPJE 4 - SKOPJE 5	OPPOSITE BASE CASE	66,0
TR 400/110 kV BITOLA	DIRECT BASE CASE	67,0
TR 400/110 kV STIP	OPPOSITE OHL 400 kV BITOLA - LARISA	67,2
OHL 400.0 kV DUBROVO - STIP	OPPOSITE BASE CASE	68,6

Table 39 List of calculated minimum MACZT values below 70% on 21 July 2021 at 19:30 h with **FB approach in North Macedonia**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
TR 400/110 kV DUBROVO	OPPOSITE TR2 400/110 kV DUBROVO	60,4
TR 400/110 kV STIP	OPPOSITE TR 400/110 kV DUBROVO	65,4
TR 400/110 kV BITOLA	DIRECT TR2 400/110 kV BITOLA	66,7
TR2 400/110 kV BITOLA	DIRECT TR 400/110 kV BITOLA	66,8

7.6.2 Comparison of the NTC and FB approaches determined minimum MACZT

For all elements having the lowest MACZT values, the following tables compare the determined minimum MACZT values for the NTC and FB approaches. All three calculated MACZT values are given: minimum, mean, and maximum value.

Table 40 Comparison of calculated minimum MACZT values **in North Macedonia** between NTC and FB approach on 20 January 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 400.0 kV BITOLA - SKOPJE 4	4,4	38,2	95,3	40,0	83,8	101,1
OHL 400.0 kV DUBROVO - THESSALONIKI	8,2	24,3	58,6	76,4	88,7	102,1
OHL 400.0 kV BITOLA - DUBROVO	8,2	71,0	129,8	51,5	85,1	109,4
OHL 400.0 kV DUBROVO - SKOPJE 4	13,0	31,5	84,3	74,8	90,1	101,3
TR2 400/110 kV BITOLA	13,0	38,0	84,3	49,4	77,5	97,0
TR 400/110 kV BITOLA	15,0	36,2	91,9	67,0	81,0	101,4
OHL 400.0 kV SKOPJE 4 - SKOPJE 5	15,2	23,8	36,9	66,0	88,7	98,2
OHL 400.0 kV STIP - VRANJE	16,1	39,2	68,9	62,2	90,8	101,7

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 400.0 kV DUBROVO - STIP	16,5	27,9	51,6	68,6	91,4	98,6
OHL 400.0 kV STIP - C. MOGILA	18,0	45,7	68,4	60,7	86,3	100,2

Table 41 Comparison of calculated minimum MACZT values **in North Macedonia** between NTC and FB approach on 21 July 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 400.0 kV BITOLA - DUBROVO	10,4	28,2	54,3			
OHL 400.0 kV STIP - VRANJE	14,1	28,5	50,9	83,1	90,8	100,7
OHL 400.0 kV BITOLA - SKOPJE 4	14,9	21,6	38,1	77,6	90,8	104,9

Clearly, MACZT values are significantly higher with FB than with NTC approach. Moreover, in January 2021 scenario the worst-case CNE(C), that with NTC approach had minimum MACZT value of only 4,4% would with FB approach increase MACZT value to 40%.

Similarly, in July 2021 scenario the worst-case CNE(C), that with NTC approach had minimum MACZT value of 10,4% would with FB approach increase MACZT value to 75,4%.

7.7 Serbia

7.7.1 Calculation results with NTC approach

The following figures show MACZT calculation results for Serbia, with NTC approach on 20 Jan 2021 at 19:30 h and 21 July 2021 at 19:30 h. There are 56 considered elements in Serbia, including both internal and cross-zonal on 8 borders (with Croatia, Bosnia and Herzegovina, Montenegro, North Macedonia, Kosovo*, Hungary, Bulgaria and Romania). In total 11050 CNE(C)s were analyzed in Serbia. This is the largest system analyzed in 2021 timeframe.

For each element minimum, mean and maximum MACZT values are presented (for both directions). On 20 Jan 2021 at 19:30 h only 3 considered elements fulfilled 70% target. 52 considered elements were detected with minimum MACZT value below 50% and 30 elements below 20%.

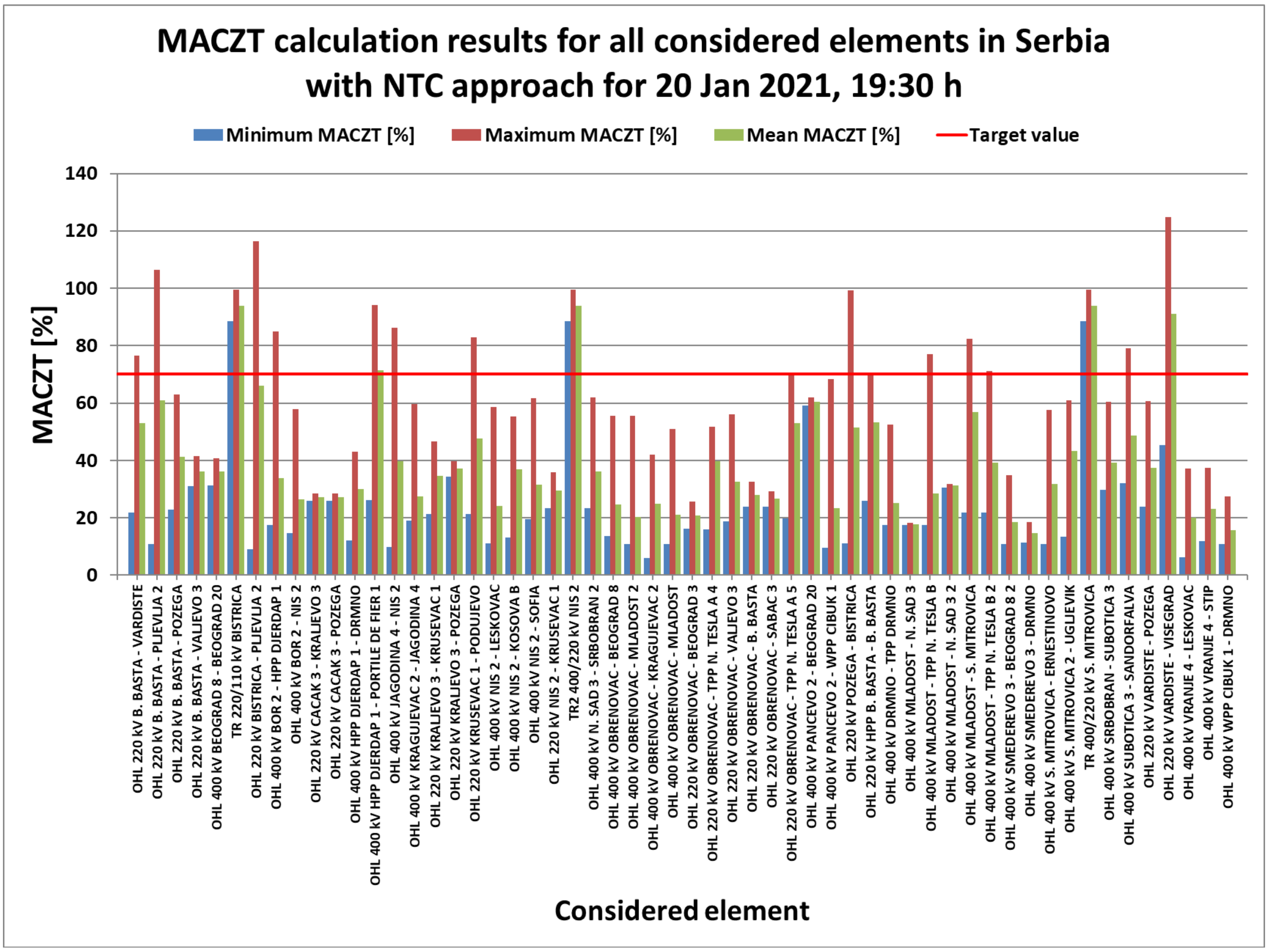


Figure 48 MACZT calculation results for Serbia, **NTC approach** on 20 January 2021 at 19:30 h

In July 2021 scenario 2 considered elements fulfilled 70% target (OHL 220 kV B.Bašta – Pljevlja (ME) and OHL 400 kV HPP Đerdap – Portile de Fier 1 (RO)), while 52 considered elements were detected with minimum MACZT value below 50%.

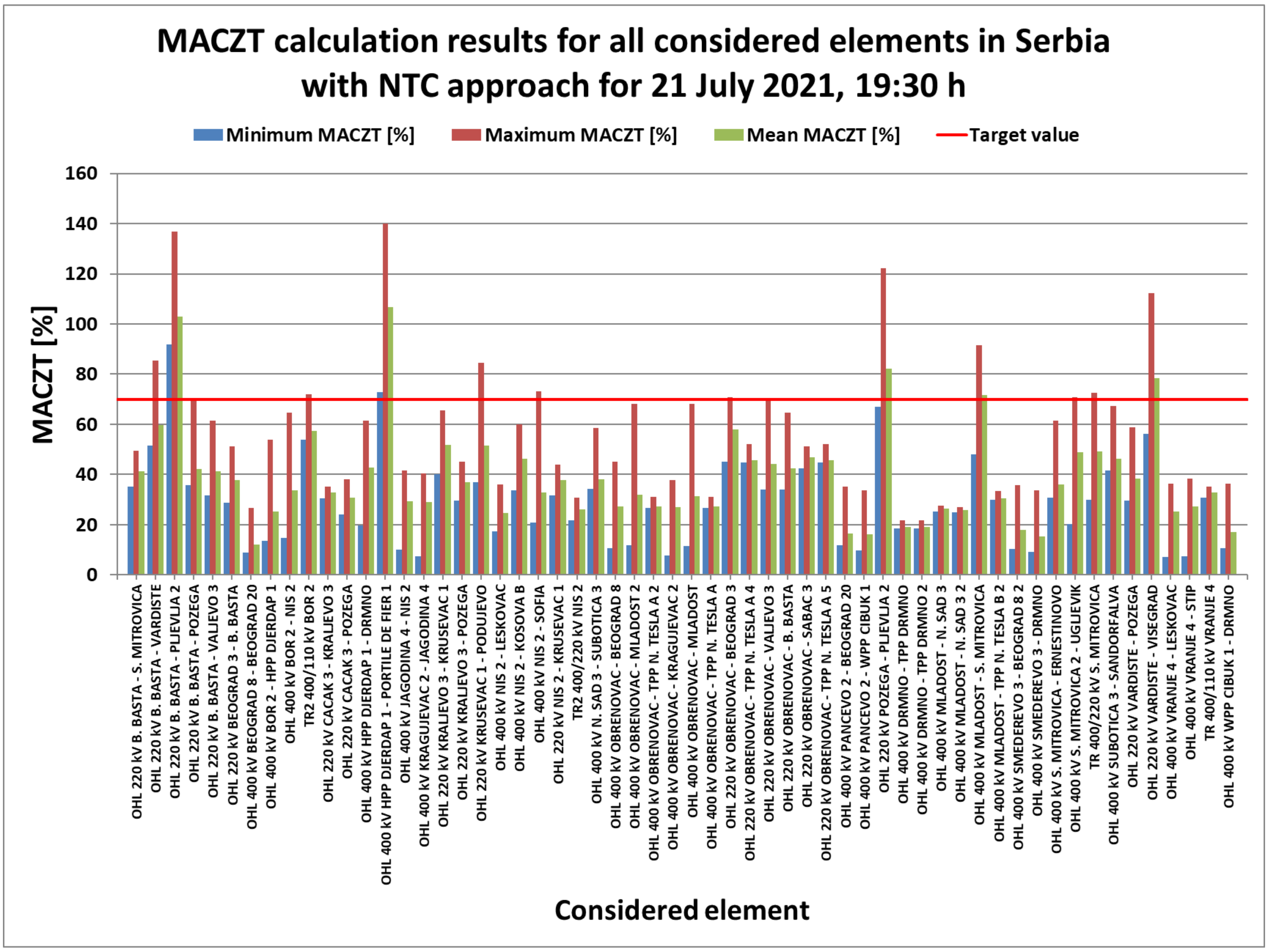


Figure 49 MACZT calculation results for Serbia, **NTC approach** on 21 July 2021 at 19:30 h

For 20 Jan 2021 at 19:30 h minimum calculated MACZT below 20% is detected on 30 elements, as shown in the following table.

Table 42 List of calculated minimum MACZT values below 20% on 20 January 2021 at 19:30 h with **NTC approach in Serbia**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV OBRENOVAC - KRAGUJEVAC 2	OPPOSITE OHL 400 kV MLADOST - N. SAD 3 2	6,0
OHL 400 kV VRANJE 4 – LESKOVAC	DIRECT OHL 220 kV OBRENOVAC - BEOGRAD 5	6,1
OHL 220 kV BISTRICA - PLJEVLJA 2	OPPOSITE OHL 220 kV OBRENOVAC - BEOGRAD 5 2	9,0
OHL 400 kV PANCEVO 2 - WPP CIBUK 1	DIRECT OHL 400 kV JAGODINA 4 - NIS 2	9,6
OHL 400 kV JAGODINA 4 - NIS 2	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B	9,7
OHL 400 kV SMEDEREVO 3 - BEOGRAD 8 2	DIRECT TR2 220/110 kV BEOGRAD 17	10,8
OHL 400 kV OBRENOVAC - MLADOST	DIRECT TR 220/110 kV BEOGRAD 17	10,8
OHL 220 kV B. BASTA - PLJEVLJA 2	OPPOSITE OHL 400 kV JAGODINA 4 - NIS 2	10,8
OHL 400 kV S. MITROVICA - ERNESTINOVO	OPPOSITE OHL 400 kV OBRENOVAC - KRAGUJEVAC 2	10,9
OHL 400 kV WPP CIBUK 1 - DRMNO	OPPOSITE TR2 400/110 kV KRAGUJEVAC 2	10,9

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV OBRENOVAC - MLADOST 2	DIRECT TR 220/110 kV BEOGRAD 17	10,9
OHL 220 kV POZEGA - BISTRICA	OPPOSITE OHL 400 kV KRAGUJEVAC 2 - JAGODINA 4	11,2
OHL 400 kV NIS 2 - LESKOVAC	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B	11,2
OHL 400 kV SMEDEREVO 3 - DRMNO	DIRECT OHL 220 kV HIP - TPP PANCEVO 2	11,5
OHL 400 kV VRANJE 4 - STIP	OPPOSITE OHL 400 kV SMEDEREVO 3 - BEOGRAD 8 2	11,9
OHL 400 kV HPP DJERDAP 1 - DRMNO	DIRECT OHL 220 kV OBRENOVAC - BEOGRAD 5 2	12,0
OHL 400 kV NIS 2 - KOSOVA B	OPPOSITE OHL 220 kV TPP PLJEVLJA - BISTIRCA	13,0
OHL 400 kV S. MITROVICA 2 - UGLJEVIK	OPPOSITE BASE CASE	13,4
OHL 400 kV OBRENOVAC - BEOGRAD 8	OPPOSITE TR2 220/110 kV KRUSEVAC 1	13,7
OHL 400 kV BOR 2 - NIS 2	OPPOSITE OHL 220 kV PANCEVO 2 - WPP KOVACICA	14,6
OHL 220 kV OBRENOVAC - TPP N. TESLA A 4	DIRECT OHL 220 kV BEOGRAD 8 - BEOGRAD 17	15,9
OHL 220 kV OBRENOVAC - BEOGRAD 3	DIRECT OHL 400 kV OBRENOVAC - BEOGRAD 8	16,1
OHL 400 kV BOR 2 - HPP DJERDAP 1	OPPOSITE OHL 400 kV SMEDEREVO 3 - DRMNO	17,4
OHL 400 kV DRMNO - TPP DRMNO	DIRECT BASE CASE	17,5
OHL 400 kV MLADOST - N. SAD 3	DIRECT OHL 400 kV MLADOST - S. MITROVICA	17,5
OHL 400 kV MLADOST - TPP N. TESLA B	DIRECT OHL 220 kV B. BASTA - S. MITROVICA	17,5
OHL 220 kV OBRENOVAC - VALJEVO 3	OPPOSITE TR2 220/110 kV POZEGA	18,7
OHL 400 kV KRAGUJEVAC 2 - JAGODINA 4	OPPOSITE TR 220/110 kV KRUSEVAC 1	19,1
OHL 400 kV NIS 2 - SOFIA	DIRECT OHL 220 kV OBRENOVAC - TPP N. TESLA A 4	19,4
OHL 220 kV OBRENOVAC - TPP N. TESLA A 5	OPPOSITE OHL 220 kV HIP - TPP PANCEVO 2	19,7

For 21 July 2021 at 19:30 h 20 CNE(C)s were detected with minimum MACZT value below 20%, as given below in the following table.

Table 43 List of calculated minimum MACZT values below 20% on 21 July 2021 at 19:30 h with NTC approach in Serbia

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV VRANJE 4 - LESKOVAC	DIRECT OHL 400 kV NIS 2 - LESKOVAC	7,1
OHL 400 kV KRAGUJEVAC 2 - JAGODINA 4	DIRECT OHL 400 kV JAGODINA 4 - NIS 2	7,3
OHL 400 kV VRANJE 4 - STIP	OPPOSITE OHL 400 kV VRANJE 4 - LESKOVAC	7,3
OHL 400 kV OBRENOVAC - KRAGUJEVAC 2	DIRECT OHL 400 kV KRAGUJEVAC 2 - JAGODINA 4	7,7
OHL 400 kV BEOGRAD 8 - BEOGRAD 20	DIRECT OHL 400 kV S.MITROVICA - ERNESTINOVO	8,8
OHL 400 kV SMEDEREVO 3 - DRMNO	DIRECT OHL 400 kV DRMNO - TPP DRMNO	9,3
OHL 400 kV PANCEVO 2 - WPP CIBUK 1	DIRECT OHL 400 kV MLADOST - S. MITROVICA	9,9
OHL 400 kV JAGODINA 4 - NIS 2	DIRECT OHL 400 kV KRAGUJEVAC 2 - JAGODINA 4	10,2
OHL 400 kV SMEDEREVO 3 - BEOGRAD 8 2	OPPOSITE OHL 400 kV MLADOST - S. MITROVICA	10,4
OHL 400 kV OBRENOVAC - BEOGRAD 8	DIRECT OHL 400 kV MLADOST - S. MITROVICA	10,6
OHL 400 kV WPP CIBUK 1 - DRMNO	DIRECT OHL 400 kV DRMNO - TPP DRMNO 2	10,8
OHL 400 kV OBRENOVAC - MLADOST	OPPOSITE OHL 400 kV MLADOST - S. MITROVICA	11,7

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV OBRENOVAC - MLADOST 2	OPPOSITE OHL 400 kV MLADOST - S. MITROVICA	11,8
OHL 400 kV PANCEVO 2 - BEOGRAD 20	OPPOSITE OHL 400 kV S.MITROVICA - ERNESTINOVO	11,8
OHL 400 kV BOR 2 - HPP DJERDAP 1	DIRECT OHL 400 kV NIS 2 - KOSOVO B	13,4
OHL 400 kV BOR 2 - NIS 2	OPPOSITE OHL 400 kV BOR 2 - HPP DJERDAP 1	14,6
OHL 400 kV NIS 2 – LESKOVAC	OPPOSITE OHL 400 kV JAGODINA 4 - NIS 2	17,5
OHL 400 kV DRMNO - TPP DRMNO	DIRECT BASE CASE	18,7
OHL 400 kV DRMNO - TPP DRMNO 2	DIRECT BASE CASE	18,7
OHL 400 kV HPP DJERDAP 1 - DRMNO	OPPOSITE OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1	19,8

7.7.2 Calculation results with FB approach

With FB approach in January scenario in Serbia 12 elements (out of 56 in total) fulfilled 70% target, while in July scenario 18 elements fulfilled 70% target, as given in the following two figures. With NTC approach 3 and 2 elements fulfilled 70% target in two scenarios, respectively.

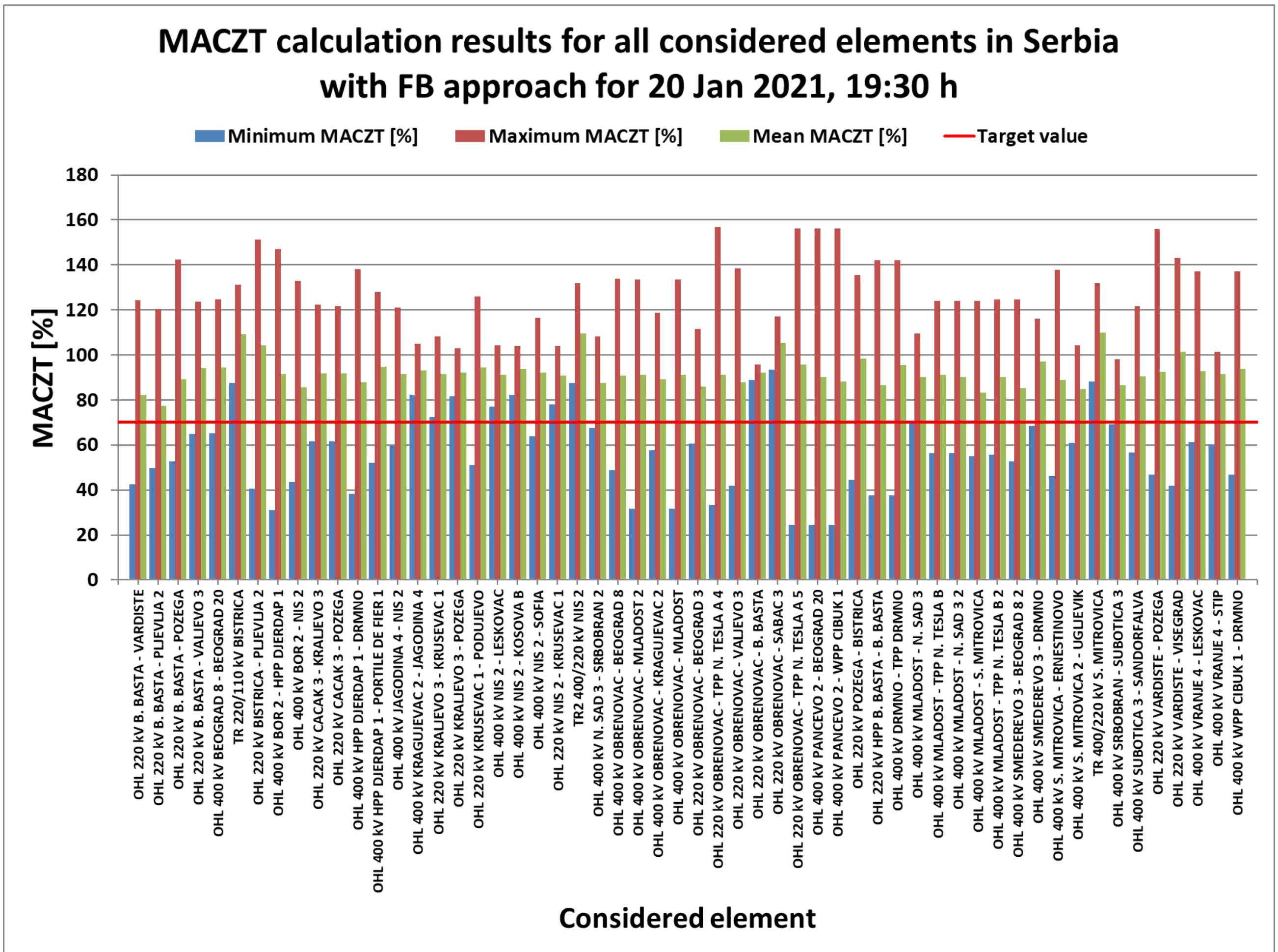


Figure 50 MACZT calculation results for Serbia, FB approach on 20 January 2021 at 19:30 h

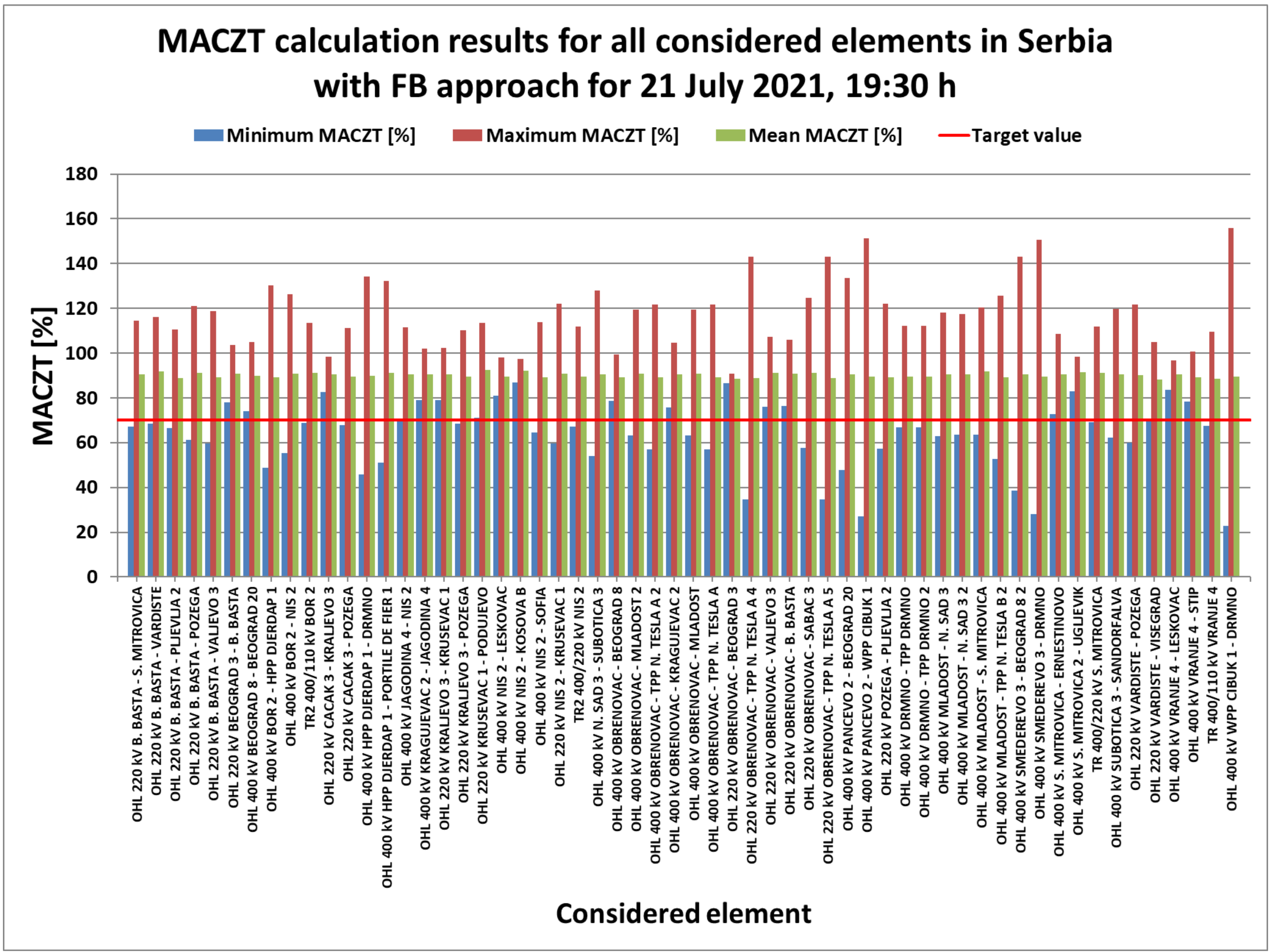


Figure 51 MACZT calculation results for Serbia, **FB approach** on 21 July 2021 at 19:30 h

In the next two tables all MACZT values below 70% are shown. In January scenario there are 44 elements with minimum MACZT value below 70%, while in July scenario there are 40 elements below 70% target. Also, with FB approach in January scenario there are 21 elements with minimum MACZT value below 50%, while in July scenario there are 9 elements with minimum MACZT value below 50%.

