Energy Technology and Governance Program:

Identification of Network Elements Critical for Increasing NTC Values in South East Europe

South East Cooperation Initiative Transmission System Planning Project (SECI TSP)

Friday, November 07, 2014

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Energy Technology and Governance Program

Identification of network elements critical for increasing of NTC values in SEE

South East Cooperation Initiative Transmission System Planning Project

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ACKNOWLEDGMENTS

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A. EXECUTIVE SUMMARY

Net Transfer Capacity (NTC) values are an indication of transmission capacities that are used by market participants to conduct electricity transactions across the borders of two or more areas (countries). Cross-border transmission capacities, which are defined by neighboring transmission system operators (TSOs), are generally restricted due to limitations on the capacity of tie-lines (interconnection lines) and due to concerns related to the secure operation of the transmission network. The purpose of this study is to analyze the NTC values in the Southeast Europe (SEE) region, identify critical network elements that limit cross border trade as a result of low NTC, and provide recommendations that may be rapidly implemented to increase cross-border trade in the SEE region. Analyses conducted within the study were based on the Southeast Europe Cooperation Initiative regional transmission system planning model for the year 2012.

A review of NTC values in SEE indicate that market-based electricity trade at the wholesale level is restricted due to low NTC values on a number of tie-lines critical to the region. This results in the collection of significant congestion revenue by TSOs and the exercise of market power by national electricity producers. The situation is exacerbated by the relatively large number of TSOs and national borders in the region, further hindering development of an economically efficient electricity market.

TSOs involved in this study (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Kosovo, Macedonia, Montenegro, Romania, Serbia, Slovenia and Turkey) often suggest that adding new interconnection lines is the optimal way to increase cross-border trading possibilities. This study notes that there are already 36 400 kV tie-lines and 18 220 kV tie-lines in the region today, making the regional transmission system in Southeast Europe extremely well-meshed in comparison to other European regions.

Recognizing that the region is endowed with a well meshed network and that construction of high voltage interconnections is costly and time consuming, the results of this study indicate that cross-border transmission capacities may be increased immediately, without the construction of new interconnection lines, if TSOs implement the following recommendations:

Recommendations related to the NTC computation methodology; transmission reliability margin; system security criteria; and the list of contingencies and monitored network elements considered in the NTC studies:

- TSOs in the Southeast Europe region should implement a coordinated flow-based approach to calculating NTC values;
- To increase NTC values, the time frame for which they are calculated should be reduced to day-ahead, week-ahead, or month-ahead, with day-ahead the preferred timeframe. When necessary, annual NTC values should be defined based on the minimum day-ahead NTC value from the previous time period;
- TSOs should employ realistic base cases for their NTC calculations and should more accurately define the generation parameters in their base case models;
- To increase NTC, TSOs should define one common value for their transmission reliability margin (TRM) and allocate it among their different borders.
- Unintentional deviations to generation schedules should be minimized through technically and economically efficient procurement of ancillary services provided through a market based balancing organization;
- When calculating NTCs, the TSOs should factor in the probability of line outages, such that low probability outages are not the limiting factor in the calculation; and
- Likewise, TSOs should consider the effects of individual contingencies, such that minor line overloads may be neglected and not become limiting factors.

Recommendations on remedial actions, including measures to deal with existing critical network elements, re-dispatching of generation, and improved coordination of tie-line transmission capacity between bordering countries:

- Possible re-dispatching (remedial) actions must be taken into consideration when calculating NTC;
- When calculating NTC, *TSOs should focus their calculations primarily on the 400 kV and 220 kV network elements, as they are the primary factor in facilitating cross-border transactions*.
- Transmission line ratings (transmission capacity) should be defined on a seasonal basis. When calculating NTC, the TSOs should strongly consider the possibility of temporarily allowing lines to be loaded at capacities greater than their technical limits, especially if re-dispatching actions are possible to relieve a line.
- It is essential that overcurrent protection settings on both sides of the tie-lines be reviewed.
- Tie-line ratings must be defined in coordination by neighboring TSOs to arrive at a unique value if the tie-line has the same technical characteristics for both sides of a border and if there are no limitations that may influence a tie-line rating on either side of the border.