Table 44 List of calculated minimum MACZT values below 70% on 20 January 2021 at 19:30 h with **FB approach in Serbia**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
OHL 220 kV OBRENOVAC - TPP N. TESLA A 5	OPPOSITE OHL 220 kV OBRENOVAC - TPP N. TESLA A 2	24,3
OHL 400 kV PANCEVO 2 - BEOGRAD 20	OPPOSITE OHL 400 kV JAGODINA 4 - NIS 2	24,3
OHL 400 kV PANCEVO 2 - WPP CIBUK 1	OPPOSITE OHL 220 kV B. BASTA - S. MITROVICA	24,3
OHL 400 kV BOR 2 - HPP DJERDAP 1	OPPOSITE OHL 220 kV RHPP B. BASTA - B. BASTA 2	31,2
OHL 400 kV OBRENOVAC - MLADOST 2	OPPOSITE OHL 400 kV VRANJE 4 - LESKOVAC	31,6
OHL 400 kV OBRENOVAC - MLADOST	OPPOSITE OHL 220 kV TPP PANCEVO 2 - RAFINERIJA	31,7
OHL 220 kV OBRENOVAC - TPP N. TESLA A 4	DIRECT OHL 220 kV HIP - TPP PANCEVO 2	33,5
OHL 220 kV HPP B. BASTA - B. BASTA	DIRECT BASE CASE	37,6
OHL 400 kV DRMNO - TPP DRMNO	DIRECT OHL 220 kV B. BASTA - S. MITROVICA	37,6
OHL 400 kV HPP DJERDAP 1 - DRMNO	DIRECT OHL 400 kV OBRENOVAC - KRAGUJEVAC 2	38,3

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 220 kV BISTRICA - PLJEVLJA 2	DIRECT OHL 400 kV BOR 2 - HPP DJERDAP 1	40,4
OHL 220 kV OBRENOVAC - VALJEVO 3	OPPOSITE OHL 220 kV B. BASTA - S. MITROVICA	41,9
OHL 220 kV VARDISTE - VISEGRAD	OPPOSITE BASE CASE	41,9
OHL 220 kV B. BASTA - VARDISTE	OPPOSITE OHL 220 kV N. SAD 3 - ZRENJANIN 2	42,6
OHL 400 kV BOR 2 - NIS 2	OPPOSITE OHL 220 kV NIS 2 - KRUSEVAC 1	43,4
OHL 220 kV POZEGA - BISTRICA	OPPOSITE BASE CASE	44,6
OHL 400 kV S. MITROVICA - ERNESTINOVO	OPPOSITE OHL 220 kV KRUSEVAC 1 - PODUJEVO	46,2
OHL 220 kV VARDISTE - POZEGA	DIRECT OHL 220 kV KRALJEVO 3 - KRUSEVAC 1	46,8
OHL 400 kV WPP CIBUK 1 - DRMNO	OPPOSITE TR 400/110 kV NIS 2	46,9
OHL 400 kV OBRENOVAC - BEOGRAD 8	DIRECT OHL 220 kV OBRENOVAC - BEOGRAD 5 2	48,6
OHL 220 kV B. BASTA - PLJEVLJA 2	DIRECT OHL 400 kV OBRENOVAC - MLADOST 2	49,7
OHL 220 kV KRUSEVAC 1 - PODUJEVO	OPPOSITE OHL 220 kV OBRENOVAC - BEOGRAD 5 2	51,0
OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1	DIRECT OHL 220 kV BEOGRAD 8 - SMEDEREVO 3	51,9
OHL 220 kV B. BASTA - POZEGA	DIRECT OHL 400 kV OBRENOVAC - MLADOST 2	52,6
OHL 400 kV SMEDEREVO 3 - BEOGRAD 8 2	DIRECT OHL 400 kV VRANJE 4 - LESKOVAC	52,6
OHL 400 kV MLADOST - S. MITROVICA	OPPOSITE TR 220/110 kV KRUSEVAC 1	54,9
OHL 400 kV MLADOST - TPP N. TESLA B 2	OPPOSITE OHL 220 kV OBRENOVAC - TPP N. TESLA A 2	55,5
OHL 400 kV MLADOST - TPP N. TESLA B	OPPOSITE OHL 220 kV OBRENOVAC - TPP N. TESLA A 2	56,2
OHL 400 kV MLADOST - N. SAD 3 2	OPPOSITE OHL 400 kV MLADOST - S. MITROVICA	56,2
OHL 400 kV SUBOTICA 3 - SANDORFALVA	OPPOSITE TR 400/110 kV LESKOVAC	56,5
OHL 400 kV OBRENOVAC - KRAGUJEVAC 2	OPPOSITE OHL 400 kV N. SAD 3 - SRBOBRAN 2	57,5
OHL 400 kV JAGODINA 4 - NIS 2	OPPOSITE OHL 400 kV BOR 2 - NIS 2	59,5
OHL 400 kV VRANJE 4 - STIP	OPPOSITE BASE CASE	60,1
OHL 220 kV OBRENOVAC - BEOGRAD 3	OPPOSITE OHL 400 kV OBRENOVAC - BEOGRAD 8	60,5
OHL 400 kV S. MITROVICA 2 - UGLJEVIK	OPPOSITE TR 400/110 kV NIS 2	61,0
OHL 400 kV VRANJE 4 - LESKOVAC	DIRECT OHL 220 kV CACAK 3 - POZEGA	61,2
OHL 220 kV CACAK 3 - KRALJEVO 3	DIRECT OHL 220 kV KRALJEVO 3 - POZEGA	61,6
OHL 220 kV CACAK 3 - POZEGA	DIRECT OHL 220 kV KRALJEVO 3 - POZEGA	61,7
OHL 400 kV NIS 2 - SOFIA	OPPOSITE OHL 220 kV PANCEVO 2 - WPP KOVACICA	64,0
OHL 220 kV B. BASTA - VALJEVO 3	DIRECT OHL 220 kV VARDISTE - VISEGRAD	64,9
OHL 400 kV BEOGRAD 8 - BEOGRAD 20	DIRECT OHL 400 kV SMEDEREVO 3 - DRMNO	65,2
OHL 400 kV N. SAD 3 - SRBOBRAN 2	DIRECT OHL 220 kV HIP - TPP PANCEVO 2	67,6
OHL 400 kV SMEDEREVO 3 - DRMNO	DIRECT OHL 220 kV HIP - TPP PANCEVO 2	68,5
OHL 400 kV SRBOBRAN - SUBOTICA 3	OPPOSITE OHL 220 kV BEOGRAD 8 - BEOGRAD 3	69,2

Table 45 List of calculated minimum MACZT values below 70% on 21 July 2021 at 19:30 h with **FB approach in Serbia**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV WPP CIBUK 1 - DRMNO	OPPOSITE OHL 400 kV SMEDEREVO 3 - DRMNO	22,7
OHL 400 kV PANCEVO 2 - WPP CIBUK 1	OPPOSITE OHL 400 kV SMEDEREVO 3 - DRMNO	27,2

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV SMEDEREVO 3 – DRMNO	OPPOSITE OHL 400 kV PANCEVO 2 - WPP CIBUK 1	28,1
OHL 220 kV OBRENOVAC - TPP N. TESLA A 4	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B 2	34,6
OHL 220 kV OBRENOVAC - TPP N. TESLA A 5	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B 2	34,6
OHL 400 kV SMEDEREVO 3 - BEOGRAD 8 2	DIRECT OHL 400 kV PANCEVO 2 - WPP CIBUK 1	38,6
OHL 400 kV HPP DJERDAP 1 - DRMNO	DIRECT OHL 400 kV BOR 2 - HPP DJERDAP 1	45,8
OHL 400 kV PANCEVO 2 - BEOGRAD 20	DIRECT OHL 400 kV SMEDEREVO 3 - DRMNO	47,9
OHL 400 kV BOR 2 - HPP DJERDAP 1	OPPOSITE OHL 400 kV HPP DJERDAP 1 - DRMNO	48,7
OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1	DIRECT OHL 400 kV BOR 2 - HPP DJERDAP 1	51,0
OHL 400 kV MLADOST - TPP N. TESLA B 2	OPPOSITE OHL 400 kV DRMNO - TPP DRMNO	52,8
OHL 400 kV N. SAD 3 - SUBOTICA 3	DIRECT OHL 400 kV MLADOST - S. MITROVICA	54,0
OHL 400 kV BOR 2 - NIS 2	DIRECT OHL 400 kV HPP DJERDAP 1 - DRMNO	55,4
OHL 400 kV OBRENOVAC - TPP N. TESLA A 2	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B 2	56,9
OHL 400 kV OBRENOVAC - TPP N. TESLA A	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B 2	56,9
OHL 220 kV POZEGA - PLJEVLJA 2	DIRECT OHL 220 kV B. BASTA - POZEGA	57,2
OHL 220 kV OBRENOVAC - SABAC 3	DIRECT OHL 400 kV MLADOST - S. MITROVICA	57,8
OHL 220 kV B. BASTA - VALJEVO 3	DIRECT OHL 400 kV HPP DJERDAP 1 - DRMNO	59,5
OHL 220 kV NIS 2 - KRUSEVAC 1	DIRECT OHL 400 kV JAGODINA 4 - NIS 2	59,5
OHL 220 kV VARDISTE – POZEGA	DIRECT OHL 220 kV B. BASTA - POZEGA	59,9
OHL 220 kV B. BASTA – POZEGA	DIRECT OHL 220 kV VARDISTE - POZEGA	61,1
OHL 400 kV SUBOTICA 3 - SANDORFALVA	DIRECT OHL 400 kV MLADOST - S. MITROVICA	62,2
OHL 400 kV MLADOST - N. SAD 3	DIRECT OHL 400 kV MLADOST - S. MITROVICA	62,8
OHL 400 kV OBRENOVAC - MLADOST 2	DIRECT OHL 400 kV OBRENOVAC - MLADOST	63,2
OHL 400 kV OBRENOVAC – MLADOST	DIRECT OHL 400 kV OBRENOVAC - MLADOST 2	63,2
OHL 400 kV MLADOST - N. SAD 3 2	DIRECT OHL 400 kV MLADOST - S. MITROVICA	63,4
OHL 400 kV MLADOST - S. MITROVICA	DIRECT OHL 400 kV N. SAD 3 - SUBOTICA 3	63,6
OHL 400 kV NIS 2 – SOFIA	OPPOSITE OHL 400 kV BOR 2 - HPP DJERDAP 1	64,6
OHL 220 kV B. BASTA - PLJEVLJA 2	DIRECT OHL 220 kV TPP PLJEVLJA - POŽEGA	66,4
OHL 400 kV DRMNO - TPP DRMNO	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B 2	66,9
OHL 400 kV DRMNO - TPP DRMNO 2	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B 2	66,9
TR2 400/220 kV NIS 2	OPPOSITE OHL 400 kV JAGODINA 4 - NIS 2	67,0
OHL 220 kV B. BASTA - S. MITROVICA	DIRECT OHL 400 kV MLADOST - S. MITROVICA	67,1
TR 400/110 kV VRANJE 4	OPPOSITE OHL 400 kV VRANJE 4 - LESKOVAC	67,5
OHL 220 kV CACAK 3 – POZEGA	OPPOSITE OHL 220 kV KRALJEVO 3 - POZEGA	67,7
OHL 220 kV KRALJEVO 3 – POZEGA	OPPOSITE OHL 220 kV CACAK 3 - POZEGA	68,4
OHL 220 kV B. BASTA – VARDISTE	DIRECT OHL 220 kV B. BASTA - POZEGA	68,4
TR2 400/110 kV BOR 2	OPPOSITE OHL 400 kV HPP DJERDAP 1 - DRMNO	68,9
TR 400/220 kV S. MITROVICA	OPPOSITE OHL 220 kV VARDISTE - VISEGRAD	69,1
OHL 400 kV JAGODINA 4 - NIS 2	OPPOSITE OHL 400 kV HPP DJERDAP 1 - DRMNO	69,4

7.7.3 Comparison of the NTC and FB approaches determined minimum MACZT

For all elements having the lowest MACZT values, the following tables compare the determined minimum MACZT values for the NTC and FB approaches. All three calculated MACZT values are given: minimum, mean, and maximum value.

Table 46 Comparison of calculated minimum MACZT values in Serbia between NTC and FB approach on 20 January 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 400 kV OBRENOVAC - KRAGUJEVAC 2	6,0	24,9	42,0	57,5	89,1	118,8
OHL 400 kV VRANJE 4 - LESKOVAC	6,1	20,0	37,1	61,2	92,8	137,1
OHL 220 kV BISTRICA - PLJEVLJA 2	9,0	66,1	116,4	40,4	104,4	151,1
OHL 400 kV PANCEVO 2 - WPP CIBUK 1	9,6	23,4	68,4	24,3	88,1	156,1
OHL 400 kV JAGODINA 4 - NIS 2	9,7	39,8	86,2	59,5	91,6	121,2
OHL 400 kV SMEDEREVO 3 - BEOGRAD 8 2	10,8	18,4	34,8	52,6	85,3	124,7
OHL 400 kV OBRENOVAC - MLADOST	10,8	21,0	50,9	31,7	91,0	133,5
OHL 220 kV B. BASTA - PLJEVLJA 2	10,8	60,9	106,5	49,7	77,3	120,3
OHL 400 kV S. MITROVICA - ERNESTINOVO	10,9	31,8	57,6	46,2	88,8	137,9
OHL 400 kV WPP CIBUK 1 - DRMNO	10,9	15,8	27,4	46,9	93,7	137,2
OHL 400 kV OBRENOVAC - MLADOST 2	10,9	20,2	55,5	31,6	91,3	133,5
OHL 220 kV POZEGA - BISTRICA	11,2	51,5	99,3	44,6	98,3	135,5
OHL 400 kV NIS 2 - LESKOVAC	11,2	24,1	58,5	76,9	91,3	104,2
OHL 400 kV SMEDEREVO 3 - DRMNO	11,5	14,8	18,4	68,5	97,0	116,2
OHL 400 kV VRANJE 4 - STIP	11,9	23,1	37,5	60,1	91,5	101,3
OHL 400 kV HPP DJERDAP 1 - DRMNO	12,0	29,9	43,0	38,3	88,0	138,1
OHL 400 kV NIS 2 - KOSOVA B	13,0	36,9	55,4	82,4	93,8	103,9
OHL 400 kV S. MITROVICA 2 - UGLJEVIK	13,4	43,3	60,9	61,0	84,9	104,3
OHL 400 kV OBRENOVAC - BEOGRAD 8	13,7	24,7	55,5	48,6	90,8	133,8
OHL 400 kV BOR 2 - NIS 2	14,6	26,5	57,8	43,4	85,7	132,7
OHL 220 kV OBRENOVAC - TPP N. TESLA A 4	15,9	39,7	51,8	33,5	91,0	156,8
OHL 220 kV OBRENOVAC - BEOGRAD 3	16,1	20,9	25,7	60,5	86,0	111,6
OHL 400 kV BOR 2 - HPP DJERDAP 1	17,4	33,7	84,9	31,2	91,4	147,0
OHL 400 kV DRMNO - TPP DRMNO	17,5	25,2	52,6	37,6	95,4	142,0
OHL 400 kV MLADOST - N. SAD 3	17,5	17,8	18,2	70,6	90,1	109,5
OHL 400 kV MLADOST - TPP N. TESLA B	17,5	28,6	77,0	56,2	91,2	124,0

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
‚OHL 220 kV OBRENOVAC - VALJEVO 3	18,7	32,6	56,0	41,9	87,7	138,4
OHL 400 kV KRAGUJEVAC 2 - JAGODINA 4	19,1	27,4	59,8	82,3	93,1	104,8
OHL 400 kV NIS 2 - SOFIA	19,4	31,5	61,6	64,0	92,1	116,6
OHL 220 kV OBRENOVAC - TPP N. TESLA A 5	19,7	53,0	70,7	24,3	95,8	156,1

Table 47 Comparison of calculated minimum MACZT values **in Serbia** between NTC and FB approach on 21 July 2021 at 19:30 h

Element	NTC			FB		
	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]	Minimum MACZT [%]	Mean MACZT [%]	Maximum MACZT [%]
OHL 400 kV VRANJE 4 - LESKOVAC	7,1	25,3	36,2	83,6	90,4	96,7
OHL 400 kV KRAGUJEVAC 2 - JAGODINA 4	7,3	29,0	40,3	79,1	90,4	101,9
OHL 400 kV VRANJE 4 - STIP	7,3	27,4	38,4	78,2	89,3	100,6
OHL 400 kV OBRENOVAC - KRAGUJEVAC 2	7,7	26,9	37,9	75,7	90,4	104,6
OHL 400 kV BEOGRAD 8 - BEOGRAD 20	8,8	12,0	26,7	74,0	89,7	104,8
OHL 400 kV SMEDEREVO 3 - DRMNO	9,3	15,4	33,8	28,1	89,6	150,5
OHL 400 kV PANCEVO 2 - WPP CIBUK 1	9,9	16,3	33,8	27,2	89,6	151,4
OHL 400 kV JAGODINA 4 - NIS 2	10,2	29,4	41,5	69,4	90,4	111,4
OHL 400 kV SMEDEREVO 3 - BEOGRAD 8 2	10,4	18,1	35,9	38,6	90,5	142,9
OHL 400 kV OBRENOVAC - BEOGRAD 8	10,6	27,3	45,2	78,6	89,3	99,5
OHL 400 kV WPP CIBUK 1 - DRMNO	10,8	17,1	36,5	22,7	89,6	155,8
OHL 400 kV OBRENOVAC - MLADOST	11,7	31,5	68,2	63,2	90,7	119,5
OHL 400 kV OBRENOVAC - MLADOST 2	11,8	31,9	68,2	63,2	90,7	119,5
OHL 400 kV PANCEVO 2 - BEOGRAD 20	11,8	16,4	35,2	47,9	90,4	133,6
OHL 400 kV BOR 2 - HPP DJERDAP 1	13,4	25,3	53,9	48,7	89,3	130,1
OHL 400 kV BOR 2 - NIS 2	14,6	33,6	64,8	55,4	90,9	126,3
OHL 400 kV NIS 2 – LESKOVAC	17,5	24,6	36,0	81,1	89,6	98,0
OHL 400 kV DRMNO - TPP DRMNO	18,7	19,0	21,8	66,9	89,5	112,2
OHL 400 kV DRMNO - TPP DRMNO 2	18,7	19,0	21,8	66,9	89,5	112,2
OHL 400 kV HPP DJERDAP 1 - DRMNO	19,8	42,6	61,4	45,8	89,8	134,3

Clearly, MACZT values are significantly higher with FB than with NTC approach. Moreover, in January 2021 scenario the worst-case CNE(C), that with NTC approach had minimum MACZT value of only 6% would with FB approach increase MACZT value to 57,5%.

Similarly, in July 2021 scenario the worst-case CNE(C), that with NTC approach had minimum MACZT value of 7,1% would with FB approach increase MACZT value to 83,6%.

7.8 Conclusions regarding the fulfillment of the 70% target in the current network

The following table shows the total number of modeled elements, considered elements, CNE(C) candidates and total number of elements with MACZT below 70% target value in all analyzed scenarios for each Contracting Party. In total, regional transmission network PSS/E model consists of 448 elements. The calculations covered around 20.000 cases in total (base cases and contingencies). Those cases were CNE(C) candidates, defined as combination of each element, each contingency and two flow directions. Among these cases 176 were initially selected for further consideration. Selection methodology is described in the previous chapter.

Overall findings indicate that the MACZT values for the majority of the selected cases using the NTC approach are below the target of 70%. The FB approach produces better results, however still far beyond target value.

Table 48 Total number of modeled elements, considered elements, CNE(C) candidates and total number of elements with MACZT below 70% target value per each Contracting Party

Contracting Party	Total number of modeled elements	Total number of considered elements (basis for CNE(C) list)	Total number of CNE(C) candidates (element+ contingency +direction)	Jan 2021		July 2021	
				NTC - Total number of elements with MACZT<70%	FB - Total number of elements with MACZT<70%	NTC - Total number of elements with MACZT<70%	FB - Total number of elements with MACZT<70%
Albania	69	24	2502	22	20	24	15
BiH	105	34	3492	33	16	33	11
Kosovo*	44	20	1198	19	14	19	3
Montenegro	32	23	1052	17	20	18	10
North Macedonia	19	19	704	19	16	15	4
Serbia	179	56	11050	55	44	56	40
TOTAL	448	176	19998	165	130	165	83

The following table shows the same values in percentages. It gives the share of elements with MACZT lower than 70% in total number of considered elements. Two main conclusions can be drawn from the following table:

1. Share of elements with MACZT value below 70% is much higher with NTC than with FB approach.
2. With NTC approach the results are about the same in January and July scenario, while with FB approach the results are different and much better in July than in January scenario.

Table 49 Share of elements with MACZT below 70% target value in total number of considered elements per each Contracting Party (%)

Contracting Party	Jan 2021		July 2021	
	NTC - Share of elements with MACZT<70% [%]	FB - Share of elements with MACZT<70% [%]	NTC - Share of elements with MACZT<70% [%]	FB - Share of elements with MACZT<70% [%]
Albania	91,7	83,3	100	62,5
BiH	97,1	47,1	97,1	32,4
Kosovo*	95,0	70,0	95,0	15,0
Montenegro	73,9	87,0	78,3	43,5
North Macedonia	100	84,2	78,9	21,1
Serbia	98,2	78,6	100	71,4
TOTAL	93,8	73,9	93,8	47,2

The identical findings are displayed in the opposite way in the two tables that follow. It displays the percentages of elements that met the 70% target.

Table 50 The share of considered elements that fulfill 70% target with NTC and FB approach on 20 January 2021 at 19:30 h

20 January 2021, 19:30 h		
Contracting Party	Share of elements with MACZT>70% NTC [%]	Share of elements with MACZT>70% FB [%]
Albania	8,3	16,7
BiH	2,9	52,9
Kosovo*	5,0	30,0
Montenegro	26,1	13,0
North Macedonia	0,0	15,8
Serbia	1,8	21,4
TOTAL	6,3	26,1

The following figure shows the same values in graphical format.

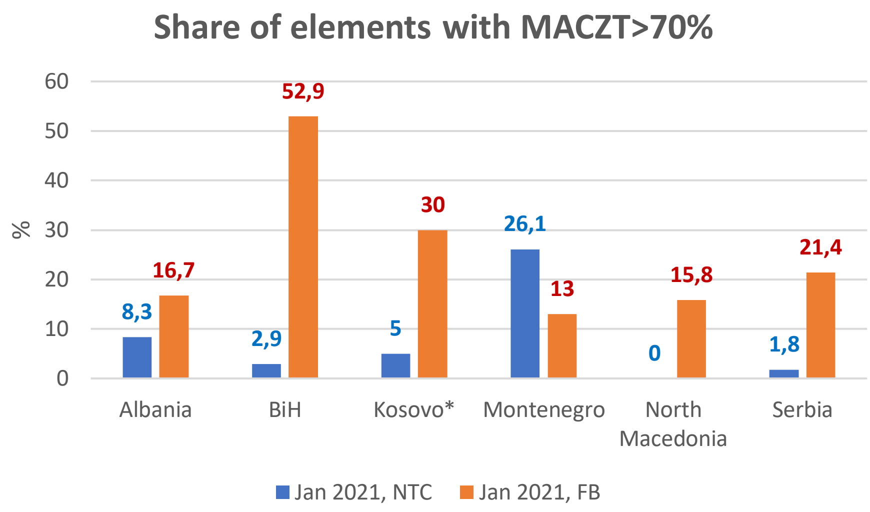


Figure 52 Share of elements with MACZT > 70%

Obviously, in the existing network the level of fulfillment of 70% target in WB6 is very low. On 20 January 2021 at 19:30 h with the NTC approach between 0% (North Macedonia) and 26% (Montenegro) of all considered elements fulfilled this requirement. On the regional level only 11 out of 176 (around 6%) of considered elements fulfilled 70% target.

As expected, with FB approach the results would be much better: between 13% (Montenegro) and 53% (Bosnia and Herzegovina) of all considered elements fulfill this requirement. On the regional level 46 out of 176 (around 26%) of considered elements fulfil 70% target. Similar results are found for 21 July 2021 at 19:30 h, as shown in the following table.

Table 51 The share of considered elements that fulfill 70% target with NTC and FB approach on 21 July 2021 at 19:30 h

21 July 2021, 19:30 h		
Contracting Party	**Share of elements with MACZT>70% NTC [%]**	**Share of elements with MACZT>70% FB [%]**
Albania	7,7	42,3
BiH	2,9	67,6
Kosovo*	5,0	85,0
Montenegro	21,7	56,5
North Macedonia	16,7	77,8
Serbia	3,4	31,0
TOTAL	**7,8**	**53,6**

The following figure shows the same values in graphical format.

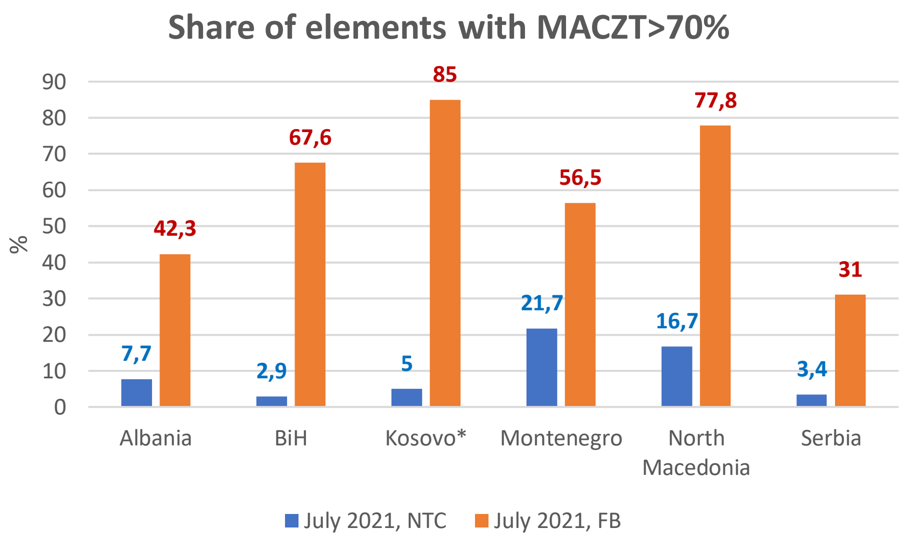


Figure 53 Share of elements with MACZT > 70%

With the NTC approach between ~3% (Bosnia and Herzegovina) and ~22% (Montenegro) of all considered elements fulfilled the requirement. On the regional level only around 8% of considered elements fulfilled 70% of the target.

As expected, with FB approach the results would be much better: between ~31% (Serbia) and 85% (Kosovo*) of all considered elements fulfill the requirement. On the regional level around 53% of considered elements fulfil 70% target.

Finally, it is important to note that this exercise is based on just two snapshots, as defined in the study scope of work, while the 70 % target must be fulfilled in all MTUs. Therefore, the resulting values are only indicative and primarily for illustrative rather than implementation purposes. The results are fully based on ACER recommendations on MACZT calculation, as mentioned above.

In the following chapter the 2028 regimes are studied, while chapter 9 deals with the identification of the structural congestions based on far more thorough calculations covering a full three-year period (2020, 2021 and 2022).

8 ESTIMATION OF EXPECTED 70% TARGET FULFILLMENT IN 2028

In this Chapter the estimation of the 70% target fulfillment in expected future network in two selected snapshots in 2028 is given. Two system snapshots are selected the same way as in the existing network: third Wednesday in January (19 January 2028 at 19:30 h) and third Wednesday in July (19 July 2028 at 19:30 h). NTC values are not defined for 2028 and it is expected that, based on the obligations from the EnC acquis (especially Article 20 of the EnC CACM GL Regulation), this region will implement FB approach till then, so the analyses for 2028 were performed only with FB approach.

The results are given both in graphical and table format for all observed Contracting Parties, the same way as in Chapter 7 for the existing network.

8.1 Albania

In Albania on 19 Jan 2028 at 19:30 h there are 13 elements (out of 33) fulfilling 70% target (minimum MACZT value (**blue bar**) higher than 70%). This is a much better result than in January 2021 scenario when only 4 elements fulfilled 70% target. Full comparison is given later in subchapter 9.7.

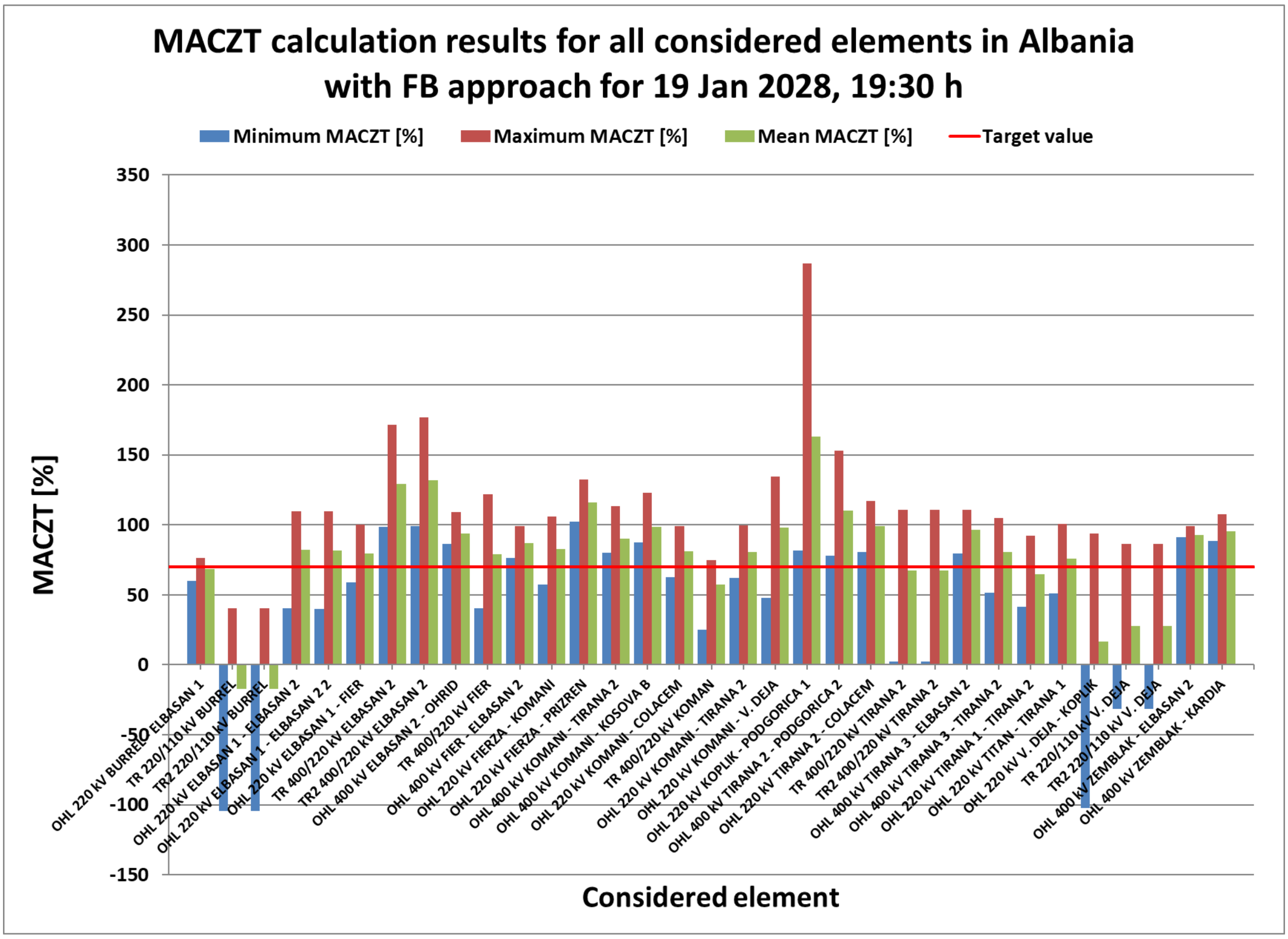


Figure 54 MACZT calculation results for Albania, **FB approach** on 19 January 2028 at 19:30 h

In given January 2028 scenario with **FB approach** there are several negative MACZT values in Albania. Negative values are rarely detected, but theoretically possible when MNCC + MCCC < 0. This can be the case for elements with no adequate alternative (bypass) power flow path, such as two parallel transformers.

Minimum calculated MACZT values below 50% are detected on 13 elements shown in the following table.

Table 52 List of calculated minimum MACZT values below 70% for considered element on 19 January 2028 at 19:30 h with **FB approach in Albania**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
TR 220/110 kV BURREL	OPPOSITE TR2 220/110 kV BURREL	-104,5
TR2 220/110 kV BURREL	OPPOSITE TR 220/110 kV BURREL	-104,5
OHL 220 kV V. DEJA - KOPLIK	OPPOSITE OHL 400 kV TIRANA 2 - PODGORICA 2	-102,1
TR 220/110 kV V. DEJA	OPPOSITE TR2 220/110 kV V. DEJA	-31,6
TR2 220/110 kV V. DEJA	OPPOSITE TR 220/110 kV V. DEJA	-31,6
TR 400/220 kV TIRANA 2	OPPOSITE OHL 400 kV TIRANA 3 - TIRANA 2	2,5
TR2 400/220 kV TIRANA 2	OPPOSITE OHL 400 kV TIRANA 3 - TIRANA 2	2,5
TR 400/220 kV KOMAN	OPPOSITE OHL 220 kV KOPLIK - PODGORICA 1	25,3
OHL 220 kV ELBASAN 1 - ELBASAN 2 2	OPPOSITE OHL 220 kV ELBASAN 1 - ELBASAN 2	39,9
TR 400/220 kV FIER	OPPOSITE OHL 220 kV KOPLIK - PODGORICA 1	40,2
OHL 220 kV ELBASAN 1 - ELBASAN 2	OPPOSITE OHL 220 kV ELBASAN 1 - ELBASAN 2 2	40,3
OHL 220 kV TIRANA 1 - TIRANA 2	OPPOSITE OHL 220 kV KOPLIK - PODGORICA 1	41,7
OHL 220 kV KOMANI - V. DEJA	OPPOSITE OHL 400 kV TIRANA 2 - PODGORICA 2	47,7
OHL 220 kV TITAN - TIRANA 1	DIRECT OHL 220 kV FIERZA - PRIZREN	51,0
OHL 400 kV TIRANA 3 - TIRANA 2	OPPOSITE TR 400/220 kV TIRANA 2	51,5
OHL 220 kV FIERZA - KOMANI	OPPOSITE OHL 220 kV BURREL - ELBASAN 1	57,2
OHL 220 kV ELBASAN 1 - FIER	DIRECT TR2 400/220 kV ELBASAN 2	58,8
OHL 220 kV BURREL - ELBASAN 1	DIRECT TR 220/110 kV FIERZA	59,8
OHL 220 kV KOMANI - TIRANA 2	DIRECT TR 400/220 kV KOMAN	62,1
OHL 220 kV KOMANI - COLACEM	DIRECT TR 400/220 kV KOMAN	62,7

On 19 July 2028 at 19:30 h there are 16 elements (out of 30) fulfilling 70% target. In this scenario there are no negative MACZT values. Minimum calculated MACZT values below 50% are detected on 4 elements shown in the following table.