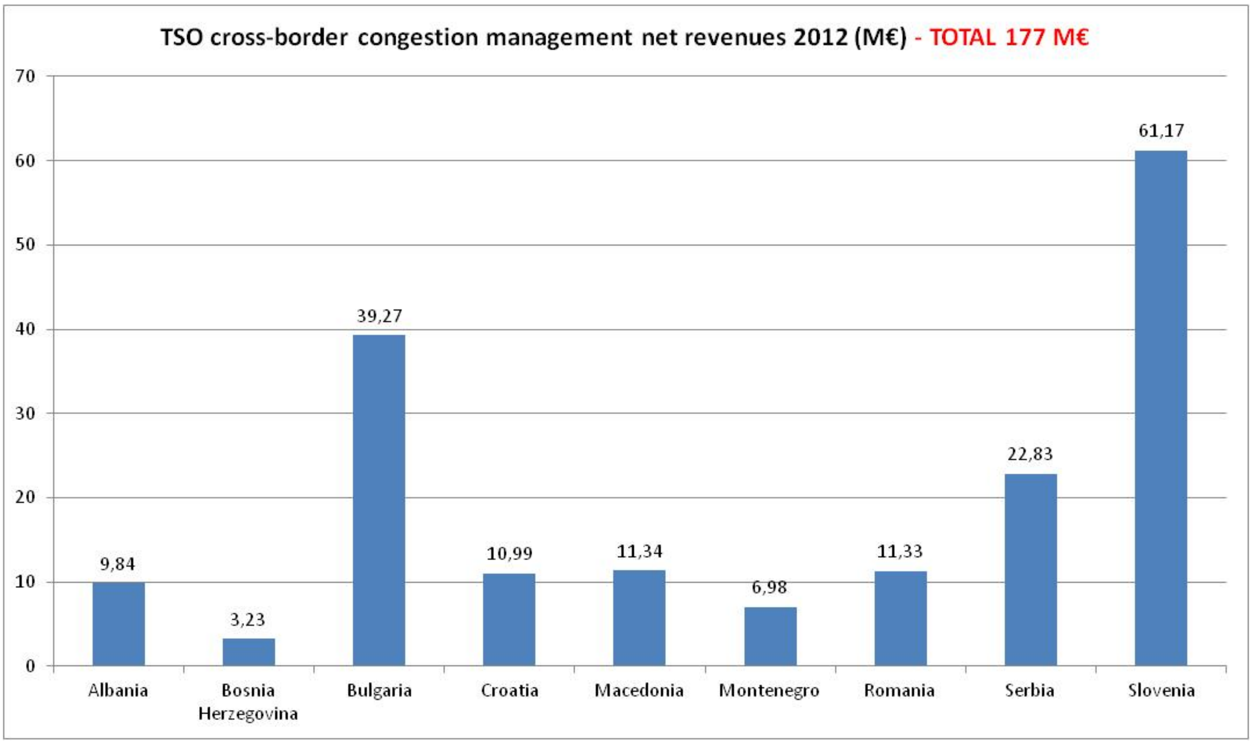
Investments in low-cost solutions including internal network investments and improved coordination among bordering TSOs on interconnection lines:

- Low-cost investments must be prioritized. These include replacement of current-measuring transformers and 110 kV network reinforcements.
- Given that a limiting factor to NTC is often found in the 110 kV internal networks of neighboring countries, it is essential that adjacent TSOs closely coordinate investments in their lower voltage networks to improve NTC. Such solutions are lower cost than investments in high voltage interconnection lines, require shorter siting and approval time-frames and their regulatory approval is more certain.
- Within Southeast Europe, some TSOs must reevaluate the significance of the 220 kV transmission lines and consider revising their operational practices to improve NTC values.
- Adjacent TSOs should use the same or very similar criteria when conducting network security evaluations. They should monitor the same voltage levels during network security calculations and include 110 kV lines only if their loading is significantly influenced by cross-border power exchanges.

In applying the recommendations in this study, TSOs must apply low-cost principles to decisions on improving NTC and prioritize lower cost transmission investments. It is especially important that they reinforce their internal transmission systems in coordination with neighboring TSOs to reduce internal limits to NTC on both sides of their common borders. Preparation of the new interconnection projects should be based on the common interests of adjacent TSOs, their feasibility and their economic justification.

While critical outages occur on 400 kV lines, their reliability within the Southeast Europe network is very high. In such circumstances, it is questionable if the region requires the number of interconnection projects envisioned for the region.

To apply these recommendations and to increase the NTC values for the SEE region in the shortest possible time, it is imperative that regulatory agencies actively engage in the regulation of congestion management revenues by directing them to the low-cost measures and investments detailed in this study.


TSO cross-border congestion management net revenues 2012 (M€) - TOTAL 177 M€
70
60
50
40
30
20
10
0
9,84
3,23
39,27
10,99
11,34
6,98
11,33
22,83
61,17
Albania
Bosnia Herzegovina
Bulgaria
Croatia
Macedonia
Montenegro
Romania
Serbia
Slovenia


SLOVAKIA
LIECH.
AUSTRIA
HUNGARY
MOLDOVA
ROMANIA
ITALY
CROATIA
BOS. & HER.
SERBIA
SAN MARINO
BULGARIA
Black Sea
VATICAN CITY
TURKEY
GREECE
tie-line 400 kV
tie-line 220 kV
planned tie-line 400 kV
planned HVDC

1. INTRODUCTION

When the electricity process in Europe began, the term, "NTC values (Net Transfer Capacity values)" was introduced in order to indicate the possible cross-border transmission capacities between different countries to market players. In the past, power systems were developed in order to satisfy individual countries' need for electricity, mainly within their national borders, while interconnection lines were planned and constructed based on bilateral agreements between countries to allow planned bilateral electricity exchanges between two or more power systems, usually in well predicted volumes and direction.

With the introduction of the electricity market, comprising of different market participants, including power producers, power traders, suppliers, and transmission and distribution system operators, power flow have changed significantly. The transmission networks have been exposed to different loadings and operational circumstances, for which they were not designed. The capacity of cross border transmissions is often a limitation for power trade and exchange, leading to restricted market activities. This limits the possibilities of increasing electricity volumes that may be traded across wide geographical areas.

Observing the electricity market at a wholesale level, Transmission System Operators (TSOs) are increasingly concerned about the security of transmission networks' operation and supply. TSOs have realized that their networks are being exposed to different operational circumstances, which could potentially jeopardize the security of their operations. The use of NTC values has allowed the TSOs to calculate possible cross-border exchanges under which their transmission networks would operate securely, thus maintaining the security of supply at a pre-defined level.

Figure 1.1 SEE region and analyzed countries (Source: worldatlasbook.com)

In 2001, the European Network of Transmission System Operators for Electricity (ENTSO-E) published a document called "Procedures for cross-border transmission capacity assessments." The document was intended to harmonize NTC calculation methodologies between European TSOs by defining basic assumptions and procedures for load flow calculations used to calculate the NTC values between different countries. TSOs in the Southeast Europe (SEE) region currently follow the procedures outlined in this document.

This report analyzes the transmission networks that fall under the responsibility of eleven SEE TSOs, which participate in the SECI Regional Transmission System Planning Prpject (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Kosovo, Macedonia, Montenegro, Romania, Serbia, Slovenia and Turkey – Figure 1.1). It analyzes the possibility of exchanging electricity between their borders, identifies critical network elements which limit NTC values, and focuses on the existing transmission networks' topology and operational conditions and their expected future development.

The main objective of this report is to analyze the existing NTC values in the SEE region and to detect critical elements of the transmission networks that restrict these values. The report will also explore the possibilities of increasing the existing NTC values. To maximize power trade and exchange in the short and mid-term, the report excludes capital intensive investments in the new interconnection lines, since their preparation and construction phases may last for ten years.

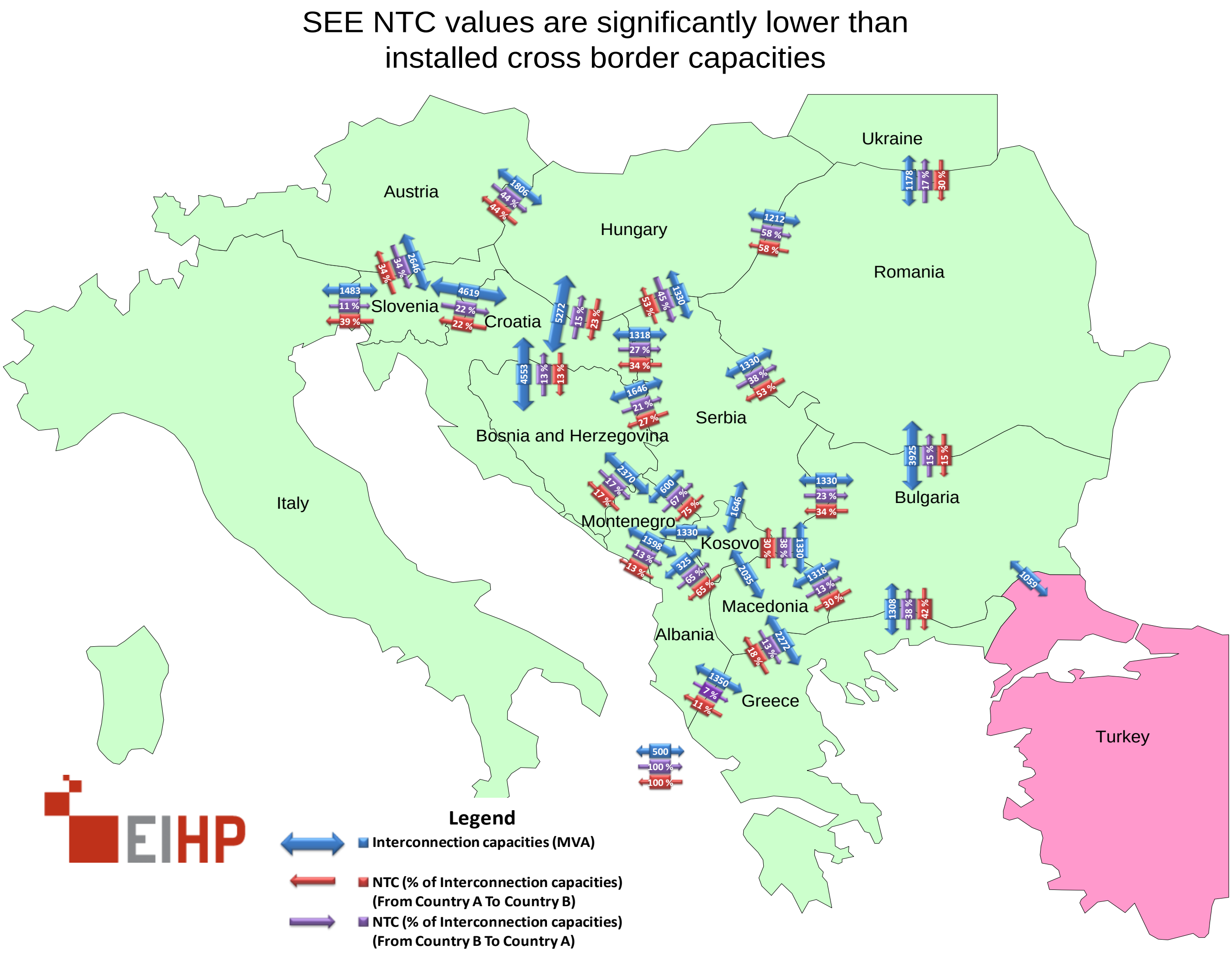


Figure 1.2 NTC values in the SEE region and total interconnected capacities

The cross-border capacities and interconnection lines between SEE countries were historically developed differently than those of central, western and northern Europe. The transmission networks of seven now independent countries (Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Kosovo and Macedonia) were constructed under the common power system of the former Yugoslavia. In compliance with the standards set by the Union for the Co-ordination of Transmission of Electricity (UCTE), these independent countries currently have very strong interconnections with each other. However, their connections with surrounding countries are more limited. Romania and Bulgaria operate together within the former the eastern synchronous area. They have interconnections to Ukraine and Moldavia, but lack strong interconnections to the former UCTE synchronous area. The Albanian transmission network was developed with a low capacity for interconnections with neighboring power systems. In recent years, Turkey has joined ENTSO-E by constructing new interconnection lines to Bulgaria and Greece. However, cross border exchange is limited during its synchronous trial operation.