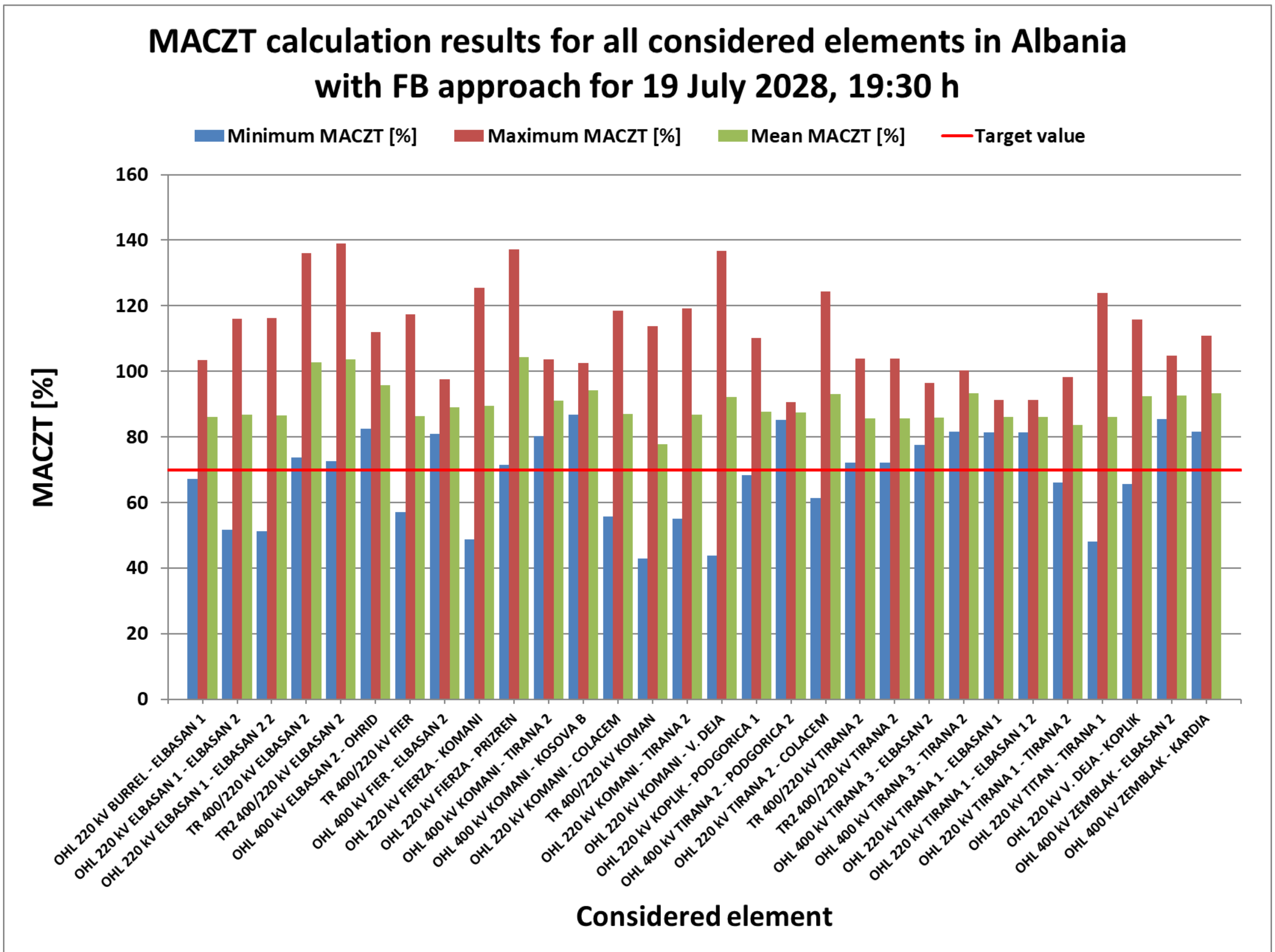


Figure 55 MACZT calculation results for Albania, FB approach on 19 July 2028 at 19:30 h

Table 53 List of calculated minimum MACZT values below 70% for considered element on 19 July 2028 at 19:30 h with FB approach in Albania

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
TR 400/220 kV KOMAN	DIRECT OHL 220 kV FIERZA - PRIZREN	42,9
OHL 220 kV KOMANI - V. DEJA	DIRECT TR 400/220 kV KOMAN	43,9
OHL 220 kV TITAN - TIRANA 1	DIRECT OHL 220 kV FIERZA - KOMANI	48,2
OHL 220 kV FIERZA - KOMANI	DIRECT OHL 220 kV TITAN - TIRANA 1	48,8
OHL 220 kV ELBASAN 1 - ELBASAN 2 2	OPPOSITE OHL 220 kV ELBASAN 1 - ELBASAN 2	51,3
OHL 220 kV ELBASAN 1 - ELBASAN 2	OPPOSITE OHL 220 kV ELBASAN 1 - ELBASAN 2 2	51,6
OHL 220 kV KOMANI - TIRANA 2	DIRECT OHL 220 kV KOMANI - COLACEM	55,1
OHL 220 kV KOMANI - COLACEM	DIRECT OHL 220 kV KOMANI - TIRANA 2	55,7
TR 400/220 kV FIER	OPPOSITE OHL 400 kV TIRANA 3 - ELBASAN 2	57,1
OHL 220 kV TIRANA 2 - COLACEM	OPPOSITE OHL 220 kV KOMANI - V. DEJA	61,5
OHL 220 kV V. DEJA - KOPLIK	DIRECT TR 400/220 kV KOMAN	65,7
OHL 220 kV TIRANA 1 - TIRANA 2	DIRECT OHL 220 kV KOMANI - TIRANA 2	66,2
OHL 220 kV BURREL - ELBASAN 1	DIRECT OHL 220 kV TITAN - TIRANA 1	67,2
OHL 220 kV KOPLIK - PODGORICA 1	OPPOSITE OHL 220 kV ELBASAN 1 - KURUM	68,3

8.2 Bosnia and Herzegovina

On 19 Jan 2028 at 19:30 h in Bosnia and Herzegovina there are 10 elements (out of 27) fulfilling 70% target.

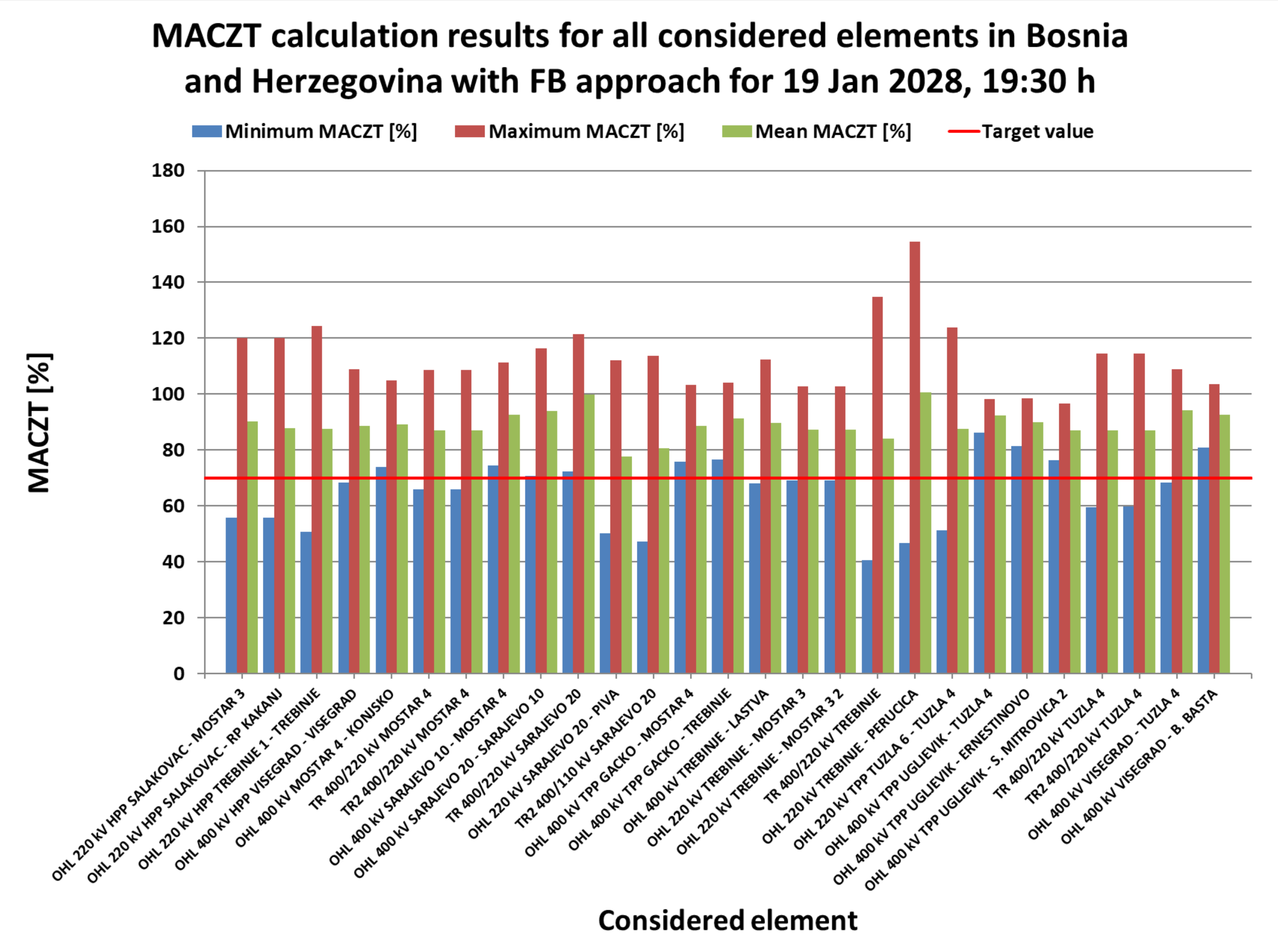


Figure 56 MACZT calculation results for Bosnia and Herzegovina, FB approach on 19 January 2028 at 19:30 h

In January 2028 scenario in Bosnia and Herzegovina minimum calculated MACZT values below 50% are detected on 4 elements, as shown in the following table.

Table 54 List of calculated minimum MACZT values below 70% for considered element on 19 January 2028 at 19:30 h with FB approach in Bosnia and Herzegovina

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
TR 400/220 kV TREBINJE	DIRECT OHL 400 kV TPP GACKO - MOSTAR 4	40,7
OHL 220 kV TREBINJE - PERUCICA	DIRECT OHL 400 kV TREBINJE - LASTVA	46,7
TR2 400/110 kV SARAJEVO 20	OPPOSITE OHL 400 kV SARAJEVO 20 - SARAJEVO 10	47,4
OHL 220 kV SARAJEVO 20 - PIVA	OPPOSITE OHL 400 kV SARAJEVO 20 - SARAJEVO 10	50,3
OHL 220 kV HPP TREBINJE 1 - TREBINJE	DIRECT BASE CASE	50,8
OHL 220 kV TPP TUZLA 6 - TUZLA 4	DIRECT BASE CASE	51,4
OHL 220 kV HPP SALAKOVAC - MOSTAR 3	DIRECT OHL 220 kV HPP SALAKOVAC - RP KAKANJ	55,9

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 220 kV HPP SALAKOVAC - RP KAKANJ	DIRECT OHL 220 kV HPP SALAKOVAC - MOSTAR 3	55,9
TR 400/220 kV TUZLA 4	OPPOSITE TR2 400/220 kV TUZLA 4	59,6
TR2 400/220 kV TUZLA 4	OPPOSITE TR 400/220 kV TUZLA 4	59,7
TR 400/220 kV MOSTAR 4	DIRECT OHL 400 kV KONJSKO - MOSTAR 4	66,1
TR2 400/220 kV MOSTAR 4	DIRECT OHL 400 kV KONJSKO - MOSTAR 4	66,1
OHL 400 kV TREBINJE - LASTVA	DIRECT OHL 400 kV SARAJEVO 10 - MOSTAR 4	68,1
OHL 400 kV HPP VISEGRAD - VISEGRAD	DIRECT BASE CASE	68,3
OHL 400 kV VISEGRAD - TUZLA 4	DIRECT OHL 400 kV VIŠEGRAD - B. BASTA	68,3
OHL 220 kV TREBINJE - MOSTAR 3	OPPOSITE OHL 400 kV TPP GACKO - MOSTAR 4	69,1
OHL 220 kV TREBINJE - MOSTAR 3 2	OPPOSITE OHL 400 kV TPP GACKO - MOSTAR 4	69,2

On 19 July 2028 at 19:30 h there are 13 elements (out of 19) fulfilling 70% target. Minimum calculated MACZT values below 50% are detected only on 1 element, as shown in the following table.

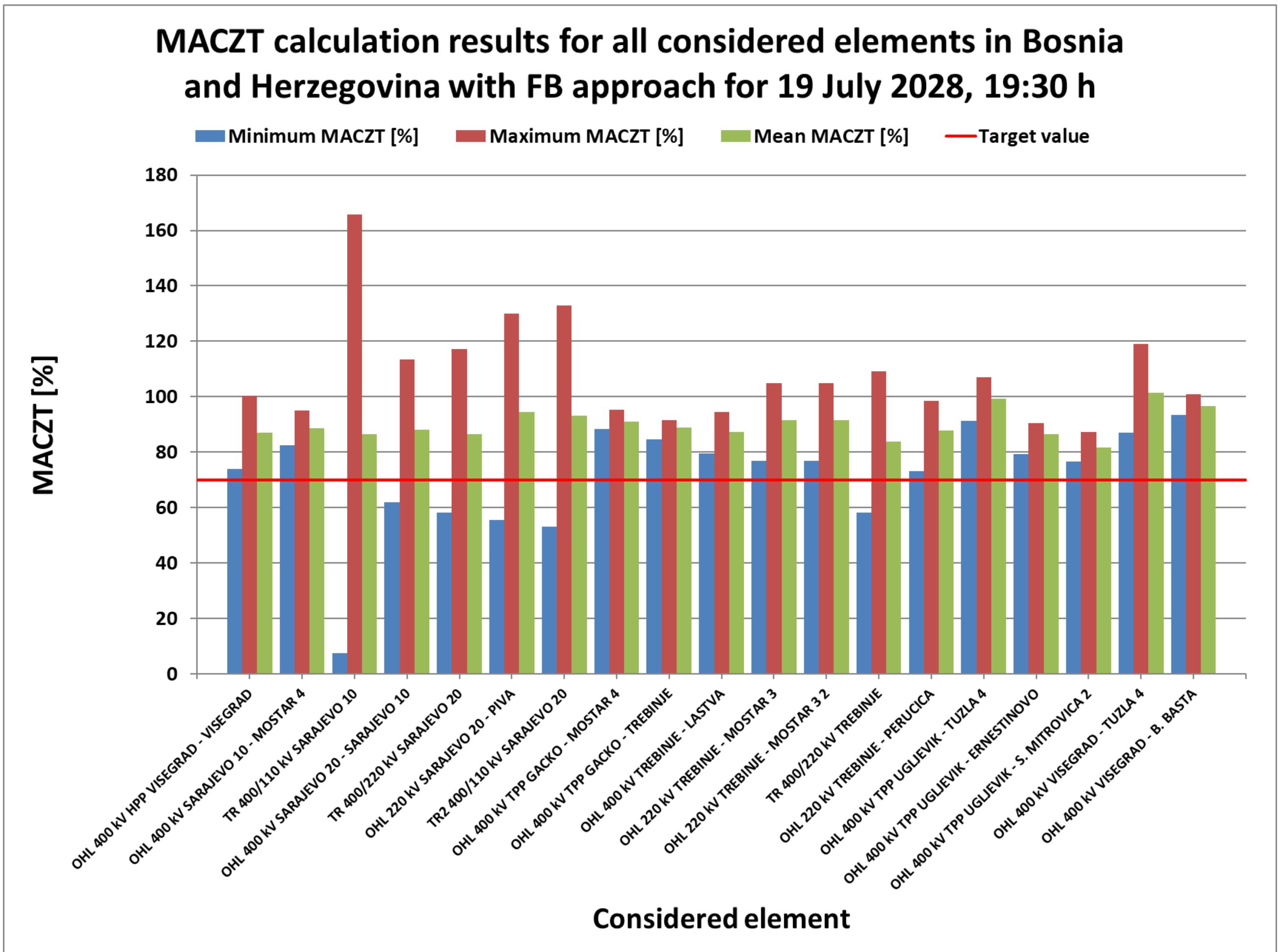


Figure 57 MACZT calculation results for Bosnia and Herzegovina, **FB approach** on 19 July 2028 at 19:30 h

Table 55 List of calculated minimum MACZT values below 70% for considered element on 19 July 2028 at 19:30 h with **FB approach in Bosnia and Herzegovina**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
TR 400/110 kV SARAJEVO 10	OPPOSITE OHL 400 kV SARAJEVO 20 - SARAJEVO 10	7,5
TR2 400/110 kV SARAJEVO 20	OPPOSITE OHL 400 kV SARAJEVO 20 - SARAJEVO 10	53,2
OHL 220 kV SARAJEVO 20 - PIVA	OPPOSITE OHL 400 kV SARAJEVO 20 - SARAJEVO 10	55,7
TR 400/220 kV TREBINJE	DIRECT TR2 220/110 kV TREBINJE	58,3
TR 400/220 kV SARAJEVO 20	DIRECT OHL 400 kV SARAJEVO 20 - SARAJEVO 10	58,3
OHL 400 kV SARAJEVO 20 - SARAJEVO 10	OPPOSITE TR 400/110 kV SARAJEVO 10	62,1

8.3 Kosovo*

On 19 Jan 2028 at 19:30 h in Kosovo* there are 5 elements (out of 22) fulfilling 70% target.

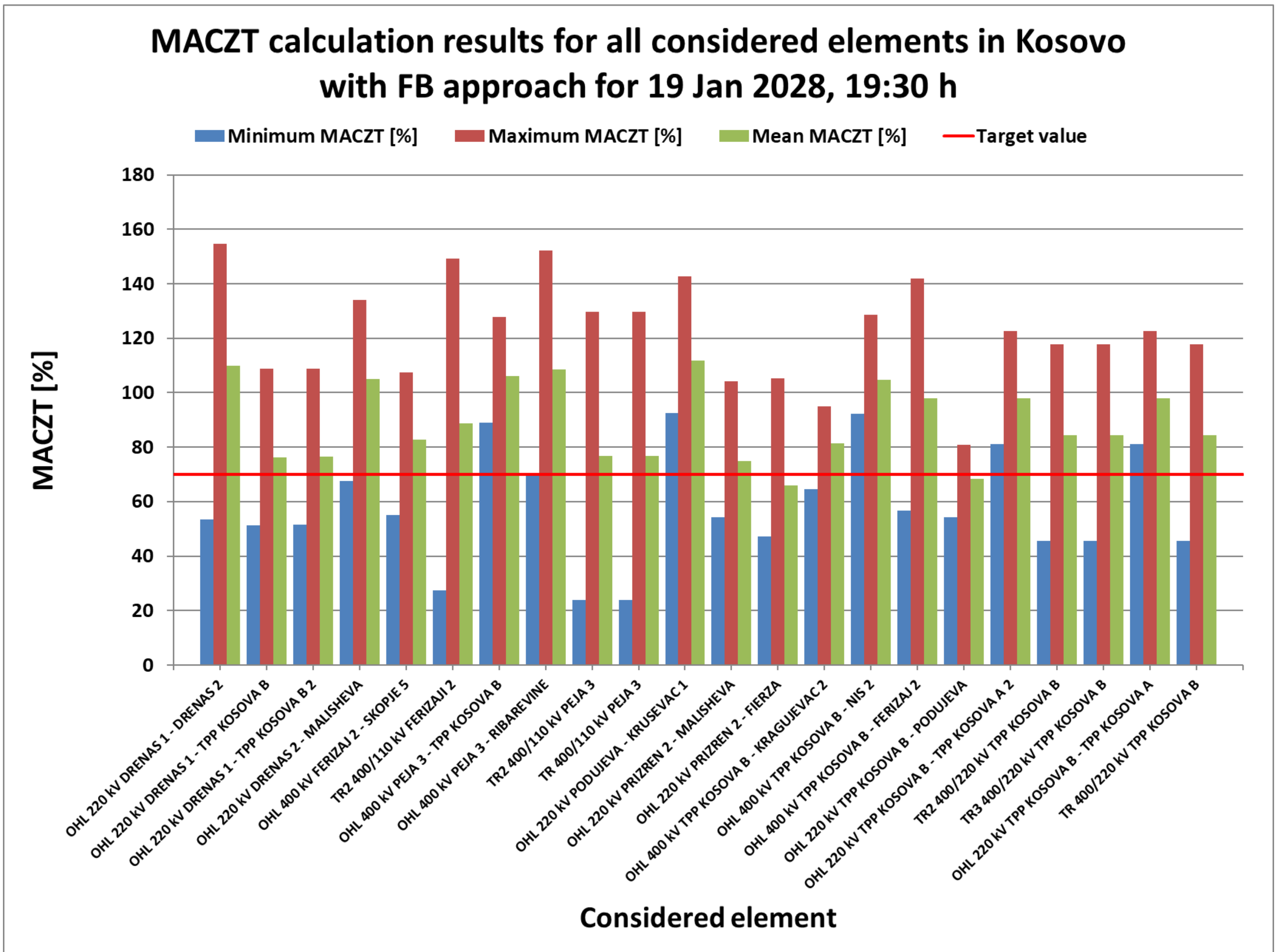


Figure 58 MACZT calculation results for Kosovo*, **FB approach** on 19 January 2028 at 19:30 h

In January 2028 scenario in Kosovo* minimum calculated MACZT values below 50% are detected on 7 elements, as shown in the following table.

Table 56 List of calculated minimum MACZT values below 70% for considered element on 19 January 2028 at 19:30 h with **FB approach in Kosovo***

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
TR 400/110 kV PEJA 3	OPPOSITE OHL 400 kV PEJA 3 - TPP KOSOVA B	23,9
TR2 400/110 kV PEJA 3	OPPOSITE OHL 400 kV PEJA 3 - TPP KOSOVA B	23,9
TR2 400/110 kV FERIZAJI 2	OPPOSITE TR 400/110 kV FERIZAJI 2	27,4
TR 400/220 kV TPP KOSOVA B	OPPOSITE OHL 400 kV TPP KOSOVE B - FERIZAJ 2	45,6
TR2 400/220 kV TPP KOSOVA B	OPPOSITE OHL 400 kV TPP KOSOVE B - FERIZAJ 2	45,6
TR3 400/220 kV TPP KOSOVA B	OPPOSITE OHL 400 kV TPP KOSOVE B - FERIZAJ 2	45,7
OHL 220 kV PRIZREN 2 - FIERZA	DIRECT OHL 220 kV DRENAS 1 - DRENAS 2	47,3
OHL 220 kV DRENAS 1 - TPP KOSOVA B	DIRECT OHL 220 kV DRENAS 1 - TPP KOSOVA B 2	51,4
OHL 220 kV DRENAS 1 - TPP KOSOVA B 2	DIRECT OHL 220 kV DRENAS 1 - TPP KOSOVA B	51,4
OHL 220 kV DRENAS 1 - DRENAS 2	DIRECT OHL 220 kV FIERZA - PRIZREN	53,5
OHL 220 kV TPP KOSOVA B - PODUJEVA	OPPOSITE OHL 400 kV RIBAREVINE - PEC 3	54,2
OHL 220 kV PRIZREN 2 - MALISHEVA	OPPOSITE OHL 400 kV TPP KOSOVE B - FERIZAJ 2	54,4
OHL 400 kV FERIZAJ 2 - SKOPJE 5	OPPOSITE OHL 400 kV KOSOVA B - KOMAN	55,1
OHL 400 kV TPP KOSOVA B - FERIZAJ 2	DIRECT OHL 400 kV KOSOVA B - NIS	56,7
OHL 400 kV TPP KOSOVA B - KRAGUJEVAC 2	OPPOSITE OHL 400 kV TPP KOSOVE B - FERIZAJ 2	64,7
OHL 220 kV DRENAS 2 - MALISHEVA	DIRECT OHL 220 kV FIERZA - PRIZREN	67,5
OHL 400 kV PEJA 3 - RIBAREVINE	DIRECT OHL 220 kV FIERZA - PRIZREN	69,6

On 19 July 2028 at 19:30 h there are 12 elements (out of 21) fulfilling 70% target. Minimum calculated MACZT values below 50% are detected on 6 elements, as shown in the following table.

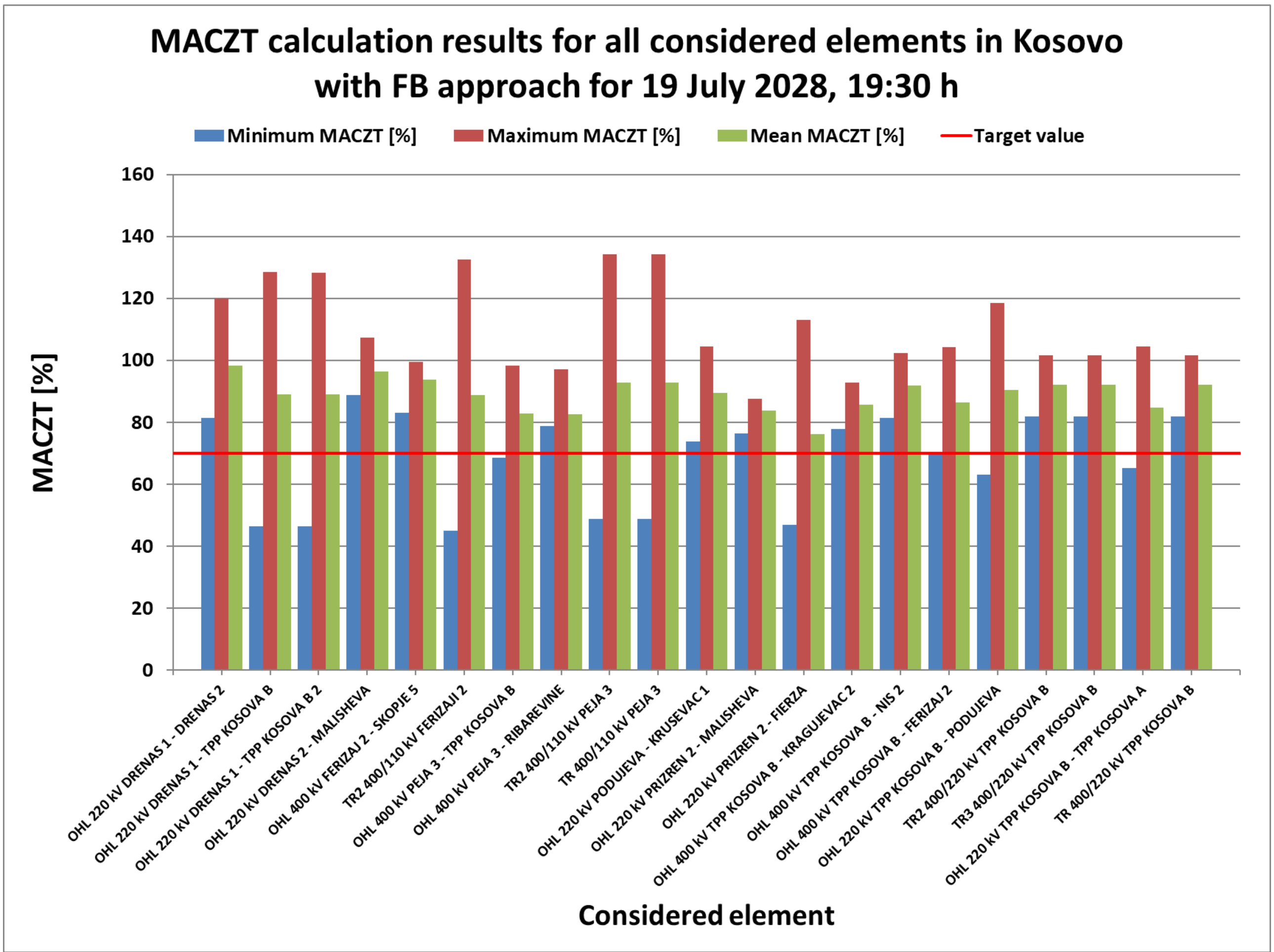


Figure 59 MACZT calculation results for Kosovo*, **FB approach** on 19 July 2028 at 19:30 h

Table 57 List of calculated minimum MACZT values below 70% for considered element on 19 July 2028 at 19:30 h with **FB approach in Kosovo***

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
TR2 400/110 kV FERIZAJI 2	OPPOSITE TR 400/110 kV FERIZAJI 2	45,1
OHL 220 kV DRENAS 1 - TPP KOSOVA B	DIRECT OHL 220 kV DRENAS 1 - TPP KOSOVA B 2	46,4
OHL 220 kV DRENAS 1 - TPP KOSOVA B 2	DIRECT OHL 220 kV DRENAS 1 - TPP KOSOVA B	46,4
OHL 220 kV PRIZREN 2 - FIERZA	DIRECT TR2 400/110 kV FERIZAJI 2	47,0
TR2 400/110 kV PEJA 3	OPPOSITE TR 400/110 kV PEJA 3	48,9
TR 400/110 kV PEJA 3	OPPOSITE TR2 400/110 kV PEJA 3	48,9
OHL 220 kV TPP KOSOVA B - PODUJEVA	DIRECT OHL 400 kV KOSOVA B - NIS	63,2
OHL 220 kV TPP KOSOVA B - TPP KOSOVA A	OPPOSITE TR3 220/110 kV KOSOVA A	65,1
OHL 400 kV PEJA 3 - TPP KOSOVA B	OPPOSITE OHL 400 kV KOSOVA B - KOMAN	68,6

8.4 Montenegro

On 19 Jan 2028 at 19:30 h in Montenegro there are 7 elements (out of 23) fulfilling 70% target.

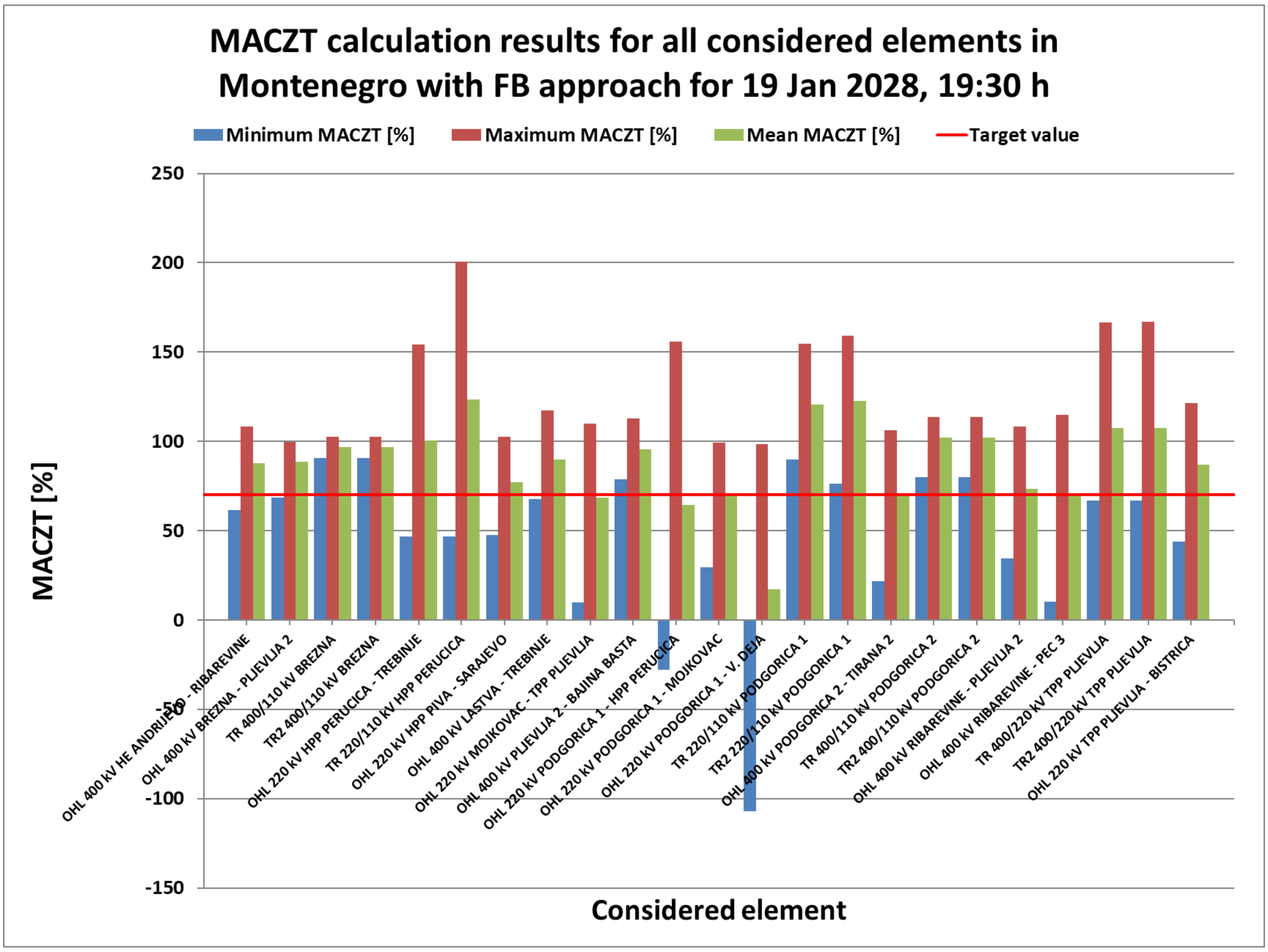


Figure 60 MACZT calculation results for Montenegro, **FB approach** on 19 January 2028 at 19:30 h

In January 2028 scenario in Montenegro minimum calculated MACZT values below 50% are detected on 11 elements, as shown in the following table, including 2 negative values.