The total interconnection capacities between SEE countries are significantly higher than the typical NTC values related to different borders– Figure 1.2. The estimated and declared NTC values for the transmission lines between countries in the SEE region range from 10 % to 60% of the values of interconnection capacity. For example, one may notice that there are two 400 kV lines and seven 220 kV lines between Croatia and Bosnia and Herzegovina with a total interconnection capacity of around 4000 MVA. However, NTC values in both directions (Croatia to Bosnia and Herzegovina; Bosnia and Herzegovina to Croatia) are set to around 13 % of this value. There are many similar situations on other borders, which is the reason why this study was initiated and performed. The authors believe that it is of the utmost importance to analyze the elements restricting NTC values and determine a plan to increase NTC values in the SEE region that is less costly than the construction of new interconnection line projects. Large transmission projects, like interconnection projects, generally consume a significant amount of time, sometimes up to 10 or 15 years needed for project feasibility analysis, preparation work, permitting, land acquisition and line construction. In the meantime, relatively low NTC values between SEE countries may become the most restrictive barrier in the development of the electricity market in the region, not allowing an increase in volumes of power trading at the wholesale level.

A questionnaire related to the NTC calculation, methodology, limitations, cross border congestion and revenues was given to SEE TSOs during the preparation stages of this study (Annex 2). All TSOs in the region calculated their annual and monthly NTC values, using the ENTSO-E methodology. Some TSOs provided a list of elements limiting their networks, mostly located at either the 400 kV or, more commonly, the 220 kV voltage level. Some of the TSOs stated that new interconnection capacities were the best way to increase NTC values.

SEE TSOs determined the cross border congestion management revenues, shown in the following figures, based on the calculated NTC values and ATC values (Available Transmission Capacity), on an annual, monthly and daily (intraday) level. In 2012, these revenues ranged between 3 million € to 61 million € individually, and 177 million € for nine observed TSOs, excluding Turkey.

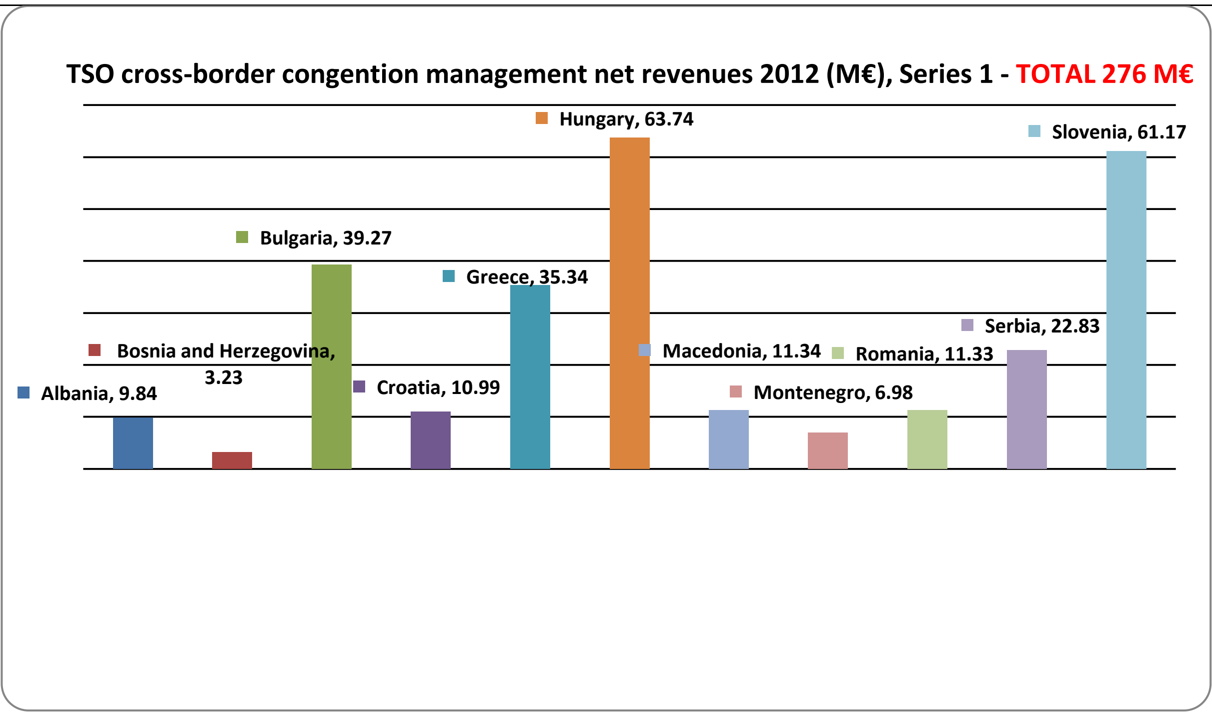


Figure 1.3 SEE and neighboring TSOs cross-border congestion management revenues in 2012

Between 2011 and 2012, the total amount of cross-border congestion management revenues was increased by 57 millions €. It is clear that relatively low NTC values (and ATC values accordingly) may increase the cross-border allocation (auction) price, depending on the interest of market participants in the use of the capacity. Some SEE TSOs stated that they use this revenue to decrease transmission fees, while some of them use it to maintain existing interconnection capacities or to invest in new interconnection capacities.

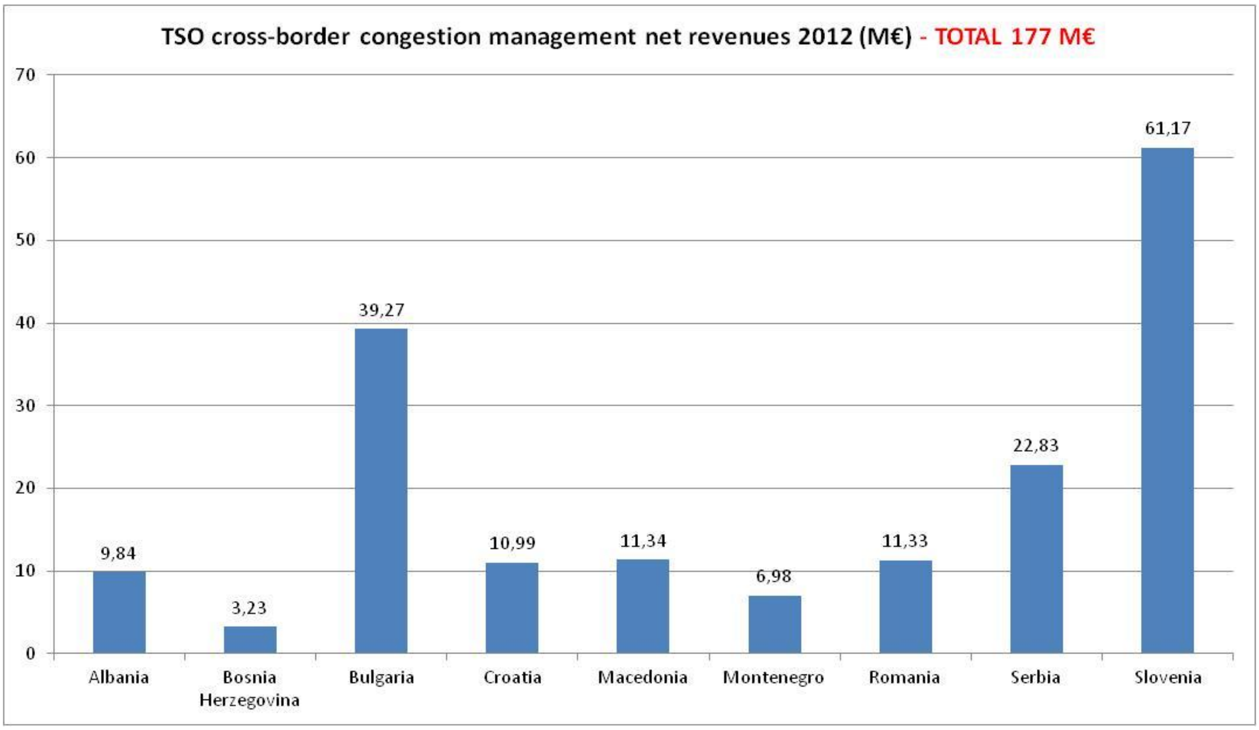


Figure 1.4 SEE TSOs cross-border congestion management revenues in 2012

MEPSO remark: Thermal rating of line is important for protection and control of power flow on respective line. This parameter is irrelevant from the network (cross-border flows) viewpoint, because flows are determined by Kirchoff's laws and topology structure. Flow on one interconnection will reach thermal rating only in critical contingency case with specific outage & generation shift that determine TTC (TTF) value. In other words, NTC (accurately calculated) is indicator that guarantees security of the grid by keeping flow on interconnection in thermal limits for any single outage. As long as flow on interconnection is below NTC, dispatcher is secure that any outage could not jeopardize the system. So, comparison of NTC versus Thermal rating could lead to wrong picture and conclusions.

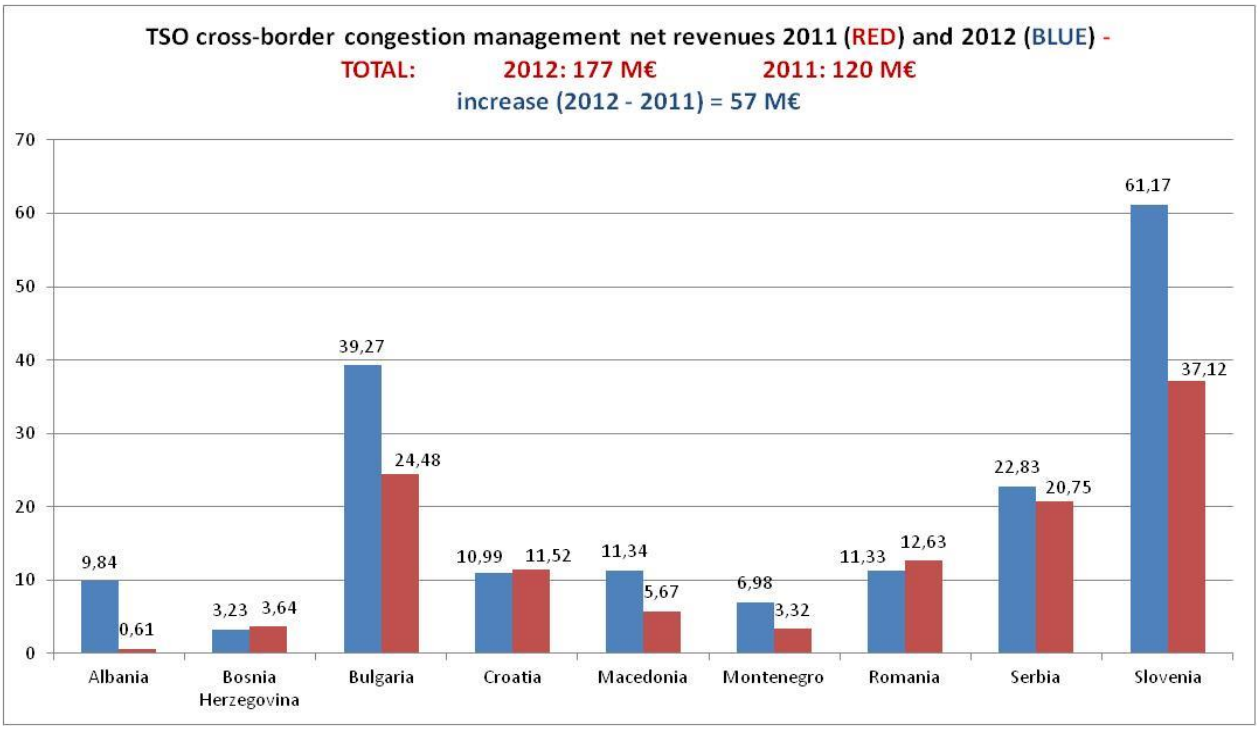


Figure 1.5 Comparison between cross-border congestion management revenues in 2011 and 2012