Table 58 List of calculated minimum MACZT values below 70% for considered element on 19 January 2028 at 19:30 h with **FB approach in Montenegro**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 220 kV PODGORICA 1 - V. DEJA	OPPOSITE OHL 400 kV TIRANA 2 - PODGORICA 2	-107,0
OHL 220 kV PODGORICA 1 - HPP PERUCICA	OPPOSITE OHL 400 kV TREBINJE - LASTVA	-27,8
OHL 220 kV MOJKOVAC - TPP PLJEVLJA	OPPOSITE OHL 400 kV RIBAREVINE - PLJEVLJA 2	9,7
OHL 400 kV RIBAREVINE - PEC 3	OPPOSITE OHL 400 kV TIRANA 2 - PODGORICA 2	10,2
OHL 400 kV PODGORICA 2 - TIRANA 2	OPPOSITE OHL 400 kV RIBAREVINE - PEC 3	21,9
OHL 220 kV PODGORICA 1 - MOJKOVAC	OPPOSITE OHL 220 kV PODGORICA 1 - HPP PERUCICA	29,4
OHL 400 kV RIBAREVINE - PLJEVLJA 2	OPPOSITE OHL 220 kV MOJKOVAC - TPP PLJEVLJA	34,4

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 220 kV TPP PLJEVLJA - BISTRICA	OPPOSITE OHL 400 kV RIBAREVINE - PEC 3	43,9
OHL 220 kV HPP PERUCICA - TREBINJE	DIRECT OHL 400 kV TREBINJE - LASTVA	46,7
TR 220/110 kV HPP PERUCICA	DIRECT BASE CASE	46,8
OHL 220 kV HPP PIVA - SARAJEVO	OPPOSITE OHL 400 kV RIBAREVINE - PLJEVLJA 2	47,5
OHL 400 kV HE ANDRIJEVO - RIBAREVINE	OPPOSITE OHL 400 kV RIBAREVINE - PEC 3	61,7
TR2 400/220 kV TPP PLJEVLJA	DIRECT TR 400/220 kV TPP PLJEVLJA	66,8
TR 400/220 kV TPP PLJEVLJA	DIRECT TR2 400/220 kV TPP PLJEVLJA	67,0
OHL 400 kV LASTVA - TREBINJE	DIRECT OHL 220 kV PODGORICA 1 - HPP PERUCICA	67,6
OHL 400 kV BREZNA - PLJEVLJA 2	OPPOSITE OHL 400 kV RIBAREVINE - PLJEVLJA 2	68,4

On 19 July 2028 at 19:30 h there are 15 elements (out of 21) fulfilling 70% target. Minimum calculated MACZT values below 50% are detected only on 2 elements, as shown in the following table.

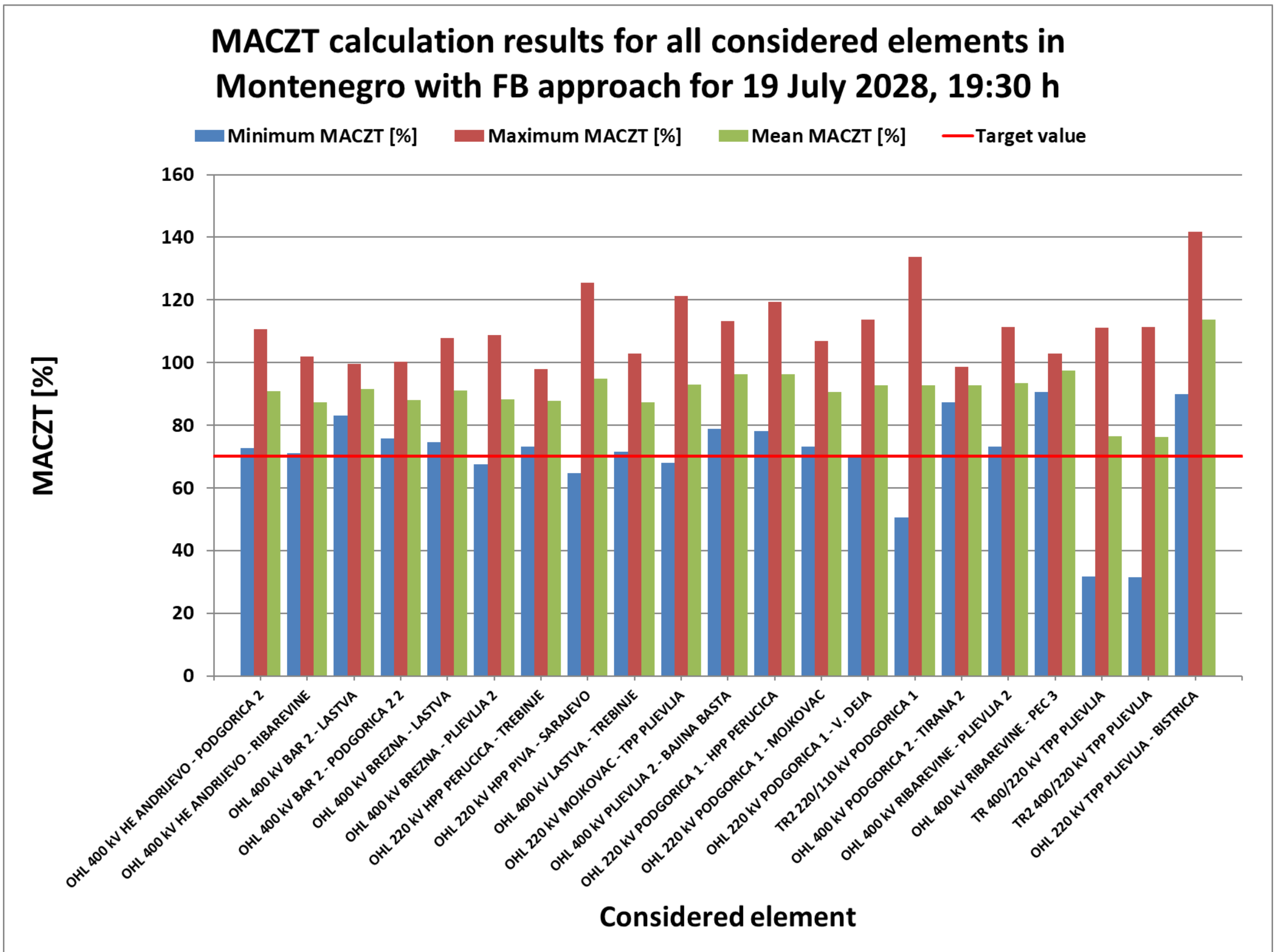


Figure 61 MACZT calculation results for Montenegro, FB approach on 19 July 2028 at 19:30 h

Table 59 List of calculated minimum MACZT values below 70% for considered element on 19 July 2028 at 19:30 h with **FB approach in Montenegro**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
TR2 400/220 kV TPP PLJEVLJA	DIRECT TR 400/220 kV TPP PLJEVLJA	31,4
TR 400/220 kV TPP PLJEVLJA	DIRECT TR2 400/220 kV TPP PLJEVLJA	31,7
TR2 220/110 kV PODGORICA 1	OPPOSITE OHL 400 kV TIRANA 2 - PODGORICA 2	50,4
OHL 220 kV HPP PIVA - SARAJEVO	OPPOSITE OHL 400 kV BREZNA - PLJEVLJA 2	64,7
OHL 400 kV BREZNA - PLJEVLJA 2	OPPOSITE OHL 400 kV LASTVA - VILLANOVA	67,6
OHL 220 kV MOJKOVAC - TPP PLJEVLJA	OPPOSITE OHL 400 kV BREZNA - PLJEVLJA 2	67,9

8.5 North Macedonia

On 19 Jan 2028 at 19:30 h in North Macedonia there are 8 elements (out of 22) fulfilling 70% target.

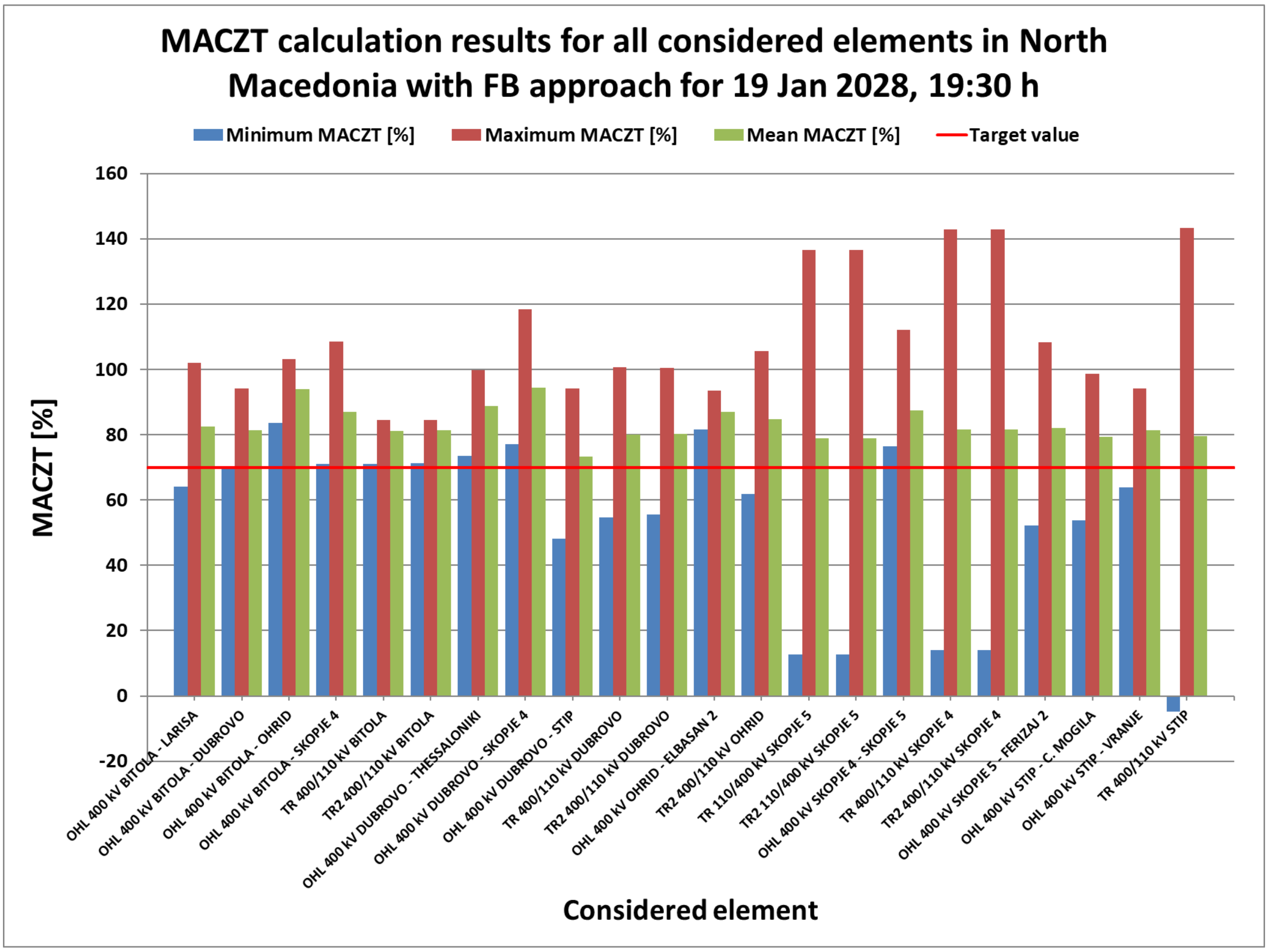


Figure 62 MACZT calculation results for North Macedonia, **FB approach** on 19 January 2028 at 19:30 h

In January 2028 scenario in North Macedonia minimum calculated MACZT values below 50% are detected on 6 elements, as shown in the following table.

Table 60 List of calculated minimum MACZT values below 70% for considered element on 19 January 2028 at 19:30 h with **FB approach in North Macedonia**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
TR 400/110 kV STIP	OPPOSITE OHL 400 kV DUBROVO - STIP	-4,8
TR 110/400 kV SKOPJE 5	OPPOSITE TR2 110/400 kV SKOPJE 5	12,8
TR2 110/400 kV SKOPJE 5	OPPOSITE TR 110/400 kV SKOPJE 5	12,8
TR 400/110 kV SKOPJE 4	OPPOSITE TR2 400/110 kV SKOPJE 4	13,9
TR2 400/110 kV SKOPJE 4	OPPOSITE TR 400/110 kV SKOPJE 4	13,9
OHL 400 kV DUBROVO - STIP	OPPOSITE TR 400/110 kV STIP	48,2
OHL 400 kV SKOPJE 5 - FERIZAJ 2	OPPOSITE OHL 400 kV DUBROVO - STIP	52,3
OHL 400 kV STIP - C. MOGILA	OPPOSITE OHL 400 kV STIP - VRANJE	53,7
TR 400/110 kV DUBROVO	OPPOSITE TR 400/110 kV STIP	54,7
TR2 400/110 kV DUBROVO	OPPOSITE TR 400/110 kV STIP	55,5
TR2 400/110 kV OHRID	OPPOSITE OHL 400 kV SKOPJE 5 - FERIZAJ 2	61,9
OHL 400 kV STIP - VRANJE	OPPOSITE OHL 400 kV STIP - C. MOGILA	63,8
OHL 400 kV BITOLA - LARISA	DIRECT OHL 400 kV BITOLA - DUBROVO	64,0
OHL 400 kV BITOLA - DUBROVO	DIRECT OHL 400 kV BITOLA - SKOPJE 4	69,4

On 19 July 2028 at 19:30 h there are 21 elements (out of 22) fulfilling 70% target. Minimum calculated MACZT values below 70% are detected only on 1 element, as shown in the following table.

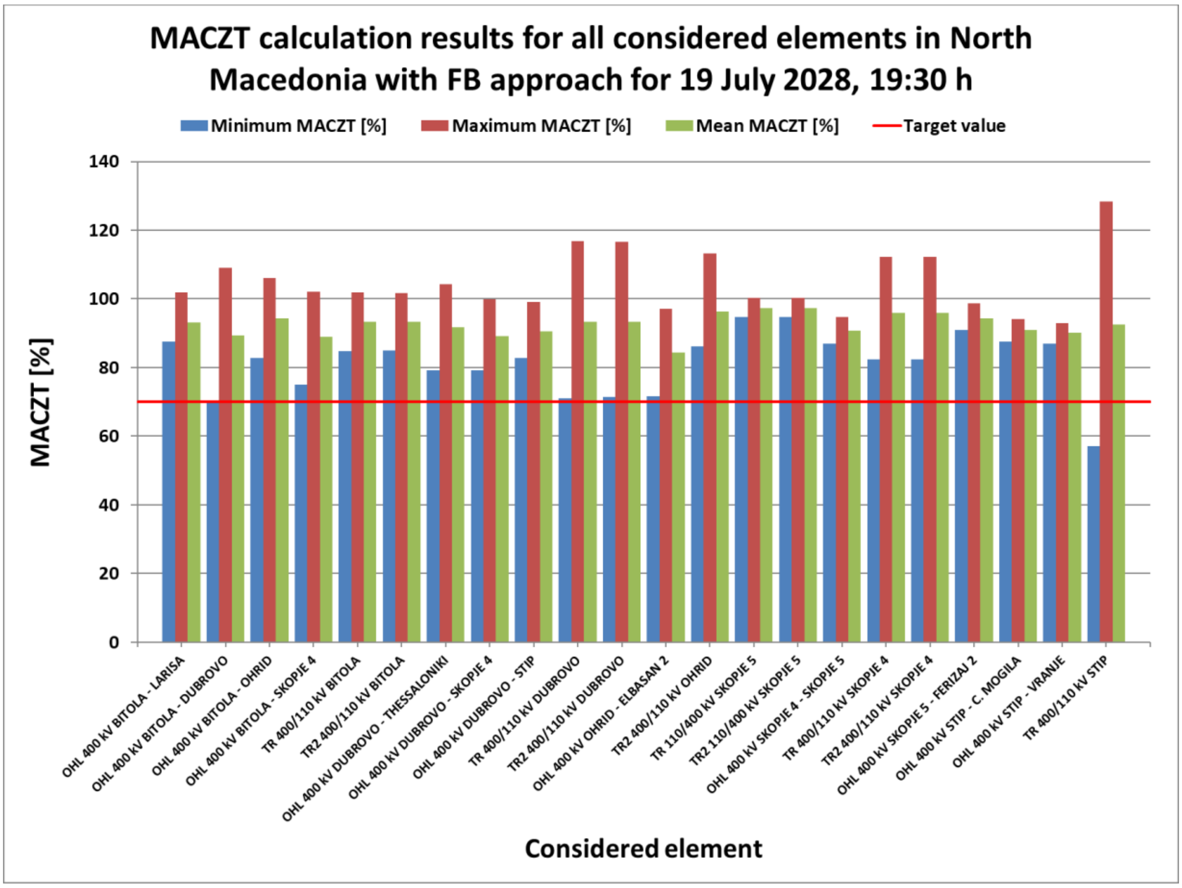


Figure 63 MACZT calculation results for North Macedonia, **FB approach** on 19 July 2028 at 19:30 h

Table 61 List of calculated minimum MACZT values below 70% for considered element on 19 July 2028 at 19:30 h with **FB approach in North Macedonia**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
TR 400/110 kV STIP	OPPOSITE TR 400/110 kV DUBROVO	57,2

8.6 Serbia

On 19 Jan 2028 at 19:30 h in Serbia there are 24 elements (out of 54) fulfilling 70% target.

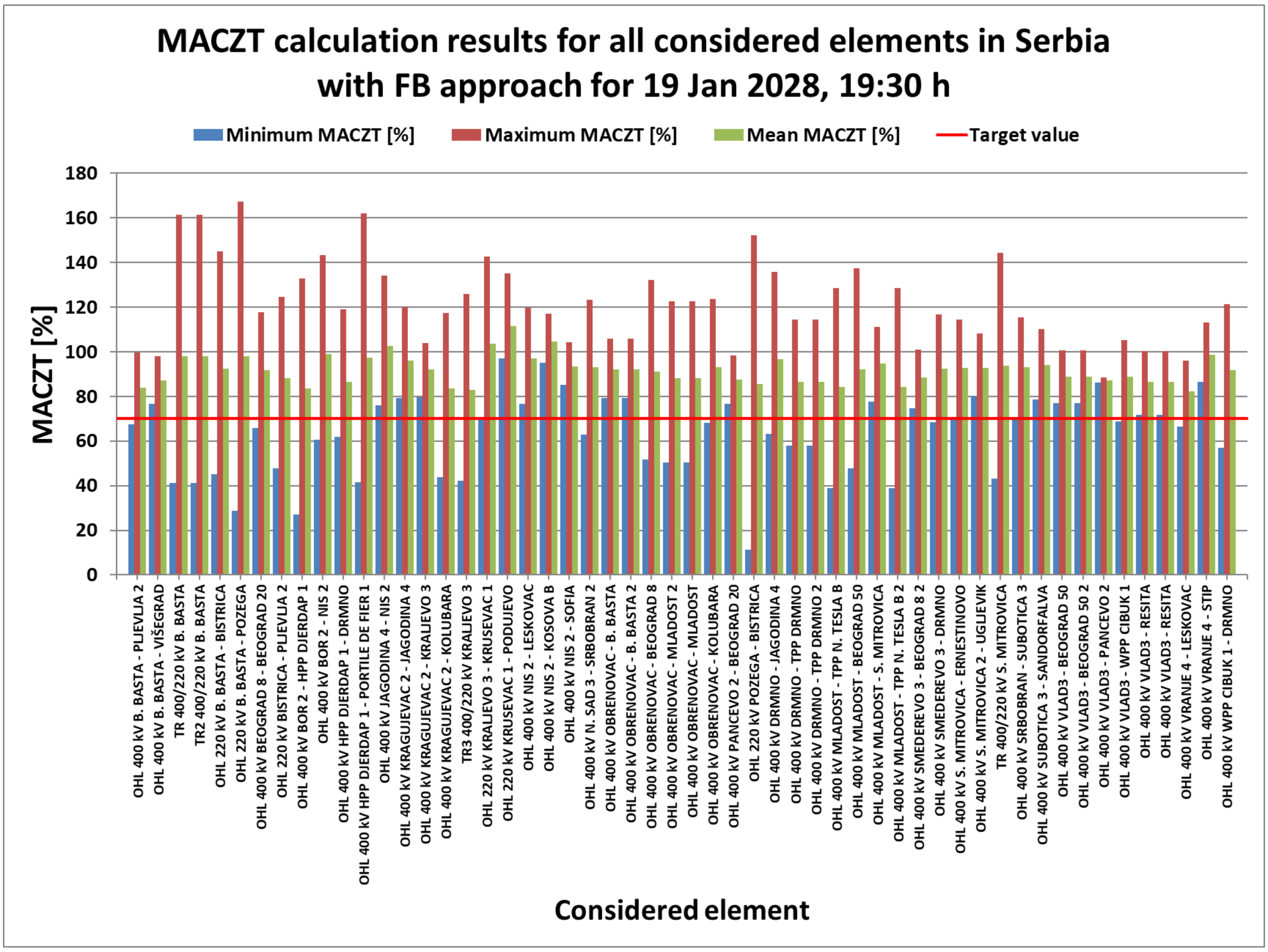


Figure 64 MACZT calculation results for Serbia, **FB approach** on 19 January 2028 at 19:30 h

In January 2028 scenario in Serbia minimum calculated MACZT values below 50% are detected on 14 elements, as shown in the following table.

Table 62 List of calculated minimum MACZT values below 70% for considered element on 19 January 2028 at 19:30 h with **FB approach in Serbia**

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 220 kV POZEGA - BISTRICA	OPPOSITE OHL 220 kV B. BASTA - POZEGA	11,2
OHL 400 kV BOR 2 - HPP DJERDAP 1	OPPOSITE OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1	27,2
OHL 220 kV B. BASTA - POZEGA	DIRECT OHL 220 kV B. BASTA - BISTRICA	28,7
OHL 400 kV MLADOST - TPP N. TESLA B	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B 2	39,0
OHL 400 kV MLADOST - TPP N. TESLA B 2	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B	39,0
TR 400/220 kV B. BASTA	DIRECT OHL 220 kV B. BASTA - POZEGA	41,2
TR2 400/220 kV B. BASTA	DIRECT OHL 220 kV B. BASTA - POZEGA	41,2
OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1	DIRECT OHL 400 kV BOR 2 - HPP DJERDAP 1	41,6
TR3 400/220 kV KRALJEVO 3	OPPOSITE OHL 220 kV B. BASTA - POZEGA	42,1
TR 400/220 kV S. MITROVICA	OPPOSITE OHL 400 kV MLADOST - S. MITROVICA	43,0
OHL 400 kV KRAGUJEVAC 2 - KOLUBARA	OPPOSITE OHL 400 kV DRMNO - JAGODINA 4	43,8
OHL 220 kV B. BASTA - BISTRICA	DIRECT OHL 220 kV B. BASTA - POZEGA	45,3
OHL 400 kV MLADOST - BEOGRAD 50	DIRECT OHL 400 kV MLADOST - N. SAD 3	47,8
OHL 220 kV BISTRICA - PLJEVLJA 2	OPPOSITE OHL 220 kV B. BASTA - POZEGA	47,9
OHL 400 kV OBRENOVAC - MLADOST 2	OPPOSITE OHL 400 kV OBRENOVAC - MLADOST	50,4
OHL 400 kV OBRENOVAC - MLADOST	OPPOSITE OHL 400 kV OBRENOVAC - MLADOST 2	50,5
OHL 400 kV OBRENOVAC - BEOGRAD 8	DIRECT OHL 400 kV MLADOST - BEOGRAD 50	51,6
OHL 400 kV WPP CIBUK 1 - DRMNO	OPPOSITE OHL 400 kV DRMNO - JAGODINA 4	56,8
OHL 400 kV DRMNO - TPP DRMNO	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B	57,8
OHL 400 kV DRMNO - TPP DRMNO 2	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B	57,8
OHL 400 kV BOR 2 - NIS 2	DIRECT OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1	60,6
OHL 400 kV HPP DJERDAP 1 - DRMNO	DIRECT OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1	61,9
OHL 400 kV N. SAD 3 - SRBOBRAN 2	DIRECT OHL 400 kV MLADOST - S. MITROVICA	62,8
OHL 400 kV DRMNO - JAGODINA 4	DIRECT OHL 400 kV KRAGUJEVAC 2 - KOLUBARA	63,1
OHL 400 kV BEOGRAD 8 - BEOGRAD 20	DIRECT OHL 400 kV MLADOST - BEOGRAD 50	65,8
OHL 400 kV VRANJE 4 - LESKOVAC	OPPOSITE OHL 400 kV NIS 2 - KOSOVO B	66,3
OHL 400 kV B. BASTA - PLJEVLJA 2	OPPOSITE OHL 220 kV B. BASTA - POZEGA	67,4
OHL 400 kV OBRENOVAC - KOLUBARA	DIRECT OHL 400 kV DRMNO - JAGODINA 4	68,1
OHL 400 kV SMEDEREVO 3 - DRMNO	OPPOSITE OHL 400 kV WPP CIBUK 1 - DRMNO	68,4
OHL 400 kV VLAD3 - WPP CIBUK 1	OPPOSITE OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1	68,7

On 19 July 2028 at 19:30 h there are 40 elements (out of 61) fulfilling 70% target. Minimum calculated MACZT values below 50% are detected only on 4 elements, as shown in the following table.

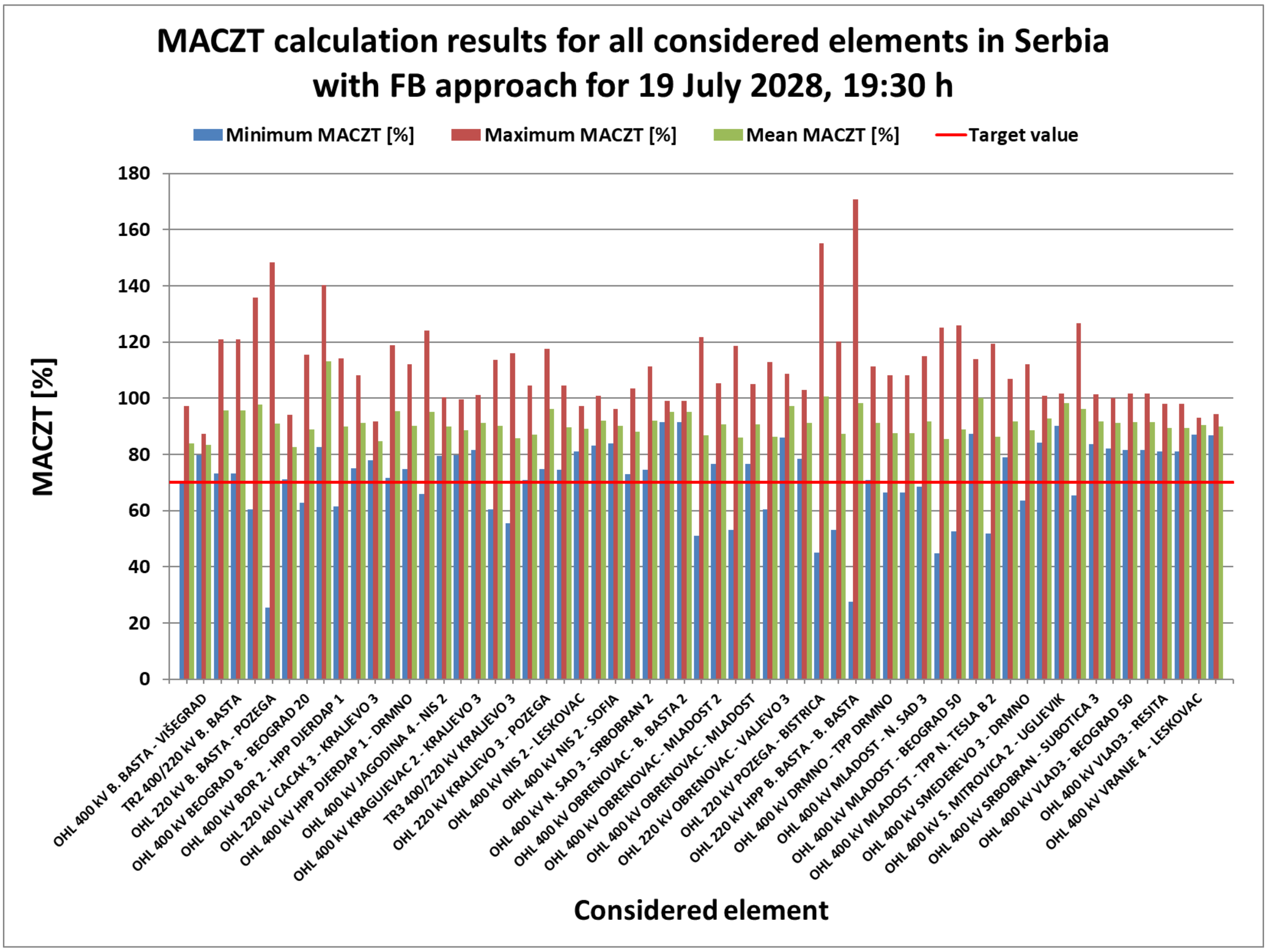


Figure 65 MACZT calculation results for Serbia, **FB approach** on 19 July 2028 at 19:30 h

Table 63 List of calculated minimum MACZT values below 70% for considered element on 19 July 2028 at 19:30 h with **FB approach in Serbia**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
OHL 220 kV B. BASTA – POZEGA	DIRECT OHL 220 kV POZEGA - BISTRICA	25,5
OHL 220 kV HPP B. BASTA - B. BASTA	DIRECT OHL 400 kV MLADOST - TPP N. TESLA B	27,6
OHL 400 kV MLADOST - TPP N. TESLA B	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B 2	44,8
OHL 220 kV POZEGA - BISTRICA	OPPOSITE OHL 220 kV B. BASTA - POZEGA	45,0
OHL 400 kV OBRENOVAC - BEOGRAD 8	DIRECT OHL 400 kV MLADOST - BEOGRAD 50	50,9
OHL 400 kV MLADOST - TPP N. TESLA B 2	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B	51,9
OHL 400 kV MLADOST - BEOGRAD 50	DIRECT OHL 400 kV MLADOST - N. SAD 3	52,6
OHL 400 kV JPRPCI 2 - DRMNO	OPPOSITE OHL 400 kV SMEDEREVO 3 - DRMNO	53,1
OHL 400 kV OBRENOVAC - TPP N. TESLA A 2	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B	53,2
TR3 400/220 kV KRALJEVO 3	OPPOSITE OHL 220 kV B. BASTA - POZEGA	55,5
OHL 220 kV B. BASTA - BISTRICA	DIRECT OHL 220 kV B. BASTA - POZEGA	60,3
OHL 400 kV KRAGUJEVAC 2 - KOLUBARA	OPPOSITE OHL 400 kV OBRENOVAC - KOLUBARA	60,5
OHL 400 kV OBRENOVAC - KOLUBARA	OPPOSITE OHL 400 kV KRAGUJEVAC 2 - KOLUBARA	60,5

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV BOR 2 - HPP DJERDAP 1	OPPOSITE OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1	61,4
OHL 400 kV BEOGRAD 8 - BEOGRAD 20	DIRECT OHL 400 kV MLADOST - BEOGRAD 50	62,7
OHL 400 kV SMEDEREVO 3 - DRMNO	OPPOSITE OHL 400 kV JPRPCI 2 - DRMNO	63,5
TR 400/220 kV S. MITROVICA	OPPOSITE OHL 400 kV MLADOST - S. MITROVICA	65,5
OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1	DIRECT OHL 400 kV BOR 2 - HPP DJERDAP 1	66,0
OHL 400 kV DRMNO - TPP DRMNO	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B	66,4
OHL 400 kV DRMNO - TPP DRMNO 2	OPPOSITE OHL 400 kV MLADOST - TPP N. TESLA B	66,4
OHL 400 kV MLADOST - N. SAD 3	DIRECT OHL 400 kV MLADOST - S. MITROVICA	68,6

8.7 Moldova

On 19 January 2028 at 19:30 h in Moldova there are 14 elements (out of 17 or 82,4%) fulfilling 70% target.

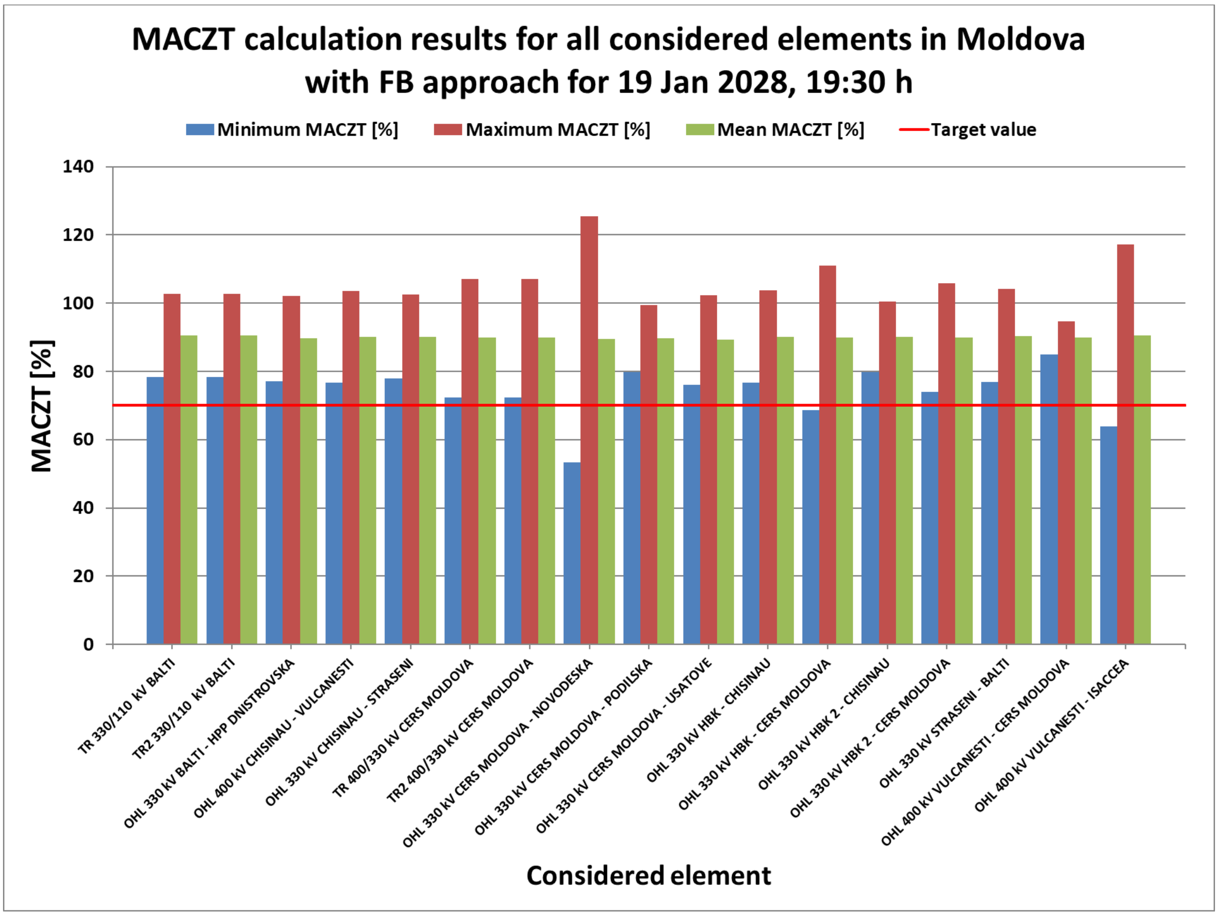


Figure 66 MACZT calculation results for Moldova, FB approach on 19 January 2028 at 19:30 h

In January 2028 scenario in Moldova minimum calculated MACZT values on all elements are higher than 53%, as shown in the following table.

Table 64 List of calculated minimum MACZT values below 70% for considered element on 19 January 2028 at 19:30 h with **FB approach in Moldova**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
OHL 330 kV CERS MOLDOVA - NOVODESKA	OPPOSITE OHL 330 kV PODILSKA - CERS MOLDOVA	53,3
OHL 400 kV VULCANESTI - ISACCEA	OPPOSITE OHL 330 kV BALTI - DNISTROVSKA	63,9
OHL 330 kV HBK - CERS MOLDOVA	OPPOSITE OHL 330 kV HBK 2 - CERS MOLDOVA	68,7

On 19 July 2028 at 19:30 h in Moldova there are 11 elements (out of 23 or 47,8%) fulfilling 70% target.

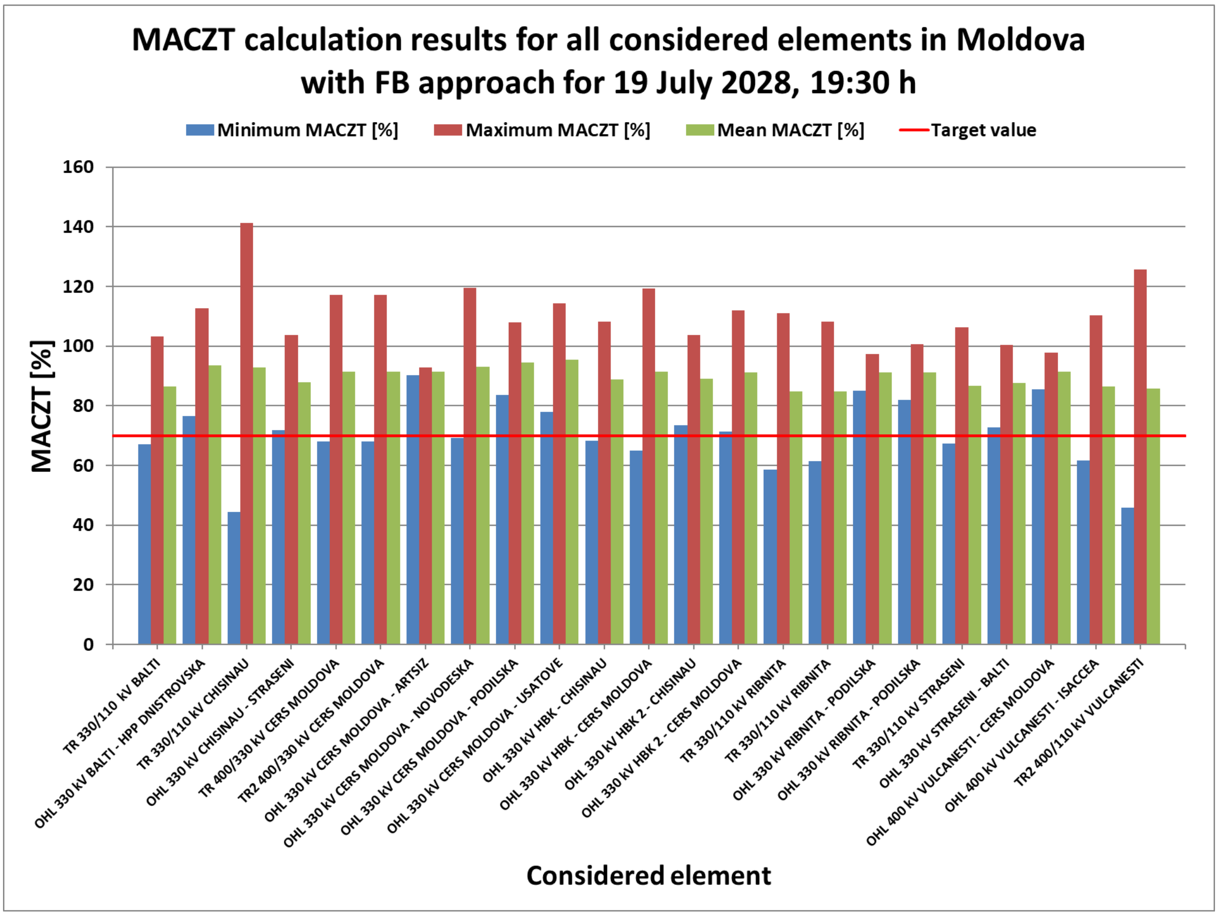


Figure 67 MACZT calculation results for Moldova, **FB approach** on 19 July 2028 at 19:30 h

Table 65 List of calculated minimum MACZT values below 70% for considered element on 19 July 2028 at 19:30 h with **FB approach in Moldova**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
TR 330/110 kV CHISINAU	OPPOSITE OHL 330 kV CHISINAU - STRASENI	44,3
TR2 400/110 kV VULCANESTI	OPPOSITE OHL 400 kV VULCANESTI - CERS MOLDOVA	45,9
TR 330/110 kV RIBNITA	OPPOSITE OHL 330 kV PODILSKA - CERS MOLDOVA	58,7
TR 330/110 kV RIBNITA	OPPOSITE OHL 330 kV PODILSKA - CERS MOLDOVA	61,5

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 400 kV VULCANESTI - ISACCEA	OPPOSITE OHL 330 kV BALTI - DNISTROVSKA	61,6
OHL 330 kV HBK - CERS MOLDOVA	OPPOSITE OHL 330 kV HBK 2 - CERS MOLDOVA	65,0
TR 330/110 kV BALTI	OPPOSITE OHL 330 kV STRASENI - BALTI	67,0
TR 330/110 kV STRASENI	OPPOSITE OHL 330 kV CHISINAU - STRASENI	67,4
TR 400/330 kV CERS MOLDOVA	OPPOSITE TR2 400/330 kV CERS MOLDOVA	68,1
TR2 400/330 kV CERS MOLDOVA	OPPOSITE TR 400/330 kV CERS MOLDOVA	68,1
OHL 330 kV HBK - CHISINAU	DIRECT OHL 330 kV HBK 2 - CHISINAU	68,3
OHL 330 kV CERS MOLDOVA - NOVODESKA	OPPOSITE OHL 330 kV USATOVO - CERS MOLDOVA	69,3

8.8 Ukraine

On 19 January 2028 at 19:30 h in Ukraine there are 20 elements (out of 66 or 30%) fulfilling 70% target.

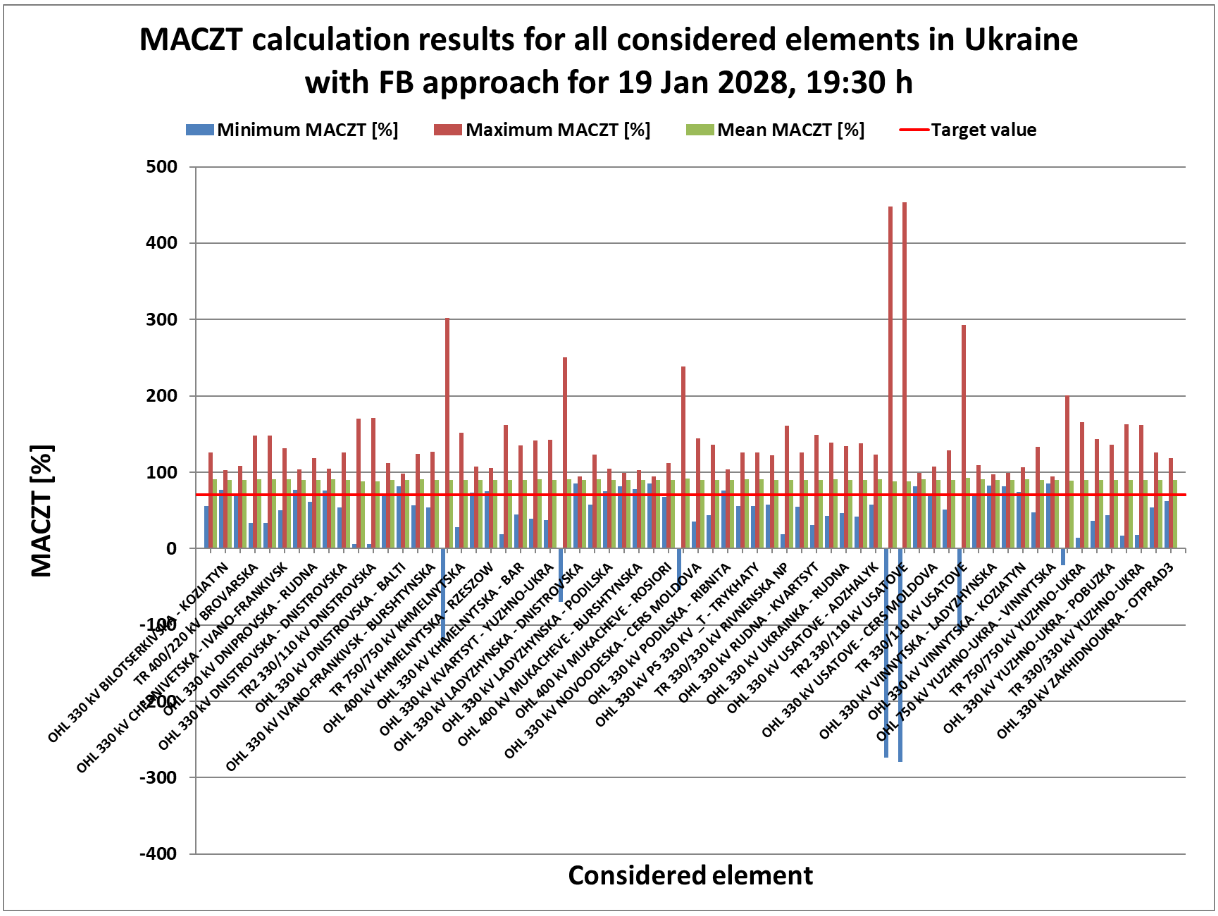


Figure 68 MACZT calculation results for Ukraine, FB approach on 19 January 2028 at 19:30 h

In January 2028 scenario in Ukraine on 30 elements (or 45%) minimum calculated MACZT values are below 50%, as shown in the following table.

Table 66 List of calculated minimum MACZT values below 70% for considered element on 19 January 2028 at 19:30 h with **FB approach in Ukraine**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
TR2 330/110 kV USATOVE	DIRECT TR 330/110 kV USATOVE	-279,5
TR 330/110 kV USATOVE	DIRECT TR2 330/110 kV USATOVE	-273,7
TR 750/330 kV KHMELNYTSKA	DIRECT TR 330/330 kV KHMELNYTSKA	-122,9
TR 330/110 kV USATOVE	DIRECT OHL 330 kV USATOVE - ADZHALYK	-108,3
TR 750/330 kV KYIVSKA	DIRECT OHL 330 kV VINNYTSKA - KOZIATYN	-70,1
TR2 330/110 kV NOVOODESKA	DIRECT OHL 330 kV USATOVE - NOVOODESKA	-54,1
TR 750/330 kV YUZHNO-UKRA	DIRECT OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	-22,0
TR2 330/110 kV DNISTROVSKA	DIRECT TR 330/110 kV DNISTROVSKA	5,5
TR 330/110 kV DNISTROVSKA	DIRECT TR2 330/110 kV DNISTROVSKA	5,8
TR 750/750 kV YUZHNO-UKRA	DIRECT TR 330/330 kV KHMELNYTSKA	14,5
TR 330/330 kV YUZHNO-UKRA	DIRECT OHL 220 kV DOBROTVIRSKA - ZAMOSC	17,0
TR 330/330 kV YUZHNO-UKRA	DIRECT TR 330/330 kV KHMELNYTSKA	18,2
TR 330/330 kV KHMELNYTSKA	DIRECT TR 330/330 kV YUZHNO-UKRA	18,3
TR 330/330 kV RIVNENSKA NP	DIRECT OHL 220 kV DOBROTVIRSKA - ZAMOSC	18,5
TR 750/750 kV KHMELNYTSKA	DIRECT OHL 220 kV DOBROTVIRSKA - ZAMOSC	27,9
OHL 330 kV RUDNA - KVARTSYT	OPPOSITE OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	30,6
TR 400/220 kV BROVARSKA	OPPOSITE TR2 400/220 kV BROVARSKA	33,4
TR2 400/220 kV BROVARSKA	OPPOSITE TR 400/220 kV BROVARSKA	33,4
OHL 330 kV NOVOODESKA - CERS MOLDOVA	OPPOSITE OHL 330 kV USATOVE - ADZHALYK	34,9
OHL 330 kV YUZHNO-UKRA - ADZHALYK	DIRECT OHL 330 kV TRYKHATY - YUZHNO-UKRA	35,8
OHL 330 kV KVARTSYT - YUZHNO-UKRA	OPPOSITE OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	37,3
OHL 330 kV KHMELNYTSKA - KHMELNYTSKA	OPPOSITE OHL 330 kV RIVNENSKA NP - OTPRAD3	38,9
OHL 330 kV UKRAINKA - YUZHNO-UKRA	OPPOSITE OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	42,1
OHL 330 kV TRYKHATY - YUZHNO-UKRA	OPPOSITE OHL 330 kV YUZHNO-UKRA - ADZHALYK	42,7
OHL 330 kV PERSHOTRAVNEVA - RUDNA	OPPOSITE OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	43,5
OHL 330 kV YUZHNO-UKRA - POBUZKA	DIRECT OHL 330 kV KHMELNYTSKA - KHMELNYTSKA	43,8
OHL 330 kV KHMELNYTSKA - BAR	DIRECT OHL 330 kV KHMELNYTSKA - TERNOPILSKA	44,7
OHL 330 kV UKRAINKA - RUDNA	DIRECT OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	46,1
OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	DIRECT OHL 330 kV KVARTSYT - YUZHNO-UKRA	47,5
OHL 330 kV CHERNIVETSKA - IVANO-FRANKIVSK	OPPOSITE OHL 330 kV DNISTROVSKA - DNISTROVSKA	49,6
OHL 330 kV USATOVE - NOVOODESKA	OPPOSITE OHL 330 kV USATOVE - ADZHALYK	51,1
OHL 330 kV DNISTROVSKA - DNISTROVSKA	DIRECT OHL 330 kV CHERNIVETSKA - IVANO-FRANKIVSK	53,3
OHL 330 kV ZAKHIDNOUKRA - BOHORODCHANY	DIRECT OHL 330 kV IVANO-FRANKIVSK - BURSHTYNSKA	53,5
OHL 330 kV IVANO-FRANKIVSK - BURSHTYNSKA	OPPOSITE OHL 330 kV ZAKHIDNOUKRA - BOHORODCHANY	54,1
OHL 330 kV RIVNENSKA NP - OTPRAD3	DIRECT OHL 330 kV KHMELNYTSKA - KHMELNYTSKA	54,3
OHL 330 kV PS 330 KV _T - TRYKHATY	OPPOSITE OHL 330 kV YUZHNO-UKRA - ADZHALYK	55,5
OHL 330 kV ADZHALYK - PS 330 KV _P	OPPOSITE OHL 330 kV YUZHNO-UKRA - ADZHALYK	55,6
OHL 330 kV PS 330 KV _P - PS 330 KV _T	OPPOSITE OHL 330 kV YUZHNO-UKRA - ADZHALYK	55,6

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 330 kV IVANO-FRANKIVSK - BOHORODCHANY	OPPOSITE OHL 330 kV IVANO-FRANKIVSK - BURSHTYNSKA	56,3
OHL 330 kV LADYZHYNSKA - POBUZKA	OPPOSITE OHL 330 kV KHMELNYTSKA - KHMELNYTSKA	57,4
OHL 330 kV USATOVE - ADZHALYK	OPPOSITE TR2 330/110 kV ADZHALYK	57,4
OHL 330 kV RIVNENSKA NP - RIVNENSKA NP	DIRECT TR 750/330 kV RIVNENSKA NP	57,5
OHL 330 kV DNIPROVSKA - RUDNA	OPPOSITE OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	61,1
OHL 330 kV ZAKHIDNOUKRA - OTPRAD3	OPPOSITE OHL 330 kV KHMELNYTSKA - KHMELNYTSKA	62,2
OHL 400 kV MUKACHEVE - ROSIORI	DIRECT TR 750/330 kV RIVNENSKA NP	67,9
OHL 330 kV DNISTROVSKA - KAMIANETS-PODILSKA	DIRECT OHL 330 kV IVANO-FRANKIVSK - BURSHTYNSKA	68,5

On 19 July 2028 at 19:30 h in Ukraine there are 18 elements (out of 66 or 27,3%) fulfilling 70% target.

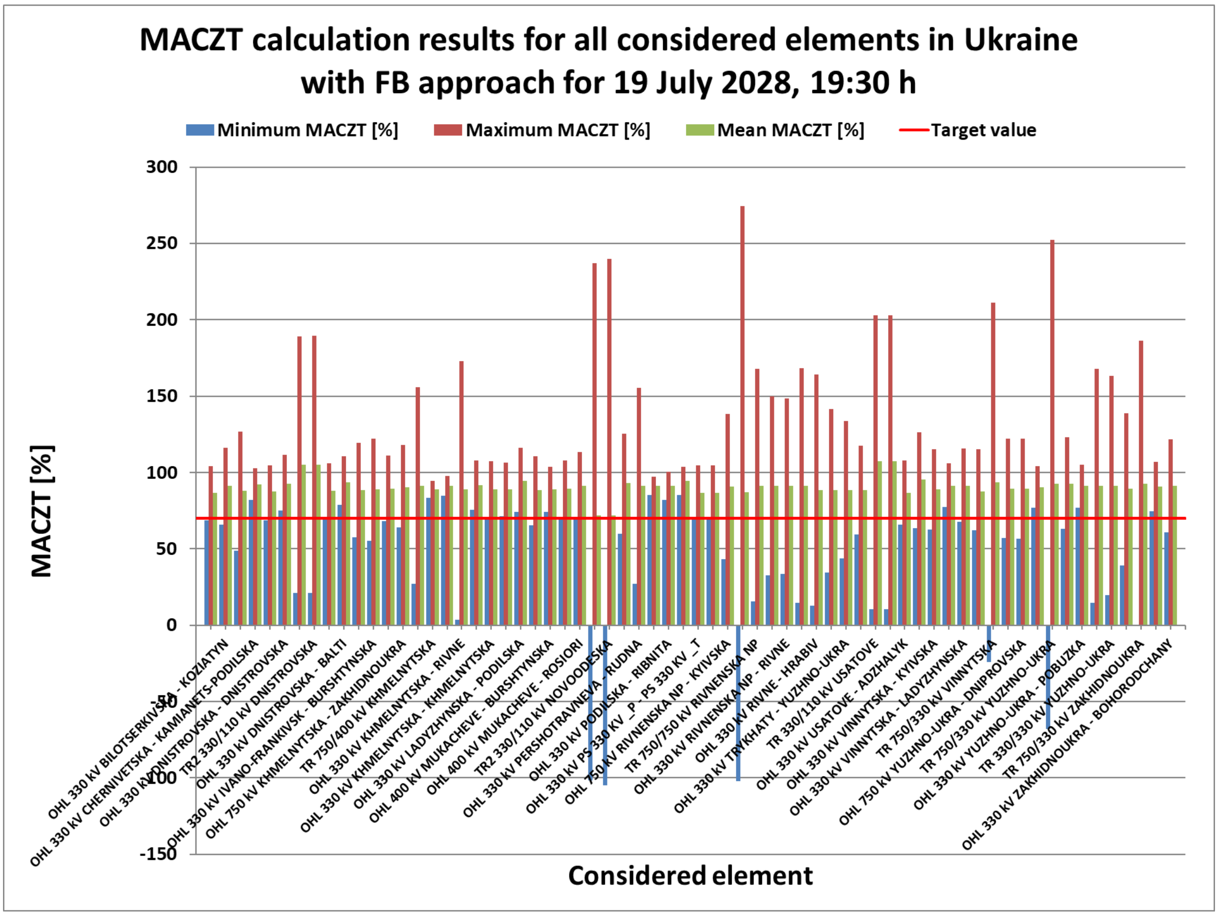


Figure 69 MACZT calculation results for Ukraine, FB approach on 19 July 2028 at 19:30 h

In July 2028 scenario in Ukraine on 25 elements (or 38%) minimum calculated MACZT values are below 50%, as shown in the following table.

Table 67 List of calculated minimum MACZT values below 70% for considered element on 19 July 2028 at 19:30 h with **FB approach in Ukraine**

Worst-case CNE(C)		Minimum MACZT [%]
Element	**Direction and contingency**	
TR2 330/110 kV NOVOODESKA	DIRECT TR 330/110 kV NOVOODESKA	-104,8
TR 750/330 kV RIVNENSKA NP	OPPOSITE OHL 330 kV KHMELNYTSKA - RIVNE	-102,2
TR 330/110 kV NOVOODESKA	DIRECT TR2 330/110 kV NOVOODESKA	-101,6
TR 750/330 kV YUZHNO-UKRA	OPPOSITE OHL 330 kV RUDNA - KVARTSYT	-67,9
TR 750/330 kV VINNYTSKA	DIRECT TR 750/330 kV KYIVSKA	-24,2
TR 750/330 kV ZAKHIDNOUKRA	DIRECT OHL 750 kV ALBERTIRSA - ZAKHIDNOUKRA	-0,8
OHL 330 kV KHMELNYTSKA - RIVNE	OPPOSITE TR 750/330 kV RIVNENSKA NP	3,4
TR 330/110 kV USATOVE	DIRECT TR2 330/110 kV USATOVE	10,3
TR2 330/110 kV USATOVE	DIRECT TR 330/110 kV USATOVE	10,3
OHL 330 kV RIVNE - HRABIV	OPPOSITE TR 750/330 kV RIVNENSKA NP	12,5
TR 330/330 kV RIVNENSKA NP	DIRECT TR 330/330 kV YUZHNO-UKRA	14,5
TR 330/330 kV YUZHNO-UKRA	DIRECT BASE CASE	14,8
TR 750/750 kV RIVNENSKA NP	DIRECT TR 330/330 kV RIVNENSKA NP	15,3
TR 330/330 kV YUZHNO-UKRA	DIRECT TR 330/330 kV RIVNENSKA NP	19,7
TR2 330/110 kV DNISTROVSKA	DIRECT TR 330/110 kV DNISTROVSKA	20,9
TR 330/110 kV DNISTROVSKA	DIRECT TR2 330/110 kV DNISTROVSKA	21,1
OHL 330 kV PERSHOTRAVNEVA - RUDNA	OPPOSITE OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	27,0
TR 750/750 kV KHMELNYTSKA	DIRECT TR 330/330 kV RIVNENSKA NP	27,0
OHL 330 kV RIVNENSKA NP - HRABIV	DIRECT TR 750/330 kV RIVNENSKA NP	32,5
OHL 330 kV RIVNENSKA NP - RIVNE	DIRECT TR 750/330 kV RIVNENSKA NP	33,7
OHL 330 kV TRYKHATY - KRYVORIZKA T	DIRECT OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	34,3
OHL 750 kV ZAKHIDNOUKRA - RIVNENSKA NP	OPPOSITE OHL 750 kV RIVNENSKA NP - KYIVSKA	39,0
OHL 750 kV RIVNENSKA NP - KYIVSKA	DIRECT OHL 750 kV ZAKHIDNOUKRA - RIVNENSKA NP	43,2
OHL 330 kV TRYKHATY - YUZHNO-UKRA	OPPOSITE TR 750/330 kV YUZHNO-UKRA	43,8
OHL 330 kV CHERNIVETSKA - IVANO-FRANKIVSK	OPPOSITE OHL 750 kV VINNYTSKA - ZAKHIDNOUKRA	48,6
OHL 330 kV IVANO-FRANKIVSK - BURSHTYNSKA	OPPOSITE OHL 330 kV ZAKHIDNOUKRA - BOHORODCHANY	55,3
OHL 750 kV YUZHNO-UKRA - DNIPROVSKA	DIRECT OHL 330 kV TRYKHATY - KRYVORIZKA T	56,6
OHL 750 kV VINNYTSKA - ZAKHIDNOUKRA	OPPOSITE TR 330/330 kV YUZHNO-UKRA	57,0
OHL 330 kV IVANO-FRANKIVSK - BOHORODCHANY	OPPOSITE OHL 330 kV IVANO-FRANKIVSK - BURSHTYNSKA	57,3
OHL 330 kV USATOVE - ADZHALYK	OPPOSITE TR 750/330 kV YUZHNO-UKRA	59,1
OHL 330 kV NOVOODESKA - CERS MOLDOVA	OPPOSITE OHL 330 kV USATOVE - ADZHALYK	59,8
OHL 330 kV ZAKHIDNOUKRA - BOHORODCHANY	DIRECT OHL 330 kV IVANO-FRANKIVSK - BURSHTYNSKA	60,8
OHL 330 kV VINNYTSKA - VINNYTSKA	OPPOSITE OHL 330 kV VINNYTSKA - LADYZHYNSKA	62,1
OHL 330 kV VINNYTSKA - KYIVSKA	DIRECT TR 750/330 kV KYIVSKA	62,7
OHL 330 kV YUZHNO-UKRA - ADZHALYK	DIRECT OHL 330 kV TRYKHATY - YUZHNO-UKRA	62,9
OHL 330 kV USATOVE - CERS MOLDOVA	OPPOSITE TR 330/330 kV YUZHNO-UKRA	63,6
OHL 750 kV KHMELNYTSKA - ZAKHIDNOUKRA	DIRECT OHL 750 kV ZAKHIDNOUKRA - RIVNENSKA NP	63,7
OHL 330 kV LADYZHYNSKA - VINNYTSKA	DIRECT OHL 330 kV VINNYTSKA - LADYZHYNSKA	65,1

Worst-case CNE(C)		Minimum MACZT [%]
Element	Direction and contingency	
OHL 330 kV USATOVE - ADZHALYK	DIRECT TR 330/330 kV YUZHNO-UKRA	65,7
OHL 330 kV BILOTSERKIVSKA - KOZIATYN	OPPOSITE OHL 330 kV VINNYTSKA - KYIVSKA	65,9
OHL 330 kV VINNYTSKA - LADYZHYNSKA	OPPOSITE TR 750/330 kV YUZHNO-UKRA	67,8
OHL 750 kV KHMELNYTSKA - KYIVSKA	DIRECT OHL 330 kV VINNYTSKA - KYIVSKA	68,0
OHL 330 kV ADZHALYK - PS 330 KV _P	OPPOSITE OHL 330 kV YUZHNO-UKRA - ADZHALYK	68,4
OHL 330 kV DNISTROVSKA - BAR	OPPOSITE OHL 330 kV CHERNIVETSKA - IVANO-FRANKIVSK	68,5
OHL 330 kV PS 330 KV _T - TRYKHATY	OPPOSITE OHL 330 kV YUZHNO-UKRA - ADZHALYK	69,0
OHL 330 kV PS 330 KV _P - PS 330 KV _T	OPPOSITE OHL 330 kV YUZHNO-UKRA - ADZHALYK	69,1
OHL 400 kV MUKACHEVE - ROSIORI	DIRECT OHL 750 kV VINNYTSKA - ZAKHIDNOUKRA	69,6
OHL 330 kV KHMELNYTSKA - KHMELNYTSKA	OPPOSITE OHL 330 kV TERNOPILSKA - BURSHTYNSKA	69,8

8.9 Conclusions on the fulfillment of 70% target in expected future network in 2028

The following table recaps above mentioned findings for WB6. Ukraine and Moldova were not analysed in 2021 scenarios. Obviously, in the future network in 2028 the level of fulfillment of 70% target in WB6 is higher than in the existing network.