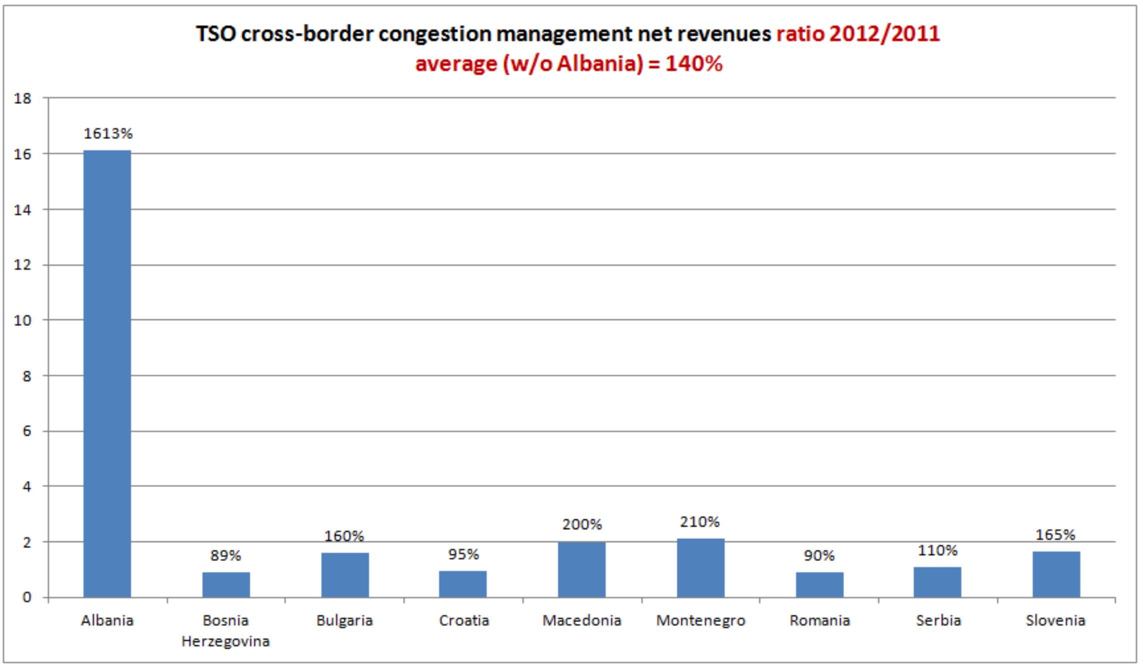


Figure 1.6 Ratio between cross-border congestion management revenues in 2012 and 2011