On 20 January 2021 at 19:30 h between 13% (Montenegro) and 53% (Bosnia and Herzegovina) of all considered elements fulfilled 70% target. On the regional level only 46 out of 176 (around 26%) of considered elements fulfilled 70% target.

On 19 January 2028 at 19:30 h between 22,7% (Kosovo*) and 42,6% (Serbia) of all considered elements fulfilled 70% target. On the WB6 regional level only 67 out of 181 (around 36%) of considered elements fulfilled 70% target, which is around 10% better result than in 2021. Adding results for Ukraine and Moldova it would be 38,3%.

Table 68 Comparison of the level of 70% target fulfillment for considered elements with FB approach on 20 January 2021 at 19:30 h and on 19 January 2028 at 19:30 h

	20 Jan 2021, 19:30 h		19 Jan 2028, 19:30 h	
Contracting Party	Total number of considered elements	Total number of elements with MACZT>70%	Total number of considered elements	Total number of elements with MACZT>70%
Albania	24	4	33	13
BiH	34	18	27	10
Kosovo	20	6	22	5

	20 Jan 2021, 19:30 h		19 Jan 2028, 19:30 h	
Montenegro	23	3	23	7
North Macedonia	19	3	22	8
Serbia	56	12	54	24
Ukraine	-	-	66	20
Moldova	-	-	17	14
TOTAL	176	46	264	101

This comparison shows that in some Contracting Parties the share of elements that fulfills 70% target increased in 2028 compared to 2021 (Albania, Montenegro, North Macedonia and Serbia), while in some Contracting Parties it decreased (Bosnia and Herzegovina, Kosovo*). Even though only two snapshots are compared here, these results can be related to the level of network investments foreseen in the period 2021 – 2028. Contracting Parties with larger network investments (primarily Montenegro and Serbia) achieved better results.

Table 69 The share of considered elements that fulfill 70% target with FB approach on 20 January 2021 at 19:30 h and on 19 January 2028 at 19:30 h

Contracting Party	Share of elements with MACZT>70% on 20 Jan 2021, 19:30 h	Share of elements with MACZT>70% on 19 Jan 2028 at 19:30 h
Albania	16,7	36,4
BiH	52,9	37,0
Kosovo*	30,0	22,7
Montenegro	13,0	30,4
North Macedonia	15,8	36,4
Serbia	21,4	42,6
Ukraine	-	30,0
Moldova	-	82,4
TOTAL	**26,1**	**38,3**

On 21 July 2021 at 19:30 h between 31% (Serbia) and 85% (Kosovo*) of all considered elements fulfilled 70% target. On the regional level 96 out of 176 (around 55%) of considered elements fulfilled 70% target.

On 19 July 2028 at 19:30 h in WB6 between 53,3% (Albania) and 95,5% (North Macedonia) of all considered elements fulfilled 70% target. On the WB6 regional level 117 out of 174 (around 67%) of considered elements fulfilled 70% target, which is around 14% better result than in 2021. If the results for Ukraine and Moldova are added, it would be 55,5% on the EnC level.

Moldovan network is having much better results than Ukraine, with 82,4% of elements fulfilling 70% target on 19 January 2028 at 19:30 h and 47,8% fulfilling it on 19 July 2028 at 19:30 h. In Ukraine 30% of elements in January scenario and 27% in July scenario are getting MACZT values above 70%.

Table 70 Comparison of the level of 70% target fulfillment for considered elements with FB approach on 21 July 2021 at 19:30 h and on 19 July 2028 at 19:30 h

	21 July 2021, 19:30 h		19 July 2028, 19:30 h	
Contracting Party	**Total number of considered elements**	**Total number of elements with MACZT>70%**	**Total number of considered elements**	**Total number of elements with MACZT>70%**
Albania	26	11	30	16
BiH	29	23	19	13
Kosovo*	20	17	21	12
Montenegro	23	13	21	15
North Macedonia	18	14	22	21
Serbia	58	18	61	40
Ukraine			66	18
Moldova			23	11
TOTAL	174	96	263	146

Table 71 The share of considered elements that fulfill 70% target with FB approach on 21 July 2021 at 19:30 h and on 19 July 2028 at 19:30 h

Contracting Party	Share of elements with MACZT>70% on 21 July 2021, 19:30 h	Share of elements with MACZT>70% on 19 July 2028 at 19:30 h
Albania	42,3	53,3
BiH	79,3	68,4
Kosovo*	85,0	57,1
Montenegro	56,5	71,4
North Macedonia	77,8	95,5
Serbia	31,0	65,6
Ukraine	-	27,3
Moldova	-	47,8
TOTAL	**55,2**	**55,5**

The following three figures show the same values in graphical format.

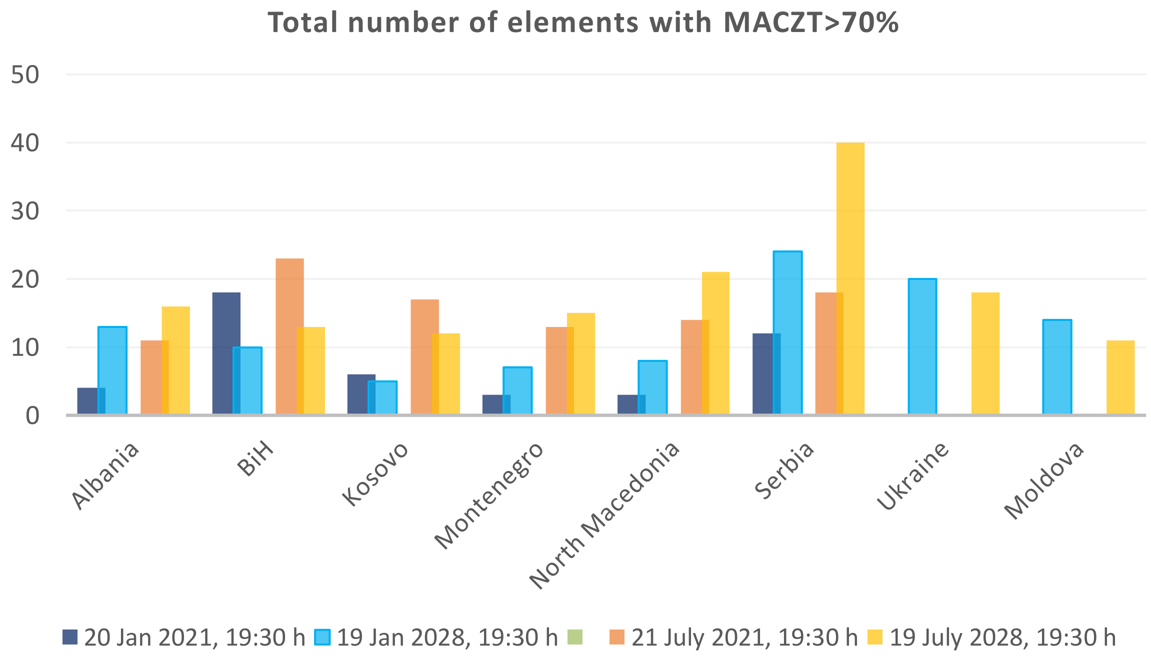


Figure 70 Comparison of total number of elements with MACZT>70% in each Contracting Party

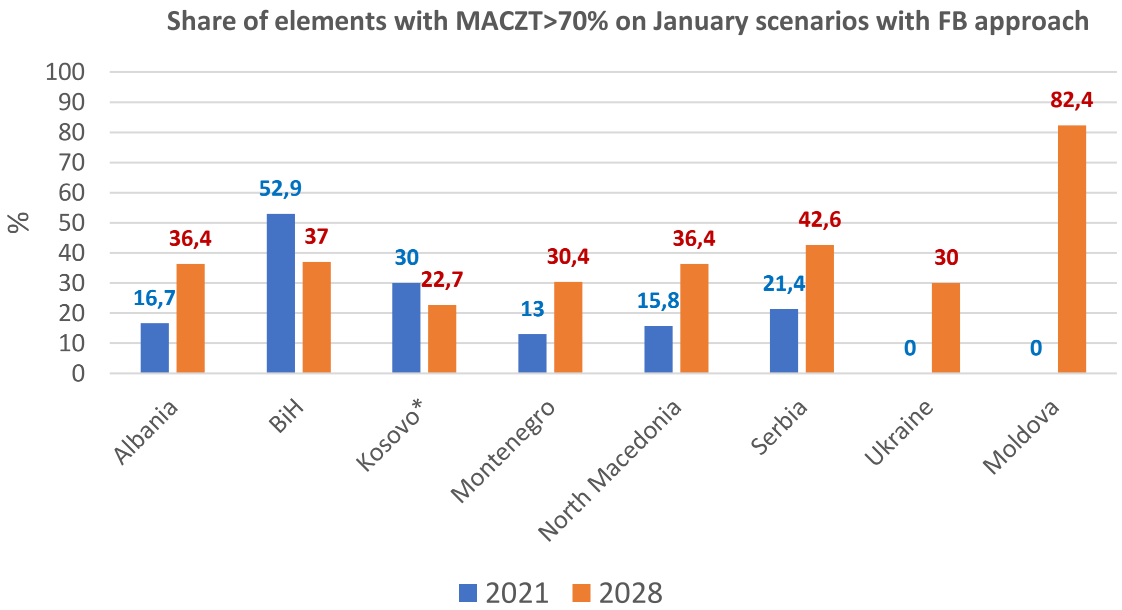


Figure 71 Share of elements with MACZT>70% in each Contracting Party in January scenarios with FB approach

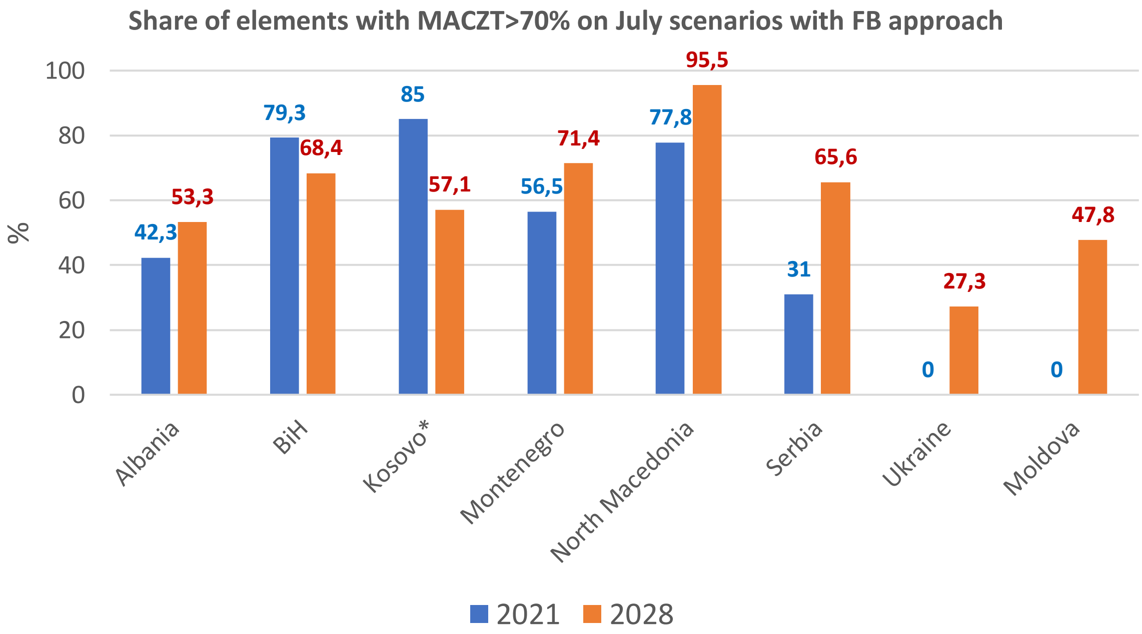


Figure 72 Share of elements with MACZT>70% in each Contracting Party in July scenarios with FB approach

9 IDENTIFICATION OF THE STRUCTURAL CONGESTIONS WITHIN THE POWER TRANSMISSION NETWORKS

In this chapter structural congestions[11] are identified in all observed power systems. Action Plan linear trajectory starting value should be based on 3-years according to Regulation (EU) 2019/943. Therefore, the calculations are done for 3-year timeframe (**2020, 2021 and 2022**) on an hourly basis, covering around 3 x 8 760 h = 26 280 snapshots for every single considered element, using NTC approach.

In total, this identification is based on around 176 considered elements x 26 280 hours = 4 625 280 results. This is a huge collection of findings, which is why consolidated findings for each Contracting Party, including both internal and cross-zonal elements, will be presented in this chapter.

The chapter is conceptually divided into two main parts. The first part gives a general description of the methodology used for structural congestion identification, while the second part gives numerical results on each Contracting Party level.

9.1 Structural congestion identification methodology

The main criterion for structural congestion is based on the EU best practices[12],[13],[14],[15] as follows:

Elements with more than 5% of hours with MACZT value below 70% are considered as elements with structural congestion.

In general, structural congestions are not initially defined in the Action Plans, but in the congestion reports issued by the TSOs and approved by relevant NRAs.

This principle was implemented for all cross-zonal elements and the most critical internal elements according to the MACZT calculation results for 2021.

For illustration, on the following two figures OHL 220 kV Koplik (AL) – Podgorica 1 (ME) fulfilled this criterion for the base case and outage of OHL 220 kV Komani (AL) – V.Deja (AL) in the opposite direction (MACZT values below 70% were detected 3,19% and 2,37% of the hours in 2020, respectively).

[11] Structural congestions may be also identified based on market and network simulations. However, this was not a part of the ToR. This approach was used in Germany where they did network simulations and checked real overloads and not for low MACZT values.
[12] Report on structural congestions, HOPS, September 2021; Structural congestion report, TenneT, November 2019
[13] https://www.acm.nl/sites/default/files/documents/goedkeuring-structurele-congestierapport-tennet-tso-def.pdf
[14] https://www.bmwk.de/Redaktion/EN/Downloads/a/action-plan-bidding-zone.pdf?__blob=publicationFile&v=6
[15] https://news.wko.at/news/oesterreich/action-plan-2020-11-19.pdf

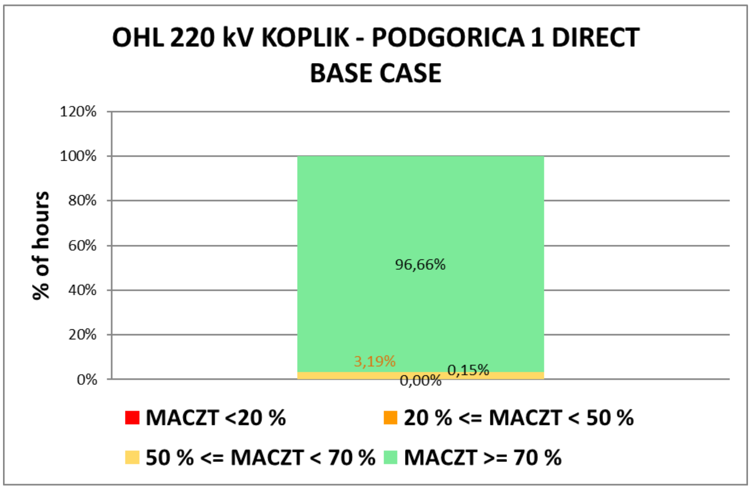


Figure 73 Percentage of hours for each MACZT interval on the OHL 220 kV Koplik – Podgorica 1 (direct) in the base case in 2020

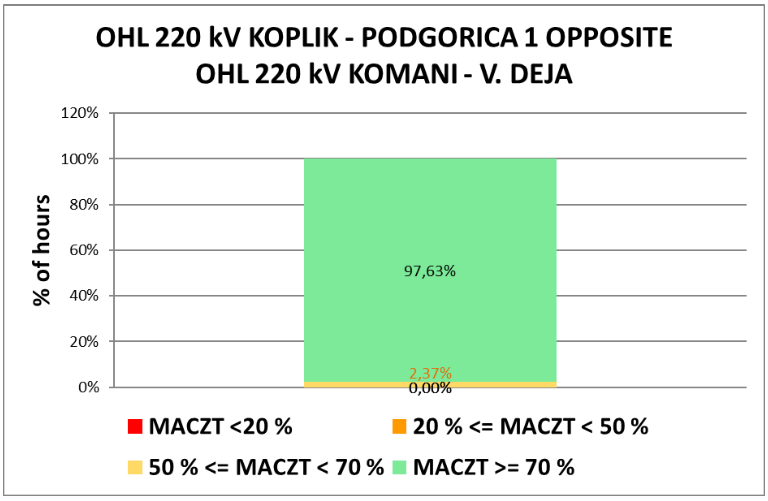


Figure 74 Percentage of hours for each MACZT interval on the OHL 220 kV Koplik – Podgorica 1 (opposite) in the case of OHL 220 kV Komani – V.Deja outage in 2020

However, the same criterion is not fulfilled for outage of OHL 220 kV Komani (AL) – V.Deja (AL) in the direct direction (MACZT values below 70% was detected 21,11% of the hours in 2020), as given on the following figure. Therefore, this element is also considered as the element with structural congestion in 2020.

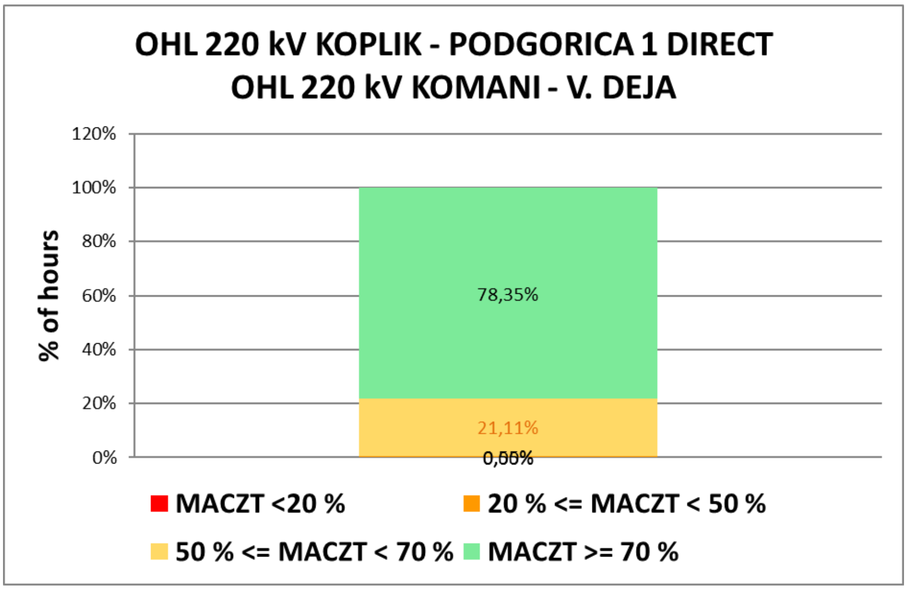


Figure 75 Percentage of hours for each MACZT interval on the OHL 220 kV Koplik – Podgorica 1 (direct) in the case of OHL 220 kV Komani – V.Deja outage in 2020

9.2 Structural congestion calculation results per borders and internal networks

The following three figures present % of time in each MACZT interval for borders and internal networks. Each border consists of all cross-zonal elements on the given border. The results presented for borders were calculated as minimum MACZT in each hour detected on individual border element(s). The same principle is used for internal networks (only the most critical elements were considered).

It is important to note that the scheduled exchange data and NTC values for Kosovo* were available on the ENTSO-e Transparency platform from September 2021 onward. Therefore, the results for Kosovo* borders on the following figures are relevant only for 2022.

The results clearly show that none of these borders and internal networks fulfill 70% target in 2020, 2021 and 2022.

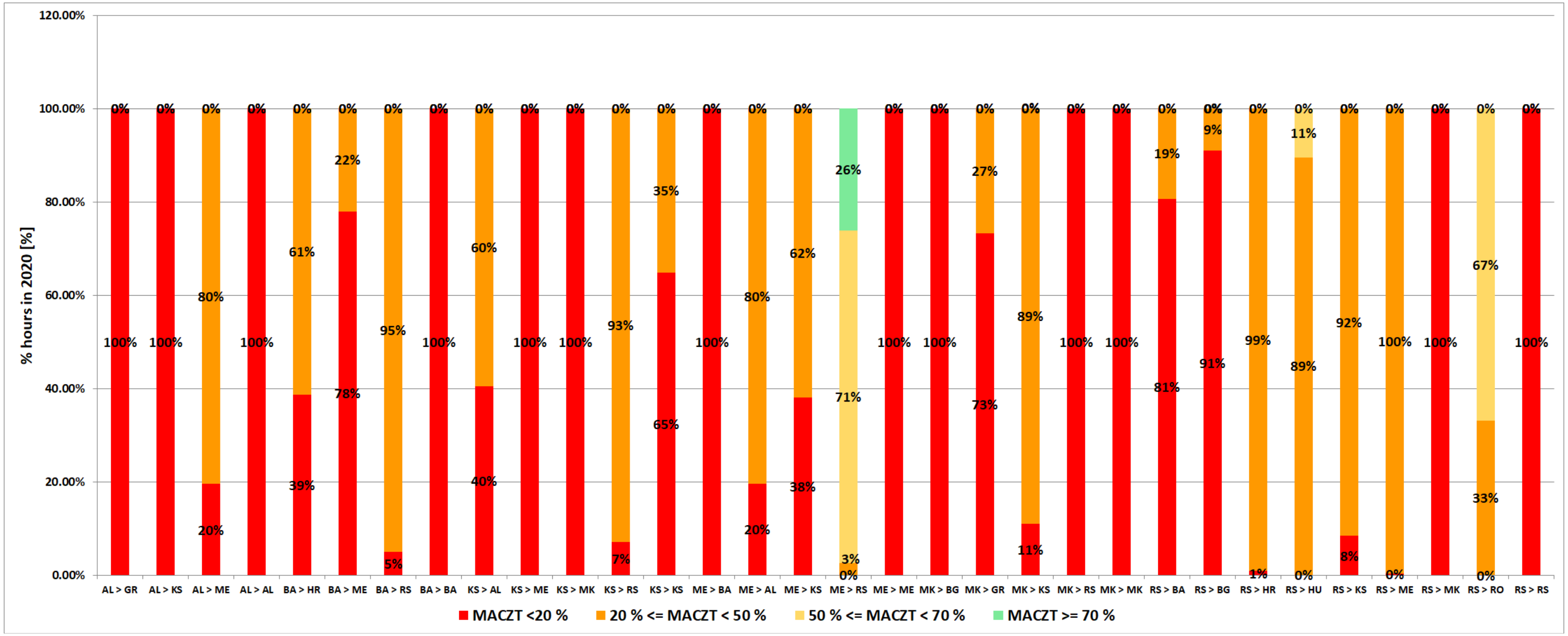


Figure 76 Percentage of time when each MACZT interval was reached in the WB6 in 2020

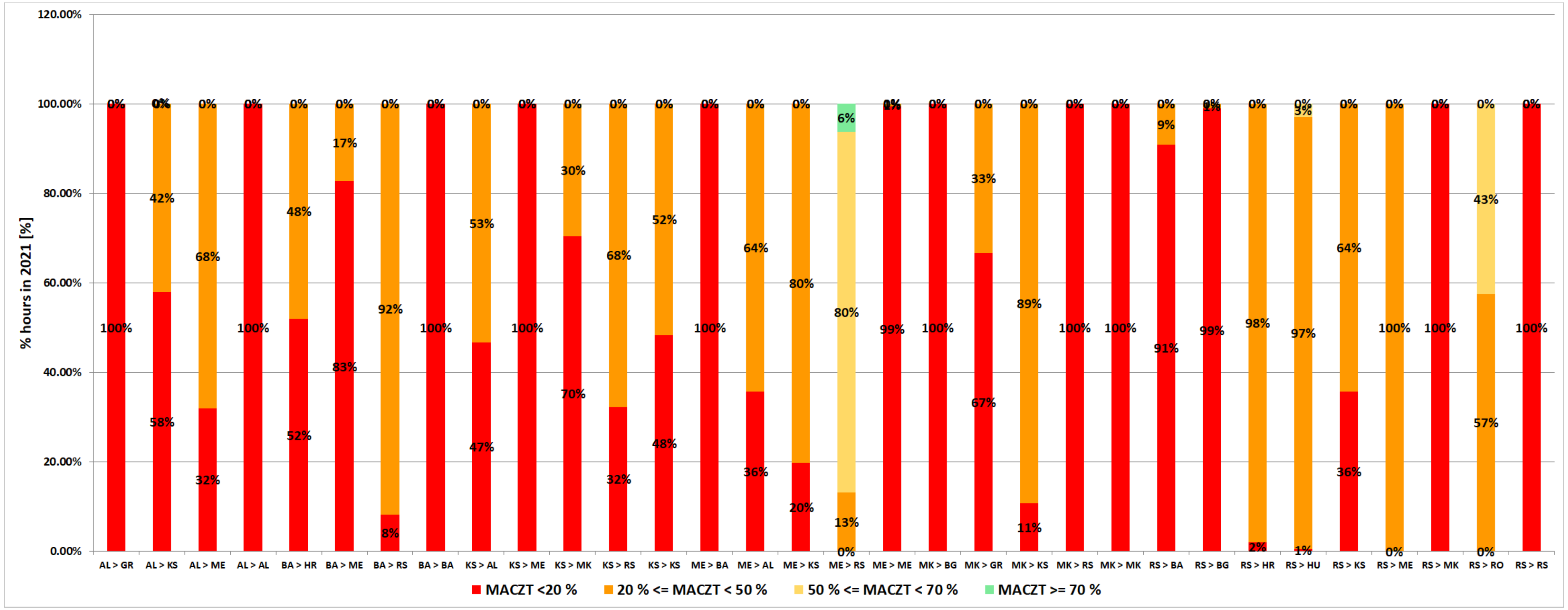


Figure 77 Percentage of time when each MACZT interval was reached in the WB6 in 2021

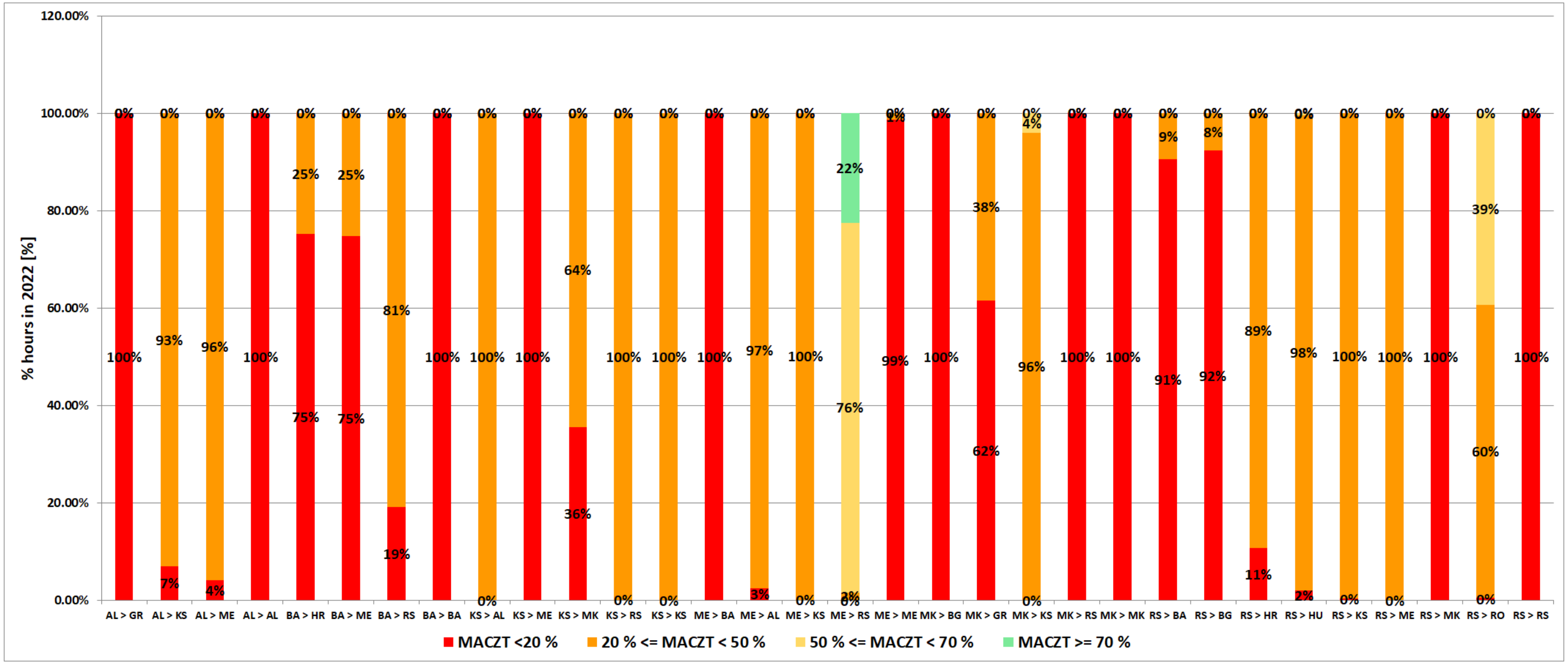


Figure 78 Percentage of time when each MACZT interval was reached in the WB6 **in 2022**

As given on the figures for Shadow SEE CCR in the period 2020 – 2022 only on one border (Montenegro – Serbia) there was a certain time during the year in which MACZT value was above 70%: 26%, 9%, 22% in 2022, 2021 and 2022, respectively. But even these values are far from fulfillment of the 70% target. On all other borders and internal networks MACZT values are dominantly below 50%, in most cases even below 20%.

Comparing Core and Shadow SEE CCR results given on the previous figures, it can be concluded that the results are significantly better in Core CCR, with few exceptions. However, most of Core CCR still didn't reach 70% target.

In the following subchapters for every single Contracting Party CNEC list is given. It consists of all cross-zonal elements and the most critical internal elements. In addition, this list is additionally checked through the questionnaire responses submitted by the relevant TSOs (see Appendix 2).

9.2.1 Albania

List of structural congestion elements identified in Albania is given in the following table. In total 12 structural congestion elements (lines) are detected: 5 on 400 kV voltage level and 7 on 220 kV voltage level. It is important to note that list of calculated minimum MACZT values given for each Contracting Party in the previous chapter 8 is based on one snapshot and not fully comparable with this list, since here the list of elements is created on the three-year hourly timeframe.

Table 72 List of elements with structural congestion in Albanian power system

No	Structural congestion elements in Albania
	400 kV
1	OHL 400 kV ZEMBLAK - KARDIA (GR)
2	OHL 400 kV KOMANI - KOSOVA B (KS)
3	OHL 400 kV TIRANA 2 - PODGORICA 2 (ME)
4	OHL 400 kV TIRANA 2 - ELBASAN 2
5	OHL 400 kV KOMANI - TIRANA 2
	220 kV
6	OHL 220 kV ELBASAN 1 - ELBASAN 2
7	OHL 220 kV TIRANA 2 – COLACEM
8	OHL 220 kV KOMANI – COLACEM
9	OHL 220 kV ELBASAN 1 - ELBASAN 2 2
10	OHL 220 kV TITAN - TIRANA 1
11	OHL 220 kV KOPLIK - PODGORICA 1 (ME)
12	OHL 220 kV FIERZA – PRIZREN (KS)

These elements are also shown graphically on the following figure with bold lines, where red lines represent 400 kV and green lines represent 220 kV.

Figure 79 Structural congestion elements in Albania

9.2.2 Bosnia and Herzegovina

List of structural congestion elements identified in Bosnia and Herzegovina is given in the following table. In total 13 structural congestion elements (lines) are detected: 10 on 400 kV voltage level and 2 on 220 kV voltage level.

Table 73 List of elements with structural congestion in Bosnia and Herzegovina power system

No	Structural congestion elements in BiH
400 kV	
1	OHL 400 kV MOSTAR 4 – KONJSKO (HR)
2	OHL 400 kV TPP UGLJEVIK – ERNESTINOVO (HR)
3	OHL 400 kV TREBINJE – LASTVA (ME)
4	OHL 400 kV TPP UGLJEVIK - S. MITROVICA 2 (RS)
5	OHL 400 kV TPP GACKO - MOSTAR 4
6	OHL 400 kV TPP GACKO – TREBINJE
7	OHL 400 kV VISEGRAD - TUZLA 4
8	OHL 400 kV SARAJEVO 20 - SARAJEVO 10
9	OHL 400 kV SARAJEVO 10 - TUZLA 4
10	OHL 400 kV SARAJEVO 10 - MOSTAR 4
220 kV	
11	OHL 220 kV SARAJEVO 20 - PIVA (ME)
12	OHL 220 kV VISEGRAD - VALJEVO (RS)

These elements are also shown graphically on the following figure with bold lines.

Figure 80 Structural congestion elements in Bosnia and Herzegovina

9.2.3 Kosovo*

List of structural congestion elements identified in Kosovo* is given in the following table. In total 7 structural congestion elements are detected: 4 on 400 kV and 3 on 220 kV voltage level.

Table 74 List of elements with structural congestion in Kosovo* power system

No	Structural congestion elements in Kosovo*
	400 kV
1	OHL 400 kV TPP KOSOVA B - KRAGUJEVAC 2 (RS)
2	OHL 400 kV PEJA 3 - RIBAREVINE (ME)
3	OHL 400 kV FERIZAJ 2 - SKOPJE 5 (MK)
4	OHL 400 kV TPP KOSOVA B - NIS 2 (RS)
	220 kV
5	OHL 220 kV DRENAS 1 - TPP KOSOVA B
6	OHL 220 kV PRIZREN 2 – FIERZA (AL)
7	OHL 220 kV PODUJEVA - KRUSEVAC 1 (RS)

These elements are shown graphically on the following figure with bold lines.

Figure 81 Structural congestion elements in Kosovo*

9.2.4 Montenegro

List of structural congestion elements identified in Montenegro is given in the following table. In total 10 structural congestion elements are detected: 5 on 400 kV and 5 on 220 kV voltage level.

Table 75 List of elements with structural congestion in Montenegro power system

No	Structural congestion elements in Montenegro
400 kV	
1	OHL 400 kV PODGORICA 2 - TIRANA 2 (AL)
2	OHL 400 kV LASTVA - TREBINJE (BIH)
3	OHL 400 kV RIBAREVINE - PEJA 3 (KS)
4	OHL 400 kV LASTVA - PODGORICA 2
5	OHL 400 kV RIBAREVINE - PODGORICA 2
220 kV	
6	OHL 220 kV TPP PLJEVLJA - BAJINA BASTA (RS)
7	OHL 220 kV TPP PLJEVLJA - BISTRICA (RS)
8	OHL 220 kV HPP PERUCICA - TREBINJE (BIH)
9	OHL 220 kV HPP PIVA - SARAJEVO (BIH)
10	OHL 220 kV PODGORICA 1 - V. DEJA (AL)

These elements are shown graphically on the following figure with bold lines.

Figure 82 Structural congestion elements in Montenegro

9.2.5 North Macedonia

List of structural congestion elements identified in North Macedonia is given in the following table. In total 8 structural congestion elements are detected, all on 400 kV voltage level.

Table 76 List of elements with structural congestion in the power system of North Macedonia

No	Structural congestion elements in North Macedonia
	400 kV
1	OHL 400 kV STIP - C. MOGILA (BG)
2	OHL 400 kV BITOLA - LARISA (GR)
3	OHL 400 kV DUBROVO - THESSALONIKI (GR)
4	OHL 400 kV SKOPJE 5 - FERIZAJ 2 (KS)
5	OHL 400 kV BITOLA - SKOPJE 4
6	OHL 400 kV DUBROVO - SKOPJE 4
7	OHL 400 kV STIP - VRANJE 4 (RS)
8	OHL 400 kV BITOLA - DUBROVO
	220 kV

These elements are shown graphically on the following figure with bold lines.

Figure 83 Structural congestion elements in North Macedonia

9.2.6 Serbia

List of structural congestion elements identified in Serbia is given in the following table. In total 29 structural congestion elements are detected: 25 all on 400 kV and 4 on 220 kV voltage level.

Table 77 List of elements with structural congestion in Serbian power system

No	Structural congestion elements in Serbia
	400 kV
1	OHL 400 kV S. MITROVICA 2 - UGLJEVIK (BIH)
2	OHL 400 kV NIS 2 - SOFIA (BG)
3	OHL 400 kV S. MITROVICA - ERNESTINOVO (HR)
4	OHL 400 kV SUBOTICA 3 - SANDORFALVA (HU)
5	OHL 400 kV NIS 2 - KOSOVA B (KS)
6	OHL 400 kV VRANJE 4 - STIP (MK)
7	OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1 (RO)
8	OHL 400 kV VRANJE 4 - LESKOVAC 2
9	OHL 400 kV KRAGUJEVAC 2 - JAGODINA 4

No	Structural congestion elements in Serbia
	400 kV
10	OHL 400 kV JAGODINA 4 - NIS 2
11	OHL 400 kV OBRENOVAC - KRAGUJEVAC 2
12	OHL 400 kV PANCEVO 2 - BEOGRAD 20
13	OHL 400 kV BEOGRAD 8 - BEOGRAD 20
14	OHL 400 kV PANCEVO 2 - WPP CIBUK 1
15	OHL 400 kV WPP CIBUK 1 - DRMNO
16	OHL 400 kV SMEDEREVO 3 - DRMNO
17	OHL 400 kV SMEDEREVO 3 - BEOGRAD 8 2
18	OHL 400 kV HPP DJERDAP 1 - DRMNO
19	OHL 400 kV NIS 2 – LESKOVAC 2
20	OHL 400 kV OBRENOVAC - MLADOST
21	OHL 400 kV OBRENOVAC - MLADOST 2
22	OHL 400 kV BOR 2 - NIS 2
23	OHL 400 kV BOR 2 - HPP DJERDAP 1
24	OHL 400 kV OBRENOVAC - BEOGRAD 8
25	OHL 400 kV DRMNO - TPP DRMNO
	220 kV
26	OHL 220 kV BISTRICA - PLJEVLJA 2 (ME)
27	OHL 220 kV VARDISTE - VISEGRAD (BIH)
28	OHL 220 kV B. BASTA - VALJEVO 3
29	OHL 220 kV KRUSEVAC 1 - PODUJEVO (KS)

The results clearly show that 70% target in 2020, 2021 and 2022 is not fulfilled on some internal and cross-zonal elements in Serbia. These elements are also shown graphically on the following figure with bold lines.

Figure 84 Structural congestion elements in Serbia

9.3 Concluding remarks on structural congestions

Based on the above-mentioned methodology and calculation results the following table recaps the number of all identified structural congestions per each EnC Contracting Party. In total, 81 elements are detected, representing 46% of all considered elements in the region. 38 out of 81 detected elements are located in Serbia, as expected, since Serbian power system is the largest in the region.

Table 78 Total number of identified structural congestions per each Contracting Party

Contracting Party	Total number of considered elements	Total number of identified structural congestions
Albania	24	12
BiH	34	13
Kosovo*	20	7
Montenegro	23	10
North Macedonia	19	8
Serbia	56	31
TOTAL	**176**	**81**

Finally, it can be concluded that with the existing NTC approach and existing network data there's no internal network or border in this region that fulfills 70% target, while almost half of the elements suffer from structural congestions.

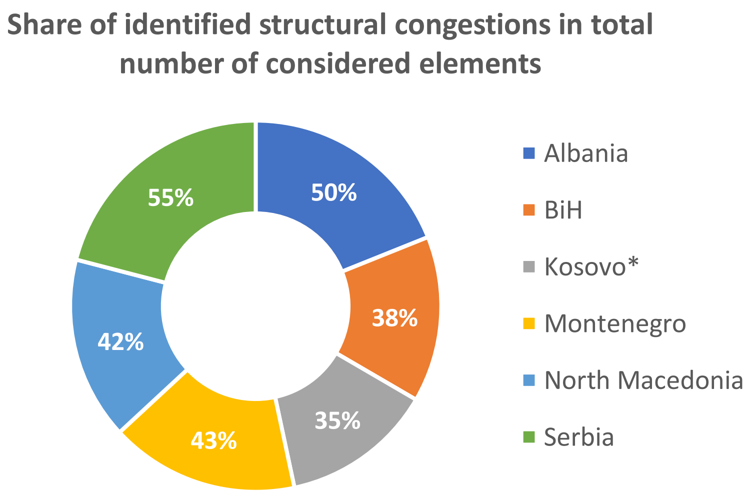


Figure 85 Share of identified structural congestions in total number of considered elements

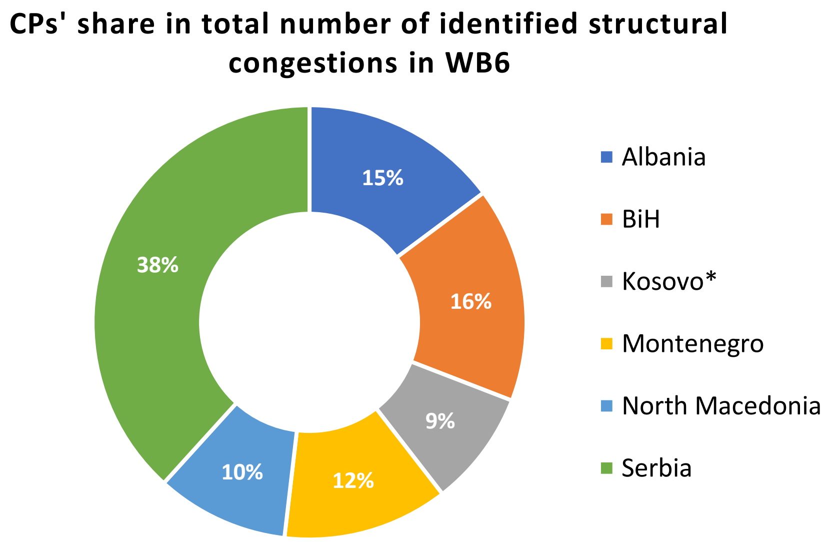


Figure 86 Share of identified structural congestions in total number of considered elements

Even though the WB6 region is very well connected the high number of structural congestions is a consequence of the applied methodology to identify them based on MACZT values and NTC approach calculation, which leads to low values of the calculated MCCC (refer to Eq. 8). Moreover, the used NTC in the calculation is bilateral NTCs (not cNTC), and the coordination area is relatively small (comparing the whole power system model). For grid reinforcement purposes in the action plans we recommend follow-up studies which are based on market and network simulations to **clearly identify structural congestions and to optimize the best grid reinforcements** and other measures to obtain the 70 % target fulfillment. Additionally, for the relevant TSOs a recommendation is to include in the following TYNDPs the identified structural congestions and the level of 70 % target fulfillment.

10 PROPOSAL OF THE ACTIVITIES AND MEASURES IN THE EnC CONTRACTING PARTIES (EXCEPT GEORGIA) AS A BASIS FOR POSSIBLE ACTION PLANS TO FULFIL THE 70% TARGET BY 2028

The actions and measures in the EnC Contracting Parties are proposed in this chapter as a starting point for potential Action Plans to reach the 70% target by 2028. The first part of the Chapter is focused on clarification of the theoretical options to fulfil the target, while in the subchapter 10.4 Action Plan concept for the EnC Contracting Parties is given in more details. The following block-diagram summarizes all steps in the process of 70% target fulfilment.

The activities and measures in the EnC Contracting Parties have to follow the above mentioned procedure. MACZT calculation results presented in Chapter 7 (existing network) have shown that WB6 EnC Contracting Parties are currently quite far from fulfilment of the 70% target. Accordingly, adequate activities and measures need to be taken to reach this target by 2028, respecting the above mentioned procedure. In brief, **Contracting Parties have three basic options to cope with 70% target**:

1. **To prove that 70% target is fully satisfied;**
2. **To request the derogation;**
3. **To prepare and adopt Action Plan.**

An additional theoretical option is bidding zone reconfiguration. However, it is not likely to happen in the short and mid-time frames.

10.1 Proof that 70% target is fully satisfied

If the TSO can prove that 70% target is fully reached and if this proof is based on the adequate calculation methodology and verified input data[16], the process is completed if NRA's monitoring confirms that. TSO should fulfill Regulation (EU) 2019/943 continuously and reports to relevant NRA. Some EU Member States declared full compliance with 70% requirement (Slovenia, France after derogation). **Even though only NRAs can confirm if 70% target is fulfilled, this study shows scenarios in which this is not the case in EnC Contracting Parties** based on the methodology recommended by ACER.

Therefore, after the NRA verifications, probably two other options will remain: derogation or Action Plan. Bidding zones reconfiguration, as an option for addressing structural congestions, is also possible, but not seem realistic in next years due to the complex process which include whole electricity market change in affected EU Member States or EnC Contracting Parties. It is important to note that Action Plans are not needed for derogation decisions. These are two different types of processes/actions. In case of structural congestions (and the respective report approved in a Contracting Party or prepared by ENTSO-E), Contracting Parties need to define Action Plans pursuant to Article 15 of the EnC Regulation (EU) 2019/943. Alternatively, derogations are based on Article 16(9) of the EnC Regulation (EU) 2019/943 and should only deal with problems not related to structural congestions. In practice, it is possible to have derogation in parallel with the action plan if the action plan is still under preparation. The details are given as follows.

[16] Assessment of calculation methodology adequacy and input data verification should be made by relevant NRA

10.2 Derogation

According to Article 16(9) of the EnC Regulation (EU) 2019/943, the TSO may request from the NRA to grant a derogation from the 70% target fulfillment. This request has to be on foreseeable grounds where necessary for maintaining operational security. Along with derogation request, the TSO has to develop and publish a methodology and projects that shall provide a long-term solution to the issue that the derogation seeks to address. Before granting a derogation, the NRA needs to consult the other NRAs from the affected CCR.

Such derogations, which shall not relate to the curtailment of capacities already allocated shall be granted for no more than one-year at a time, or, provided that the extent of the derogation decreases significantly after the first year, up **to a maximum of two years**. The extent of such derogations shall be strictly limited to what is necessary to maintain operational security and they shall avoid discrimination between internal and cross-zonal exchanges. Lot of discussions are still underway about maximum derogation duration and its repetition in the EU.

Unlike the Action Plans, which include measures in mid-term period, derogation can be granted for shorter period (one year with possibility to renew it). The derogation shall expire when the time limit for the derogation is reached or when the solution is applied, whichever is earlier. However, derogation may be granted for no more than one-year at a time, or, provided that the extent of the derogation decreases significantly after the first year, up to a maximum of two years. But, with repetitive derogations the problem of inefficient usage of transmission capacities will not be resolved, especially not till the 31 December 2027 deadline, which is binding upon the Contracting Parties. A long derogation period would result in even more challenging system conditions due to new network users, deviation from the activities and measures in the neighbouring systems, pressure from market participants to increase network capacities etc. Therefore, it is **strongly recommended not to use derogation repetitively**, but, if needed, to use a derogation in one-year timeframe just to adequately prepare, calculate and find solutions to reach the 70% target.

10.3 Action Plan

The common option used around Europe to reach 70% target is preparation of an Action Plan. An Action Plan needs to be prepared pursuant to Article 15 of the EnC Regulation (EU) 2019/943. It should be prepared and approved by the Contracting Party (in other words by the competent ministry in charge with energy), in cooperation with the NRA based on TSO inputs of relevant data. That Action Plan shall contain a concrete timetable for adopting measures to reduce the structural congestions identified within four years of the adoption of the decision. During the action plan implementation, the cross-zonal trade capacity should linearly increase on an annual basis until the minimum capacity (70% target) is reached.

In general, the Action Plan can propose one or more of the following activities from these two sets:

1. **Power network investments (reinforcements, constructing new lines, improve operation of existing network, optimizations of system operation etc.)**

2. **Improvements concerning congestion management (capacity methodology calculation approach improvements, coordination of remedial measures, redispatching, countertrading etc.)**

Long-term structural congestions identified by the TSO and reported to the NRA are the basis for the Action Plan. Action Plan can be prepared on the national or even regional (multinational) level to better address congestion issues. Proposed measures and activities in the Action Plan should cover the following three most important pillars:

- Optimal techno-economic solution, without jeopardising market liquidity
- Precise adoption and implementation schedule
- Definition of the starting MACZT value and linear trajectory through the implementation period in which the 70% target will be fully reached.

Member States and Contracting Parties have an opportunity to choose between using remedial actions (in order to create different flow structure, i.e., decrease amount of internal and loop flows on cross border elements) and/or reconfiguration of the network (reinforcements of existing elements or construction of new elements). Addressing congestion through remedial actions is on Contracting Parties and they bear the costs of those activities. They are fully independent to choose the measures that are the best option for their system. However, some of the measures might have significant impact on the neighbouring systems (new internal line, phase-shifting transformers, etc.) and some of them cannot be implemented without coordination between neighbouring TSOs (new cross-zonal line, coordinated capacity calculation). For these reasons, **joint consideration of the measures between relevant TSOs is strongly encouraged**.

In Chapter 9 structural congestions are identified in the WB6 Contracting Parties. This is the first precondition and the baseline for the action plan preparation. This study shows that structural congestions are detected in all WB6 Contracting Parties based on defined criterion, so the primary condition for Action Plan preparation is theoretically fulfilled. However, it is important to note that structural congestions are formally identified through structural congestion report prepared by the TSO and approved by the NRA. There is no EU harmonized rule or template about it, so this study is not a formal identification of the structural congestions, but just a showcase.

In this chapter possible actions that may be included in the Action Plan are provided. Each Contracting Party has some local specifics, different number of elements affected by the structural congestions, geographical distribution and neighbouring systems' contribution to the structural congestions, individual Action Plans are quite different and cannot be transposed from one system to another.

Nevertheless, general concept of the Action Plan can be shaped, as defined by the Regulation (EU) 2019/943, but also in line with the best practice the EU Member States that already adopted their Action Plans [6], [38], [39], [40], [41], [42], [43].

General structure of the Action Plan consists of the following topics:

- Introduction
- Legal background and decision on adoption of the Action Plan

- Starting point calculation results and linear trajectory
- Measures to reduce structural congestions
- Supervision and Action Plan implementation monitoring
- Appendix – concrete list of activities.

More details are given in the following subchapters.

10.3.1 Introduction and/or Summary

An Action Plan should begin with Introduction and/or summary chapter(s). A short overview of the CEP and energy transition in the Contracting Party may be included. Also, the commitment to a new decarbonized vision of Europe should also be clearly indicated. Short comments on the motivation for Action Plan adoption, besides the objectives of the EnC Regulation (EU) 2019/943, may also be given, such as:

- Advantages of the open electricity market approach in power trade (as opposed to the regulated one)
- Ensuring transparency and non-discriminatory approach to all market participants
- Encouraging the development of technologies and RES investments
- Social welfare aspects
- Cross-border cooperation for power system reliability increase, etc.

10.3.2 Legal background and decision on adoption of the Action Plan

An Action Plan should give legal background, including the EnC Regulation (EU) 2019/943, the CACM GL, the ACER's decisions and recommendation, the NRA decisions related to the EnC Regulation (EU) 2019/943 implementation, such as congestion report approval (Articles 14 – 16 of the EnC Regulation (EU) 2019/943) and other relevant documents.

In line with Article 15 of the EnC Regulation (EU) 2019/943, the first step for the TSO is to prove the existence of structural congestion in the transmission network, if not been already proven by the ENTSO-E. In that case, the TSO prepares **structural congestion report** and submits it to the NRA for approval. The next step for the TSO is **Action Plan preparation**, which is then sent to the NRA and finally to the ministry/Government for approval and publishing.

To recap, if the TSO can prove the existence of structural congestion in the transmission network, in line with Article 15 of the EnC Regulation (EU) 2019/943, the Contracting Party is supposed to publish an Action Plan. That means that the relevant TSO should create structural congestion report and submit it to the NRA. Only if the NRA approves the report and the TSO may suggest adoption of the action plan. Their draft should be prepared by the Contracting Party, given on public consultation and finally approved and published.

10.3.3 Starting point and linear trajectory

In the case of structural congestions in its power system, the Contracting Party shall ensure the cross-zonal trade capacity is increased on an annual basis until 70% target is reached. The method of minimum capacity increase is strictly prescribed in Article 15(2) of the EnC Regulation (EU) 2019/943 as follows:

Those annual increases shall be achieved by means of a linear trajectory. The starting point of that trajectory shall be either the capacity allocated at the border or on a critical network element ***in the year before adoption of the Action Plan*** *or the* ***average during the three years*** *before adoption of the Action Plan, whichever is higher.*

As Article 15(2) of the EnC Regulation (EU) 2019/943 refers to allocated capacities, the starting point has to be calculated on the basis of the cross-zonal schedules for **every single market time unit (hour)**.

The starting point of the linear trajectory depends on the capacity allocated on each CNE(C) in the calculated period. In accordance with the current practice in EnC, structural congestion calculations and starting point calculation are **based on the NTC approach** of capacity calculation methodology. The starting point may be defined separately for each CNE(C) or for the whole power system (bidding zone) [38].

The power systems in the Contracting Parties are of relatively **small size** and **strongly interconnected**. Hence the CNE(C) utilisation in Contracting Parties is much more dependent on the neighbouring systems than it is the case in most of EU Member States. Due to these interdependencies and in order to avoid complex and confusing application of a multiple linear trajectories, both during the capacity calculation processes and ex-post, **it is recommended to use one starting value for all CNE(C)s**. This simplified approach with one starting value increases the trajectory transparency and its monitoring. Therefore, it is recommended to be used in the EnC Contracting Parties.

The starting value is defined as the highest of the following three values:

1. Average capacity allocated at the border or on a critical network element **for one year timeframe** before the adoption of the Action Plan OR
2. Average capacity allocated at the border or on a critical network element **during three years** before the adoption of the Action Plan OR
3. **20%** of thermal capacity of each CNE(C).

In other words, if the lowest calculated MACZT value is below 20%, then starting value is set to 20%, as prescribed in the Regulation (EU) 2019/943 and ACER Decision [7].

Examples of linear trajectory included in the EU Member States' Action Plans are given in the following table [38] – [42].

Table 79 Linear trajectory defined in EU Member States' Action Plans

	Border or CNE(C)	Year					
		Starting value	2022	2023	2024	2025	2026
Croatia	HR – Core CCR	20,4	20,4	32,8	45,2	57,6	70,0
Austria	CWE	20,0	28,7	39,0	49,4	59,7	70,0
	AT-CZ	18,4					
	AT-HU						
	AT-SI						
	Italy North						
Hungary	Oroszlány–Dunamenti	25,0	25,0	36,25	47,50	58,75	70,0
	Oroszlány–Győr	25,0	25,0	36,25	47,50	58,75	70,0
	Győr-Neusiedl	25,0	25,0	36,25	47,50	58,75	70,0
	Győr-Vienna	25,0	25,0	36,25	47,50	58,75	70,0
	Paks–Sándorfalva	33,0	33,0	42,25	51,50	60,75	70,0
The Netherlands (only extract)	DTC-NDR380	60,0	62,0	64,0	66,0	68,0	70,0
	GNA-HGL380	44,0	49,0	54,0	60,0	65,0	70,0
	MBT-OBZ380	36,0	43,0	50,0	57,0	63,0	70,0
	MBT-SDF380	46,0	50,0	55,0	60,0	65,0	70,0
	MBT-VYK380	36,0	43,0	50,0	57,0	63,0	70,0
	MEE-DIL380	28,0	37,0	45,0	53,0	62,0	70,0
	BKK-DIM380	28,0	37,0	45,0	53,0	62,0	70,0
Poland	SE4-PL	45,0	50,0	55,0	60,0	65,0	70,0
	LT-PL	70,0	70,0	70,0	70,0	70,0	70,0

Romania adopted linear trajectory in MW of total thermal capacity on the borders to Hungary (Core CCR) and Bulgaria (SEE CCR). Germany published all relevant information for the starting value calculation and calculation of the linear trajectory and made it transparent by the German NRA and TSOs (links available in the Action Plan).

10.3.4 Measures to reduce structural congestions

Pursuant to Article 15(1) of the EnC Regulation (EU) 2019/943, the Action Plan contains a concrete timetable for adopting measures to reduce identified structural congestion. These measures include, but are not limited to:

- Investments in the network topology and operation
  - Network development and optimisation
  - Network expansion

- Improvements concerning congestion management

- Coordinated capacity calculations
- Network reserves for redispatching purposes
- Coordination of remedial measures.

These investments and improvements are supposed to be listed in the TYNDP. The TYNDP is an annual or biannual document which includes all investments in power transmission system. TSO proposes network development and enforcement to increase reliability of the system operation and investors request connections of power generation modules, demand or storage systems. A new aspect of TYNDP is the requirement regarding the 70% from the EnC Regulation (EU) 2019/943 requirement. The TYNDP is supposed to intend to increase transmission capacity, to reduce grid congestions and to facilitate development goal achievement. The measures to achieve these goals include strengthening and optimisation of the existing network and development of the new infrastructure.

Possible options for **development and optimisation** of power transmission network include:

- Construction of new network elements
- Transmission capacity upgrade
    - Changes in construction elements (increase conductor cross-section)
    - Using of smart metering systems (dynamic thermal rating - DTR)
    - Using of new materials (high temperature low sag - HTLS)
    - Upgrading voltage level of the transmission network elements
- Installation of highly controllable elements for power flow redirection
- Using the power system optimization models to optimize grid topology (i.e., remedial actions optimization),
- Other measures in coordination with neighbouring TSOs.

Construction of the new transmission line is usually a very challenging and time-consuming process. So, the first option for TSOs is consideration of existing network optimization and upgrade. In most cases these optimization measures can be implemented with reasonable efforts and relatively fast. Now, 70% target is an important trigger to start changes quickly, using common power grid models, both on the regional and synchronous zone level. For evaluation of the TYNDP solutions, the appropriate and harmonized approach to MACZT calculation is needed. The target cannot be reached without close cooperation between all TSOs in CCR which include coordination of optimizing measures on the region level and implementation of efficient capacity calculation methodology.

Improvements concerning congestion management imply implementation of congestion management methods according to the EU Regulations. According to CACM GL, coordinated capacity calculation has either to follow FB or coordinated NTC approach.
FB approach Is defined as default, but TSOs in CCR may jointly request the competent regulatory authorities to apply the coordinated NTC approach in region if the TSOs concerned are able to demonstrate that the application of the capacity calculation methodology using the FB approach would not yet be more efficient compared to the coordinated net transmission capacity approach and assuming the same level of operational security in the concerned region. Unilateral and bilateral NTC approaches are not acceptable and must be replaced with coordinated calculations as soon as the technical prerequisites are acquired. One of the main reasons for the low MACZT values obtained and presented in this study is inadequate approach to cross-zonal capacity availability.

Results of MACZT presented in this study case have shown advantages of FB approach. Most of the EU CCR adopted coordinated capacity calculation based on the grid model, forecasted exchanges and day-ahead limitations in the power grid. A coordinated approach to capacity calculation within a Shadow SEE and EE CCRs, which is already a legally obligation binding for the Contracting Parties, is expected to provide the following advantages over the currently applied approach, when calculating cross-zonal capacities [38]:

- Common forecast and, with that, a harmonised assumption
- Computation of cross-zonal capacities based on a CMG and
- Coordination of remedial actions in order to maximise cross-zonal capacities while maintaining secure network operation.

Operationalisation of all European power systems in CCRs, including the EnC CCRs established by Ministerial Council Decision, and coordinated capacity calculation would further reduce uncertainties in the capacity calculation process by expanding the regional scope of the capacity calculation processes. Above-mentioned improvement in the coordination of cross-border capacity calculations are expected to reduce uncertainties and lead to more precise determination and allocation of available cross-zonal capacities, optimizing overall process and, consequently, allowing to increase the capacity made available for cross-zonal trade, while always maintaining secure operation of the electricity system [38].

Remedial actions available to the TSOs are:

- Power shifting transformers tap changes
- Changes of network topology
- Redispatching
- Countertrading.

All remedial actions aimed at reducing congestion must be carried out, primarily taking into account power system security. Some remedial actions have no financial effect and can be used without limit, while redispatching, as the most efficient measure, has direct financial consequences caused by reduced production or energy consumption and must therefore be carefully planned and implemented. However, more significant usage of redispatching as an essential measure for achieving the 70% target can be expected in the period until all necessary network expansions and reinforcements are executed [39].

Similar to the implementation of the coordinated capacity calculation, the basic advantages of a coordinated approach to the implementation of remedial measures include [39]:

- Common input data for the coordinated capacity calculation
- Identification of congestions in the common network model
- Optimisation and coordination of remedial measures to mitigate congestions throughout the region.

10.3.5 Supervision and Action Plan implementation monitoring

Pursuant to Article 15(4) of the EnC Regulation (EU) 2019/943, during the implementation of the Action Plan and within six months after its expiry, the TSO assesses each year for the preceding 12 months whether the available cross-zonal capacity has reached the linear trajectory or whether, starting on 1 January 2026 in the EU Member States and 1 January 2028 in the EnC Contracting Parties, the minimum capacities envisaged in Article 16(8) of the Regulation (EU) 2019/943 have been achieved. Accordingly, the TSOs are required to submit a report on the assessment of the achieved minimum capacities firstly to the NRA for approval, and then to the ECRB.

The relevant NRA and the ministry in charge with energy shall agree the reporting submission dynamics and procedures for approval. The Ministry may invite the stakeholders to report more details and propose possible steps required to comply with the linear trajectory and the provisions from the Regulation (EU) 2019/943

10.4 Action Plan concept for the EnC Contracting Parties

Before going into the Action Plan concept for the EnC Contracting Parties, it is necessary to recap the calculation results. The following table shows total number of identified structural congestions, based on the methodology of 5% of MACZT < 70%, per each WB6 Contracting Party on 400 kV and 220 kV voltage level.

Table 80 Total number of identified structural congestions in WB6 Contracting Parties

No of structural congestions	Albania	BiH	Kosovo*	Montenegro	North Macedonia	Serbia	TOTAL
400 kV	5	10	4	5	8	25	57
220 kV	7	2	3	5	0	4	21
TOTAL	**12**	**12**	**7**	**10**	**8**	**29**	**78**

In the WB6 Contracting Parties there are 78 identified structural congestions in total, in line with the methodology used. Most of them (57 or 73%) are detected on 400 kV voltage level, while remaining 21 are in 220 kV network. As expected, due to its largest size, in the Serbian system by using described methodology there are 29 (or 37% of total) structural congestions detected, dominantly in 400 kV network. The lower number of structural congestions is identified in Kosovo* (7) and North Macedonia (8).

The following table shows identified individual elements detected as structural congestions in each WB6 Contracting Party on 400 kV and 220 kV voltage level. Around half of all structural congestions (40 out of 78) are detected on cross-border lines. So, it can be concluded that around **half of the structural congestions in WB6 is identified to internal networks, while remaining half on the interconnections**.

The following figure shows geographical positions of all structural congestions in the region.

Table 81 Structural congestion elements identified in WB6 Contracting Parties

No	Structural congestion elements in Albania
	400 kV
1	OHL 400 kV ZEMBLAK - KARDIA (GR)
2	OHL 400 kV KOMANI - KOSOVA B (KS)
3	OHL 400 kV TIRANA 2 - PODGORICA 2 (ME)
4	OHL 400 kV TIRANA 2 - ELBASAN 2
5	OHL 400 kV KOMANI - TIRANA 2
	220 kV
6	OHL 220 kV ELBASAN 1 - ELBASAN 2
7	OHL 220 kV TIRANA 2 – COLACEM
8	OHL 220 kV KOMANI – COLACEM
9	OHL 220 kV ELBASAN 1 - ELBASAN 2 2
10	OHL 220 kV TITAN - TIRANA 1
11	OHL 220 kV KOPLIK - PODGORICA 1 (ME)
12	OHL 220 kV FIERZA – PRIZREN (KS)

No	Structural congestion elements in BiH
	400 kV
1	OHL 400 kV MOSTAR 4 – KONJSKO (HR)
2	OHL 400 kV TPP UGLJEVIK – ERNESTINOVO (HR)
3	OHL 400 kV TREBINJE – LASTVA (ME)
4	OHL 400 kV TPP UGLJEVIK - S. MITROVICA 2 (RS)
5	OHL 400 kV TPP GACKO - MOSTAR 4
6	OHL 400 kV TPP GACKO – TREBINJE
7	OHL 400 kV VISEGRAD - TUZLA 4
8	OHL 400 kV SARAJEVO 20 - SARAJEVO 10
9	OHL 400 kV SARAJEVO 10 - TUZLA 4
10	OHL 400 kV SARAJEVO 10 - MOSTAR 4
	220 kV
11	OHL 220 kV SARAJEVO 20 - PIVA (ME)
12	OHL 220 kV VISEGRAD - VALJEVO (RS)

No	Structural congestion elements in Montenegro
	400 kV
1	OHL 400 kV PODGORICA 2 - TIRANA 2 (AL)
2	OHL 400 kV LASTVA - TREBINJE (BIH)
3	OHL 400 kV RIBAREVINE - PEJA 3 (KS)
4	OHL 400 kV LASTVA - PODGORICA 2
5	OHL 400 kV RIBAREVINE - PODGORICA 2
	220 kV
6	OHL 220 kV TPP PLJEVLJA - BAJINA BASTA (RS)
7	OHL 220 kV TPP PLJEVLJA - BISTRICA (RS)
8	OHL 220 kV HPP PERUCICA - TREBINJE (BIH)
9	OHL 220 kV HPP PIVA - SARAJEVO (BIH)
10	OHL 220 kV PODGORICA 1 - V. DEJA (AL)

No	Structural congestion elements in Serbia
	400 kV
1	OHL 400 kV S. MITROVICA 2 - UGLJEVIK (BIH)
2	OHL 400 kV NIS 2 - SOFIA (BG)
3	OHL 400 kV S. MITROVICA - ERNESTINOVO (HR)
4	OHL 400 kV SUBOTICA 3 - SANDORFALVA (HU)
5	OHL 400 kV NIS 2 - KOSOVA B (KS)
6	OHL 400 kV VRANJE 4 - STIP (MK)
7	OHL 400 kV HPP DJERDAP 1 - PORTILE DE FIER 1 (RO)
8	OHL 400 kV VRANJE 4 - LESKOVAC 2
9	OHL 400 kV KRAGUJEVAC 2 - JAGODINA 4
10	OHL 400 kV JAGODINA 4 - NIS 2
11	OHL 400 kV OBRENOVAC - KRAGUJEVAC 2
12	OHL 400 kV PANCEVO 2 - BEOGRAD 20
13	OHL 400 kV BEOGRAD 8 - BEOGRAD 20
14	OHL 400 kV PANCEVO 2 - WPP CIBUK 1
15	OHL 400 kV WPP CIBUK 1 - DRMNO
16	OHL 400 kV SMEDEREVO 3 - DRMNO
17	OHL 400 kV SMEDEREVO 3 - BEOGRAD 8 2
18	OHL 400 kV HPP DJERDAP 1 - DRMNO
19	OHL 400 kV NIS 2 – LESKOVAC 2
20	OHL 400 kV OBRENOVAC - MLADOST
21	OHL 400 kV OBRENOVAC - MLADOST 2
22	OHL 400 kV BOR 2 - NIS 2
23	OHL 400 kV BOR 2 - HPP DJERDAP 1
24	OHL 400 kV OBRENOVAC - BEOGRAD 8
25	OHL 400 kV DRMNO - TPP DRMNO
	220 kV
26	OHL 220 kV BISTRICA - PLJEVLJA 2 (ME)
27	OHL 220 kV VARDISTE - VISEGRAD (BIH)
28	OHL 220 kV B. BASTA - VALJEVO 3
29	OHL 220 kV KRUSEVAC 1 - PODUJEVO (KS)

No	Structural congestion elements in N.Macedonia
	400 kV
1	OHL 400 kV STIP - C. MOGILA (BG)
2	OHL 400 kV BITOLA - LARISA (GR)
3	OHL 400 kV DUBROVO - THESSALONIKI (GR)
4	OHL 400 kV SKOPJE 5 - FERIZAJ 2 (KS)
5	OHL 400 kV BITOLA - SKOPJE 4
6	OHL 400 kV DUBROVO - SKOPJE 4
7	OHL 400 kV STIP - VRANJE (RS)
8	OHL 400 kV BITOLA - DUBROVO

No	Structural congestion elements in Kosovo
	400 kV
1	OHL 400 kV TPP KOSOVA B - KRAGUJEVAC 2 (RS)
2	OHL 400 kV PEJA 3 - RIBAREVINE (ME)
3	OHL 400 kV FERIZAJ 2 - SKOPJE 5 (MK)
4	OHL 400 kV TPP KOSOVA B - NIS 2 (RS)
	220 kV
5	OHL 220 kV DRENAS 1 - TPP KOSOVA B
6	OHL 220 kV PRIZREN 2 – FIERZA (AL)
7	OHL 220 kV PODUJEVA - KRUSEVAC 1 (RS)

Figure 87 Geographical positions of all structural congestions in the region

Along with the structural congestions as an important component in the decision to create an Action Plan, it is important to consider how measures foreseen in the TYNDP affect MACZT value. In chapter 8 the comparison of the level of 70% target fulfilment is presented. In most of the EnC Contracting Parties the number of elements with MACZT value higher than 70% increases in 2028 models. In Table 69 and Table 71 the share of considered elements that fulfil 70% target is presented. The improvements are clear in all WB6 Contracting Parties except Bosnia and Herzegovina and Kosovo*.

All measures previously mentioned in chapter 10.3 may be included in Action Plan of each EnC Contracting Party. Even though measures should be implemented individually, it is very important for small, well-connected systems in this CCR to coordinate it in advance. **One of the crucial measures that should be implemented by all TSOs in CCR is coordinated capacity calculation**. It assumes operationalisation of the CCRs in WB6 and EE. Coordinated NTC approach or FB approach would increase existing MACZT values on bidding zones borders. NRAs will decide on it, but common calculation and capacity allocation is the only way to ensure more capacity on cross zonal lines for market participants.

To recap, regarding fulfilment of 70% target in all Contracting Parties it can be concluded that[17]:

- Operationalization of the coordinated capacity region in WB6 and EE would increase existing MACZT values,
- Construction of new OHLs enables each TSO to get closer to the target
- Reinforcement (nominal capacity increase) of the existing 220 kV network should also be carefully considered
- Coordinated capacity calculation and allocation should be implemented in the whole Shadow SEE and Eastern Europe CCRs
- TSO should consider new technologies to increase power capacity of existing lines (smart metering systems, dynamic thermal rating etc.)
- Remedial actions (power flow control, network topology optimization, redispatching, countertrading) should also be considered to improve system security.

Each EnC Contracting Party has a specific need regarding network developments, especially under current rapid and growing RES grid connection requirement. So, the measures that will be taken to fulfil 70% have to be carefully selected and fit in the individual network development plan and needs. This study gives few specific proposals based on given calculations. However, before an Action Plan is drafted each EnC Contracting Party should perform more detailed and comprehensive calculations with more scenarios and input data.

In the following subchapters main findings on the: 1) level of structural congestions, 2) development plan impact and 3) system specifics are given for each Contracting Party.

[17] The proposed actions are not listed on the basis of priority and whether one or another action will be taken depends on the specificities of each Contracting Party.

10.4.1 Albania

Structural congestions based on criterion defined in Chapter 9 are detected in Albanian power transmission system on 5 OHLs 400 kV and 7 OHL 220 kV.

Until 2028, 2 new OHL 400 kV (Elbasan - Ohrid (MK) – Bitola (MK) and Elbasan 2 - Fier) and 2 new OHL 220 kV (Fier - TPP Vlore and Tirana 2 – Rrashbull) are planned and therefore modelled for MACZT calculation in 2028.

Consequently, significant improvement in share of elements with MACZT>70% is found. In scenario of 20 January 2021 at 19:30 h only 16,7% elements fulfilled 70% requirements, while 36,4% fulfilled it in January 2028 scenario. In July scenarios, rapid improvement is detected, from 42,3% (21 July 2021, 19:30 h) to 53,3% (19 July 2028, 19:30 h). Those findings indicate that planned construction of new OHLs significantly improve MACZT values.

Special attention in Albanian network topology should be devoted to OHLs 220 kV. Reinforcement of these lines or even voltage level upgrade should also have favourable effects on 70% target fulfilment.

10.4.2 Bosnia and Herzegovina

Structural congestions based on criterion defined in Chapter 9 are detected in the power transmission system of Bosnia and Herzegovina on 10 OHLs 400 kV and 2 OHLs 220 kV.

Until 2028, no new internal OHLs 220 kV or 400 kV are planned, while only one cross zonal OHL 400 kV Višegrad – Bajina Bašta (RS) is to be constructed.

In Bosnia and Herzegovina significant decrease in 70% target fulfilment is detected: from 52,9% to 37,0% in January 2021 and 2028, respectively, and from 79,3% to 68,4% in July 2021 and 2028. This is clear indication that lack of transmission network investments and other measures in the next few years would result with unfavourable and even lower MACZT values.

It is strongly recommended to modify network development plan in Bosnia and Herzegovina by adding appropriate network investments targeted to increase cross-border capacities to the neighbouring countries. TSO needs to accelerate network construction, reinforcement activities and efficiently use transmission capacities to enable enough capacity for all market participants.

10.4.3 Kosovo*

Structural congestions based on criterion defined in Chapter 9 are detected in Kosovo*, too. In total, there are 4 OHLs 400 kV and 3 OHLs 220 kV identified as structural congestions.

Until 2028, no new 220 kV or 400 kV internal OHLs are found in network development plan and only one interpolation of SS Malisheva (220 kV switchgear) has been planned.

Consequently, and similar to Bosnia and Herzegovina, in Kosovo* significant decrease in 70% target fulfilment is detected in both scenarios: from 30,0% to 22,7% in January 2021 and January 2028, respectively and from 85,0% to 57,1% in July 2021 and July 2028, respectively.

Power system models for 2028 assume a large increase of RES capacities all around the region. To accommodate all RES capacities and enable enough capacity for all market participants in the next couple years, it is strongly recommended to adequately upgrade network development plan targeted to increase cross-border capacities.

10.4.4 Montenegro

Structural congestions based on criterion defined in Chapter 9 are identified in Montenegro on 5 OHLs 400 kV and 5 OHLs 220 kV.

Unlike previous cases, network development plan in Montenegro is very ambitious. Until 2028, several new 400 kV OHLs are foreseen in network development plan. For such a small power system, this network capacity increase on 400 kV level is really a tectonic improvement.

The effects of very ambitious network development plan are clearly seen on MACZT results. MACZT values will grow from 13,0% in January 2021 to 30,4% in January 2028 and from 56,5% in July 2021 to 71,4% in July 2028.

With new OHLs planned until 2028 Montenegro will be able to reconfigure transmission network, chose more remedial actions and to decrease structural congestions. However, implementation of this ambitious plan should be monitored.

10.4.5 North Macedonia

In the power transmission system of North Macedonia, structural congestions based on criterion defined in Chapter 9 are detected on 8 OHLs, all on 400 kV voltage level.

Until 2028 two new 400 kV OHLs are identified for construction in the network development plan: internal OHL 400 kV Bitola 2 – Ohrid and cross-zonal OHL 400 kV Ohrid – Elbasan 2 (AL).

Simulations show significant improvement in MACZT values: from 13,0% in January 2021 to 30,4% in January 2028 scenario and in July from 77,8% in 2021 to 95,5% in 2028 scenario.

With the planned new OHLs North Macedonia will be very close to fully comply with 70% requirement. In 2028 scenarios, most of the OHLs fulfill the target while the power transformers have low values of MACZT. Therefore, the TSO should pay attention to power transformers and take measures to increase MACZT on those elements (increase nominal power or run power transformers in parallel operation). Some remedial actions (such as redispatching) may also be needed so it is recommended to introduce high level of system monitoring to enable adequate and timely actions to fully reach 70% target.

10.4.6 Serbia

In Serbia structural congestions based on criterion defined in Chapter 9 are detected on 25 OHLs on 400 kV and 4 OHLs on 220 kV voltage level.

Until 2028 four new 400 kV OHLs are foreseen in network development plan, including two double circuit lines: OHL 2x400 kV Pančevo – Resita (RO) to be put in operation, OHL 2x400 kV Obrenovac – B.Bašta, OHL 400 kV B.Bašta – Pljevlja (ME), OHL 400 kV B.Bašta – Višegrad (Bosnia and Herzegovina).

The calculation results show MACZT value to significantly increase in Serbia in 2028 compared to 2021. In January scenarios MACZT values increased from 21,4% in 2021 to 42,6% in 2028, while in July scenarios it increased from 31,0% in 2021 to 65,6% in 2028.

New elements in Serbian transmission network almost double MACZT value and can be concluded that activities from network development plan have a beneficial effect on MACZT value. In WB6 region, Serbian transmission network is the biggest and the most elements with structural congestion are detected within Serbia. Additional actions proposed in chapter 10.3 need to be implemented to improve MACZT value on all monitored elements.

10.4.7 Moldova

Calculation of structural congestions in Moldova is not covered in this study due to lack of input data in the previous period. This calculation should be carried out as soon the complete data of capacity allocation will be available.

Until 2028, one new 400 kV OHL is found in network development plan OHL 400 kV Vulcănești – Chisinau, which significantly contributes to Moldovan transmission network operational security.

On models developed to analyse MACZT values in 2028 Moldovan power system shows very good results. In January 2028 model share of elements with MACZT higher than 70% is 82,4% and in July that share is 47,8%.

In case of Moldova, numerous steps are performed to connect and synchronize Moldovan power system to European network. Moldova's willingness and commitment to accession to continental synchronous zone should be appreciated. Moldovan TSO need support to overcome all issues and challenges in access process.

10.4.8 Ukraine

Calculation of structural congestions in Ukraine is not covered in this study due to lack of input data in the previous period. This calculation should be carried out as soon the complete data of capacity allocation will be available.

No changes to the transmission topology are anticipated until 2028 (pre-war topology is assumed), as agreed with the EnCS for this assignment, with the exception of one interconnection line, the OHL 400 kV Khmelnytskyi (UA) - Rzeszów (PL), which was formerly operational at 750 kV voltage level.

Ukrainian TSO is currently facing complex challenges mainly due to military aggression but at the same time Ukraine tries to transpose and implement Regulation (EU) 2019/943 among other legislative acts. With the support of Continental European TSOs, Ukrenergo has been able to increase the stability of the grid and maintain the security of its power system through the most difficult periods. The investments including construction of new lines and reconfiguration of the network may be expected in next period. It is recommended to keep in mind the Regulation (EU) 2019/943 requirements and address the 70% issue in the next network developments plans.

11 CONCLUSION

With the entry into force of the CEP, especially the adoption of the **Regulation (EU) 2019/943**, the European TSOs have been given a series of tasks to make available **maximum possible transmission infrastructure capacity** for the needs of uninterrupted transmission of electricity, which is a prerequisite for a truly unified electricity market in Europe.

As elaborated in Chapter 2, in December 2022, the Energy Community Ministerial Council incorporated the electricity market integration package in the Energy Community. With the adoption of Decision 2022/03/MC-EnC, and incorporating the Regulation (EU) 2019/943, the TSOs from the Contracting Parties are under a legally binding obligation to comply with the minimum 70% target. The Contracting Parties have the same legal obligations as the EU Member States, with different (shorter) deadlines and certain adjustments.

The Regulation (EU) 2019/943 set clear tasks and obligations to the TSOs to operate within the maximum extent of safety limits, all in order facilitate the implementation of a fully integrated, interconnected, and digitalized European electricity market by making available maximum possible level of **cross-zonal transmission capacities**. The TSOs across Europe are considering various measures to achieve the most important requirement – cross-zonal capacity minimum 70% target.

In 2019 ACER issued a recommendation on the MACZT calculation methodology. This methodology is quite complex, both in its mathematical background, as well as in its implementation. During the first study workshop discussions (including ACER), and Inception Report approved by the EnC Secretariat, the calculation methodology was clarified, agreed, and used in this study. It was additionally verified with comparison to the relevant indicators from JAO platform.

The TSOs are also required to implement a harmonized approach in calculating transmission capacities. The EnC CACM GL requires the most efficient approach between FB and cNTC. However, FB is set as default option, while cNTC approach has to be justified and approved by relevant NRAs. Numerous analyses and operation experience in heavily meshed networks like in Core CCR proved that coordinated multilateral capacity calculation method, applied within a CCR, and **based on FB approach** is more efficient than bilateral **NTC method**. **It is important to note that bilateral NTC is no option, since the EnC CACM GL requires FB or cNTC also for the Contracting Parties.**

Based on the above-mentioned legal framework the main purpose of this project is to support primarily TSOs and NRAs in the Contracting Parties in a very challenging process of 70% target fulfillment. The 70% target was administratively set in the EU and then in the EnC, but the main oint was to calculate and make available maximum possible transmission infrastructure capacity for market activities. It is important to note **this study's findings are not obligatory for the TSOs and the NRAs but can serve as a good foundation for their future calculations and formal steps**.

As initially defined in the scope of work, this project had 6 main objectives. These objectives and the main study conclusions are given as follows:

1. Address forthcoming **obligations** by the EnC Contracting Parties pursuant to the EnC Ministerial Council Decision 2022/03/MC-EnC regarding Regulation (EU) 2019/943

   These obligations are given in detail in Chapter 2, along with the EU Member States' experience given in Chapter 3, including relevant ACER and ENTSO-E documents. Since this study also serves for educational purposes, mathematical background of MACZT and the illustrative calculation example are given in Chapter 6. It is important to note that **MACZT values are supposed to be calculated by each TSO and have to be approved by the relevant NRA.**

2. Estimate the **existing situation** in each WB6 Contracting Party related to the 70% target

   The level of fulfillment of 70% target in the WB6 Contracting Parties in existing network is given in Chapter 7. The simulations are performed for two selected characteristic power system regimes: third Wednesday in January (20 January 2021 at 19:30 h) and third Wednesday in July (21 July 2021 at 19:30 h). The main conclusion is based on these two illustrative power system regimes. In the existing network **the level of fulfillment of 70% target in WB6 is very low**. On 20 January 2021 at 19:30 h with the NTC approach between 0% (North Macedonia) and 26% (Montenegro) of all considered elements fulfilled this requirement. On the regional level only 11 out of 176 (around 6%) of considered elements fulfilled 70% target.

   Similar results are found on 21 July 2021 at 19:30 h. With the NTC approach between 3% (Bosnia and Herzegovina) and 22% (Montenegro) of all considered elements fulfilled this requirement. On the regional level only 14 out of 176 (around 8%) of considered elements fulfilled 70% target. It clearly indicated that adequate steps and measures have to be taken as soon as possible to reach 70% target.

3. Analyze and reflect on the 70% target in cases of perspective application of **FB capacity calculation approach and allocation through market coupling and** demonstrate the effect of applying the **FB capacity calculation**

   A comparison between NTC-based and FB capacity calculation approach is given in Chapter 7 for each WB6 Contracting Party. As given above, **with NTC approach** on 20 January 2021 at 19:30 h between 0% (North Macedonia) and 26% (Montenegro) of all considered elements fulfilled this requirement. On the regional level only 11 out of 176 (around **6%**) of considered elements fulfilled 70% target.

   With the FB approach the results would be much better: between 13% (Montenegro) and 59% (Bosnia and Herzegovina) of all considered elements that fulfill this requirement. On the regional level around **26%** of considered elements fulfill 70% target.

   Similar results are found on 21 July 2021 at 19:30 h. With the **NTC approach** between ~3% (Bosnia and Herzegovina) and ~22% (Montenegro) of all considered elements fulfilled the requirement. On the regional level only around 8% of considered elements fulfilled 70% target.

With the **FB approach** the results would be much better: between ~37% (Albania) and 85% (Kosovo*) of all considered elements fulfill this requirement. On the regional level only 93 out of 176 (around **53%**) of considered elements fulfil 70% target.

This numerical example on selected characteristic power system regimes is clear evidence of the **expected positive effect of applying the FB capacity calculation** and allocation through market coupling in this region. However, this example is drawn from selected 2 snapshots, with agreed methodology and bilateral NTC values. As defined in Article 20 (1) of the EnC CACM GL for the day-ahead market time frame and intraday market time frame the approach used in common capacity allocation methodology shall be a FB approach, except if the TSOs jointly justify and request relevant NRAs to apply cNTC.

4. Estimate the **future situation in 2028** in each Contracting Party (except Georgia) related to the 70% target

   On 19 January 2028 at 19:30 h between 22,7% (Kosovo*) and 42,6% (Serbia) of all considered elements fulfilled 70% target. On the WB6 regional level only 67 out of 181 (around 36%) of considered elements fulfilled 70% target, which is around 10% better result than for the same snapshot in 2021. Adding results for Ukraine and Moldova it would be 38,3%.

   On 19 July 2028 at 19:30 h in WB6 between 53,3% (Albania) and 95,5% (North Macedonia) of all considered elements fulfilled 70% target. On the WB6 regional level 117 out of 174 (around 67%) of considered elements fulfilled 70% target, which is around 14% better result than in 2021. If the results for Ukraine and Moldova are added, it would be 55,5% on the EnC level.

   These results show that national TYNDPs should elaborate in more details and include appropriate actions and measures, starting from the low-costs to high-costs, which would serve to increase cross-border capacity available for market participants.

5. Identify **structural congestions** within the power transmission networks of the WB6 Contracting Parties.

   Structural congestions are identified in Chapter 9, based on the methodology used by some TSOs in the EU.

   In this study elements with more than 5% of hours in a year with MACZT value below 70% are considered as elements with structural congestion[18]. The calculation is based on a full 3-year time frame (2020, 2021 and 2022). According to the methodology used in WB6 Contracting Parties **there are 78 identified structural congestions in total.** Most of them (57 or 73%) are detected on 400 kV voltage level, while remaining 21 are in 220 kV network. As expected, due to its largest size, in Serbian system there are 29 (or 37% of total) structural congestions detected, dominantly in 400 kV network.

[18] Disclaimer: Definition of structural congestion is expected to come from ACER and should be taken by the TSOs and ENTSO-E.

It can be concluded that around **half of the structural congestions in WB6 is identified to internal networks, while remaining half on the interconnections**.

In order to address the issue of structural congestions in their networks in more details, TSOs would need to consider the application of market and network simulations and to decide should they use MACZT values or detail calculations to identify congestions within their report on the structural congestions.

6. Suggest, based on the calculations, **activities and measures** in the EnC Contracting Parties (except Georgia) as a basis for possible action plans to fulfil the 70% target by 2028

   Based on the above-mentioned calculations, in Chapter 10 proposal of activities and measures in the EnC Contracting Parties are given to fulfil the 70% target by 2028. **Although only the NRAs can confirm if the 70% target is fulfilled, this study shows scenarios in which 70% target is not fulfilled for the EnC Contracting Parties.** Therefore, after the NRA verifications, probably two other realistic options will remain: derogation or Action Plan. The third option is to change the bidding zones configuration.
   It is important to note that in case of identification of structural congestions, only action plans or bidding zone reconfiguration can be adopted because derogation decisions are not intended to solve structural congestions but rather to address short-term issues and prepare for an action plan.

   Action plans seems to be more realistic way to solve structural congestions in comparison with bidding zones reconfiguration. Bidding zones reconfiguration is a very complex process and includes actions of different relevant bodies (ACER, ECRB, ENTSO-e, relevant NRAa, relevant NEMOs etc). Action Plans are not needed for derogation decisions because these are two different types of processes/actions. The Contracting Party need to define Action Plans pursuant to Article 15 of the EnC Regulation (EU) 2019/943. On the other side, derogations are based on Article 16(9) of the EnC Regulation (EU) 2019/942 and should only deal with problems not related to structural congestions. In practice, it is possible to have derogation in parallel with the Action Plan. Derogation shall be granted for no more than one-year at a time, or, provided that the extent of the derogation decreases significantly after the first year, up to a maximum of two years. But, with repetitive derogations the problem of inefficient usage of transmission capacities will not be resolved, especially not till 31 December 2027 deadline. A long derogation period would result in even more challenging system conditions due to new network users, deviation from the activities and measures in the neighbouring systems, pressure from market participants to increase network capacities etc. **Therefore, it is strongly recommended not to use derogations repetitively, but, if needed, to use it in a one-year timeframe just to adequately prepare, calculate and find solutions to reach the 70% target and to prepare Action Plan.** In Chapter 10 **general structure of Action Plan is given**, along with the main conclusions valid for all Contracting Parties[19]:

   1. Operationalization of the coordinated capacity region in Shadow SEE and EE in given deadlines should be a priority and would increase existing MACZT values.

[19] The proposed actions are not listed on the basis of priority and whether one or another action will be taken depends on the specificities of each Contracting Party.

2. Adoption of coordinated capacity calculation methodology, going from existing bilateral NTC to coordinated NTC, but even more to FB approach would make capacity available. Interconnectivity study by the EnCS shows that these systems are very well interconnected, so changing the approach of calculating will improve situation with structural congestions.
3. More efficient usage of existing and construction of justified new OHLs enables each TSO to get closer to 70% target. However, half of congestions under given conditions are found in internal network. It indicates that there is no need to build many new interconnectors if the calculation methodology is improved.
4. Reinforcement (nominal capacity increase with conductor cross-section upgrade, HTLS technology etc.) of the existing 220 kV network should be also carefully considered.
5. TSO should consider other relevant existing and new technologies (smart metering systems, dynamic thermal rating etc.).
6. Remedial actions (redispatching, demand side response, topology changes, energy storages, active power flow control etc.) should also be considered to improve system security.

Besides the relevant regulatory framework and methodology details, as well as individual power system specifics and development plans, this study includes a comprehensive set of calculation results. The calculations are done for two selected characteristic snapshots in 2021 and 2028, as well as for 3-year timeframe (2020, 2021 and 2022) on hourly basis, covering around 26280 snapshots for every single considered element. In total, the analysis is based on around 180 considered elements for 26280 hours, which resulted in more than 4,6 million numerical results. The results are available both in table and graphical format for every single critical network element, per each Contracting Party and per each timeframe. This is a very comprehensive set of calculation results that was carefully selected and interpreted in the study to maintain study readability and avoid cluttered figures.

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13 APPENDIX – QUESTIONNAIRE RESPONSES

The following Tables give replays of each transmission operators of Energy Community Contracting Parties, WB6 considered countries (Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, North Macedonia, and Serbia) on NTC values and limiting critical network elements with contingency (CNEC) for two analysed time units in 2021.

Table 82 NTC values and list of limiting critical network elements with contingency on 20 Jan 2021, 19:30 and 21 July 2021, 19:30 in Albania transmission network

Border	20 Jan 2021, 19:30 h		21 July 2021, 19:30 h	
	NTC (MW)	Limiting critical network elements with contingency (CNEC)	NTC (MW)	Limiting critical network elements with contingency (CNEC)
AL->KS	250	OHL 400 Koman-KosovaB	400	OHL 220 Fierz - Prizren
KS->AL	250	OHL 400 Koman-KosovaB	400	OHL 220 Fierz - Prizren
AL->GR	400	OHL 400 Zemblak - Kardia	400	OHL 400 Zemblak - Kardia
GR->AL	400	OHL 400 Zemblak - Kardia	400	OHL 400 Zemblak - Kardia
AL->ME	300	OHL 220 Koplik - Podgorica	300	OHL 220 Koplik - Podgorica
ME->AL	300	OHL 220 Koplik - Podgorica	300	OHL 220 Koplik - Podgorica

Table 83 NTC values on 20 Jan 2021, 19:30 and 21 July 2021, 19:30 in Bosnia and Herzegovina transmission network

Border	20 Jan 2021,19:30 h		21 July 2021, 19:30 h	
	NTC (MW)	Limiting critical network elements with contingency (CNEC)	NTC (MW)	Limiting critical network elements with contingency (CNEC)
BA->HR	1000		700	
HR->BA	1000		450	
BA->RS	500		500	
RS->BA	600		600	
BA->ME	500		500	
ME->BA	450		500	

Table 84 NTC values on 20 Jan 2021, 19:30 and 21 July 2021, 19:30 in Kosovo* transmission network

Border	20 Jan 2021,19:30 h		21 July 2021, 19:30 h	
	NTC (MW)	Limiting critical network elements with contingency (CNEC)	NTC (MW)	Limiting critical network elements with contingency (CNEC)
RS->KS	0		0	
KS->RS	0		0	
KS->ME	300		300	
ME->KS	300		300	
AL->KS	250		400	
KS->AL	250		400	
MK->KS	250		450	
KS->MK	400		450	

Table 85 NTC values and list of limiting critical network elements with contingency on 20 Jan 2021, 19:30 and 21 July 2021, 19:30 in Montenegro transmission network

Border	20 Jan 2021,19:30 h		21 July 2021, 19:30 h	
	NTC (MW)	Limiting critical network elements with contingency (CNEC)	NTC (MW)	Limiting critical network elements with contingency (CNEC)
RS->ME	400	TIE 400 kV Podgorica 2 - Tirana 2	200	Transformer T1 400/110 kV Lastva
ME->RS	300	TIE 400 kV Podgorica 2 - Tirana 2	200	Transformer T1 400/110 kV Lastva
BA->ME	500	TIE 400 kV Podgorica 2 - Tirana 2	500	Transformer T1 400/110 kV Lastva
ME->BA	500	TIE 400 kV Podgorica 2 - Tirana 2	500	Transformer T1 400/110 kV Lastva
AL->ME	300	TIE 400 kV Podgorica 2 - Tirana 2	300	Transformer T1 400/110 kV Lastva
ME->AL	300	TIE 400 kV Podgorica 2 - Tirana 2	300	Transformer T1 400/110 kV Lastva
KS->ME	300	TIE 400 kV Ribarevine - Peć 3	300	Transformer T1 400/110 kV Lastva
ME->KS	300	TIE 400 kV Ribarevine - Peć 3	200	Transformer T1 400/110 kV Lastva

Table 86 NTC values on 20 Jan 2021, 19:30 and 21 July 2021, 19:30 in North Macedonia transmission network

Border	20 Jan 2021,19:30 h		21 July 2021, 19:30 h	
	NTC (MW)	Limiting critical network elements with contingency (CNEC)	NTC (MW)	Limiting critical network elements with contingency (CNEC)
RS->MK	300		450	
MK->RS	250		450	
MK->KS	250		450	
KS->MK	400		450	
GR->MK	400		500	
MK->GR	400		450	
BG->MK	300		400	
MK->BG	250		400	

Table 87 NTC values and list of limiting critical network elements with contingency on 20 Jan 2021, 19:30 and 21 July 2021, 19:30 in Serbia transmission network

Border	20 Jan 2021,19:30 h		21 July 2021, 19:30 h	
	NTC (MW)	Limiting critical network elements with contingency (CNEC)	NTC (MW)	Limiting critical network elements with contingency (CNEC)
RS->HR	600		400	
HR->RS	500	DV 220 kV Višegrad - Vardište	500	DV 220 kV Trebinje - Perućica
BA->RS	500	DV 220 kV Višegrad - Vardište	500	DV 220 kV Trebinje - Perućica
RS->BA	600		600	
RS->KS	200		0	
KS->RS	200		0	
RS->RO	800	DV 400 Portile de Fier - Đerdap	450	
RO->RS	800		350	
RS->BG	300		400	
BG->RS	350		400	

Border	20 Jan 2021,19:30 h		21 July 2021, 19:30 h	
	NTC (MW)	Limiting critical network elements with contingency (CNEC)	NTC (MW)	Limiting critical network elements with contingency (CNEC)
RS->HU	800		800	
HU->RS	700		700	
RS->ME	300		200	
ME->RS	200		200	
RS->MK	300	DV 220 kV Trebinje - Perućica	450	
MK->RS	250		450	

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