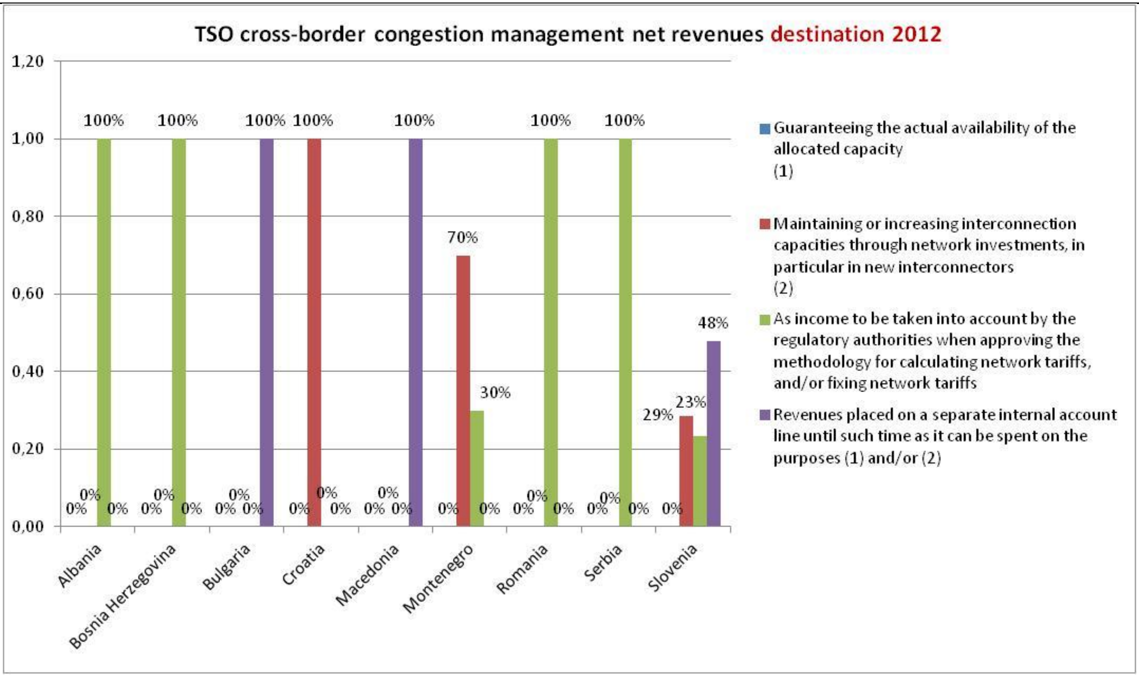


Figure 1.7 Usage of the cross-border congestion management revenues in 2012

This report is structured as follows: Chapter 2 describes the current principles of NTC value calculations and allocation and revenue distribution; Chapter 3 describes relevant ENTSO-E activities related to this topic. Chapter 4 explains an expected development of the SEE transmission grid according to the SEE TSOs official development plans; In chapter 5, NTC values for 2012 and 2015 are determined and described, using the SEE transmission network model; In Chapter 6, critical network elements that limit NTC values on different borders are identified and described; Chapter 7 investigates different actions to be implemented in order to increase present NTC values, with special attention to low-cost actions; Chapter 8 analyzes the impact of the NTC values on the future regional balancing market due to an expected large integration of intermittent power sources like wind and solar; In Chapter 9, the report is concluded. It is followed by relevant literature and appendices related to this report.

2. CURRENT PRINCIPLES OF NTC VALUE CALCULATION, ALLOCATION AND REVENUE DISTRIBUTION

2.1 General description

In October 2001, the basic procedure for calculating NTC values calculation was defined in the ENTSO-E document “Procedures for cross-border transmission capacity assessments”. This report attempted to create a harmonized basis for NTC calculations between interconnected countries, which is applicable to allocating commercial exchanges to market participants. The calculation methodology is also defined in the UCTE Operation Handbook, Policy 3 (Coordinated operational planning) and Chapter B: Capacity Assessment.

All SEE TSOs use UCTE and ENTSO-E’s procedure in either its original or modified form. According to the results of the questionnaire filled out by the TSOs, the majority of them are satisfied with this procedure. However, some of the TSOs had concerns about its applicability and efficiency, especially in highly meshed, but smaller, power systems like the ones in the SEE.

The NTC definitions between interconnected countries are based on load flow calculations. It is suggested that each TSOs model their own networks using the best available input data. The modeling process is usually based on historic data and real operational situations that have occurred. TSOs usually model transmission network conditions when the most critical transmission elements are exposed to high loadings or other operational difficulties.

According to the procedure, network representation should be as expansive as possible and should contain a full representation of all the network elements. Networks should be operated securely, based on the standards set by national grid codes. Currently, every SEE TSOs uses the N-1 criterion to evaluate the security of their system operations. The TSOs also use a very broad contingency description defined in the UCTE Operational handbook.

To commence the process, individual transmission models are exchanged and merged to form the base case model. It represents estimated generation and load patterns to stimulate the base case cross-border exchanges. All TSOs must agree with the base case model representing analyzed wide area.

Using the base case model, the NTC values are calculated for each border by increasing the generation in one country and decreasing the generation in another. Increase/ decrease of generation (generation shift) should be performed using a predefined step. For each load flow calculation, security criteria in both countries should be checked. The process ends when there is a security violation in one country.

In this procedure, adjacent TSOs, both interested in their common border, perform load flow calculations. Each of them calculates load flows for different generation shifts and checks the security criteria. TSOs should identify which network they intend to analyze and decide which network elements to focus on (by defining contingency lists and monitored elements). A TSO may evaluate 400 kV and 220 kV networks only, but it also may evaluate important 110 (150) kV network elements. If two TSOs find different NTC values, they will usually agree that the lower value will be published as the final one.

The following figure (Figure 2.1) presents the NTC calculation procedure, as defined by the ENTSO-E.

2.2 NTC: calculation procedures

The TTC value (Total Transfer Capacity) from area A to area B is calculated as follows:

- Generation is increased stepwise in control area A and decreased in control area B (the shifts of generation are named as ΔE^{+} and ΔE^{-} for increase and decrease respectively).

- This process is carried out up to the point where security rules are violated in systems A, B, or in some of the neighboring systems (resulting to values $\Delta Emax^{+}$ and $\Delta Emax^{-}$).
- The maximum exchange from A to B, without taking into account uncertainties and inaccuracies, is actually the TTC from A to B, calculated according to the following expression:

$$TTC = BCE + \Delta Emax^{+}$$

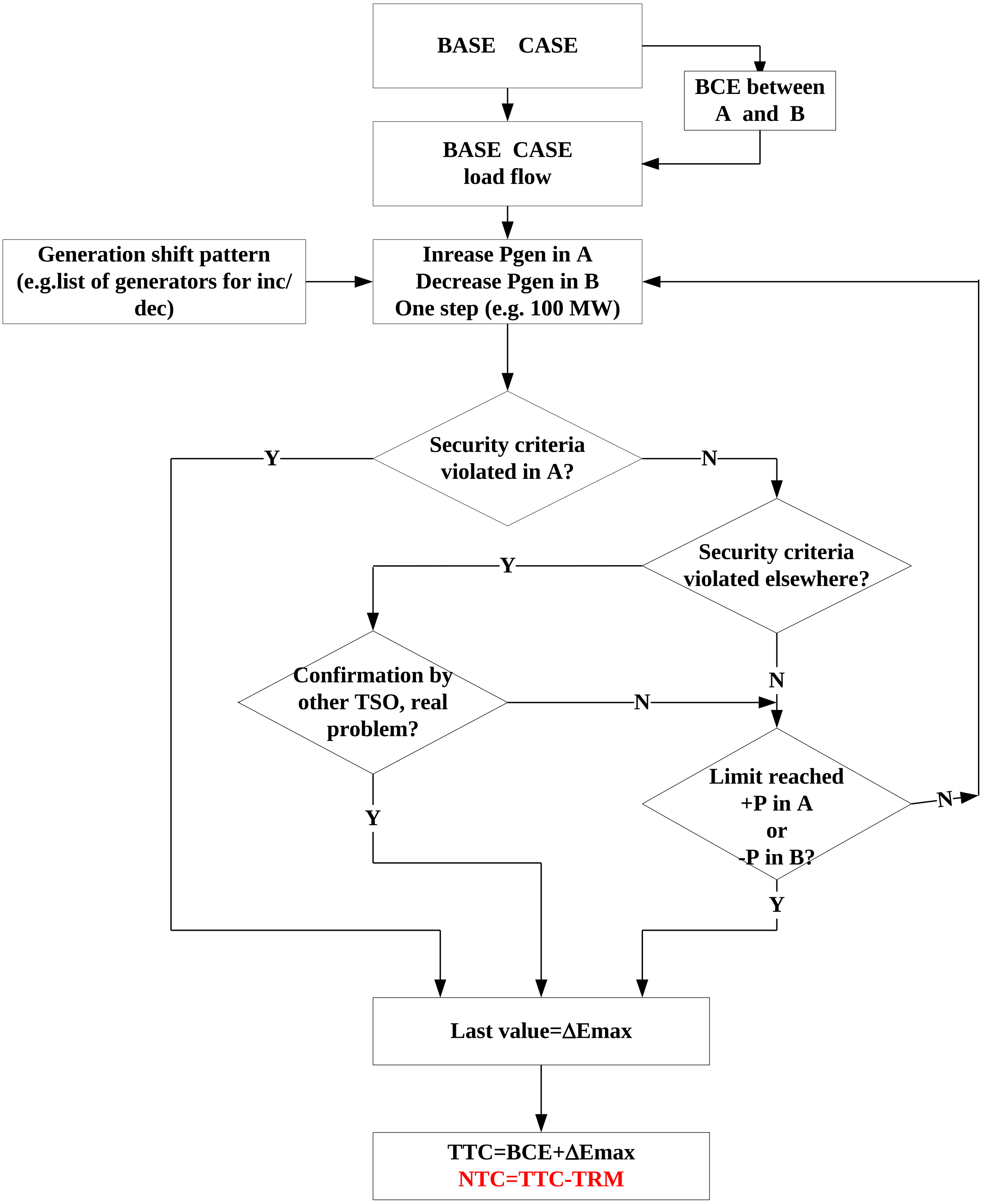


Figure 2.1 The NTC calculation procedure

Basic calculation values are described in the following chapters.

2.3 Base Case Exchange (BCE)

Base Case Exchange is the starting point for NTC calculations, prior to calculating additional electricity exchange between countries. In order to determine base case exchanges, TSOs merge together and approve them, based on the base case flow model. This model includes the network model, input data describing load, generation patterns forecasts and network topology at the studied time frame.

Input data for the base case model contains the electrical parameters and thermal ratings of network elements (with possible use of seasonal values of thermal ratings). It also includes the maximum and minimum values of generator engagement, as well as, network topology at the time frame considered (TSO may exclude some network elements because of planned maintenance activities or any other reason), expected load pattern, the common set of programs of cross-border transactions and the net balances of each TSO area at the time frame considered (based on the best forecast) and maximum power expected available.

2.4 Additional exchange (ΔE)

Additional exchange is the maximum exchange of electricity between the areas that is compatible with the security standards defined in national grid codes (usually the N-1 criterion or criteria defined in the UCTE OH, Policy 3). Additional exchange is performed on the base case model by increasing generation on the exporting side and by decreasing the same value of generation on the importing side. TSOs should perform generation shift step-by-step until there is a network security violation. The value, ΔE, is used to define the maximum generation shift for which network operation is still secure.

Each TSO will determine which generators will be taken into account during generation shift. The procedure defines possible ways to distribute the generation increase or decrease. It may be performed using proportional increase/decrease (mostly used by SEE TSOs), generation shift according to previously observed behavior of generators and according to a merit order list:

1. Proportionally to the active power reserve in respective production units:

$$P_{new}^{inc} = P_i + \Delta E \cdot \frac{P_i^{\max} - P_i}{\sum_n (P_i^{\max} - P_i)} \qquad P_{new}^{dec} = P_i - \Delta E \cdot \frac{P_i^{\min} - P_i}{\sum_n (P_i^{\min} - P_i)}$$

2. Proportionally to the engagement of the production units in base case:

$$P_{new}^{inc} = P_i + \Delta E \cdot \frac{P_i}{\sum_n (P_i)} \qquad P_{new}^{dec} = P_i - \Delta E \cdot \frac{P_i}{\sum_n (P_i)}$$

Where:

P_i : Actual active power generation (MW)
P_{new}^{inc} : New increased injection
P_{new}^{dec} : New decreased injection
ΔE : Shift generation, negative for increasing and positive for decreasing
P_i^{max} : Maximum permissible generation (MW)

P_i^{min} : Minimum permissible generation (MW)

3. According to the priority list of the production units (order & active generation shift)

When TSOs calculate the generation shift, they must take into account the maximum potential of the generator, as well as its technical minimum, and other influential factors including expected hydrological conditions, fuel availability, etc.

2.5 Total Transfer Capacity (TTC)

The TTC value is defined as the maximum exchange program between two areas, compatible with operational security standards applicable at each system (typically: n-1 security criteria).

$$TTC = BCE + \Delta Emax$$

The security assessment comprises of the exhaustive analysis of system behavior under disturbances (usually single or double). Single contingencies typically include:

- HV and EHV overhead line outages.
- Transformer 400/x and 220/x outages.
- Where necessary, selected double-line outages.
- Where necessary, selected generation outages.

The maximum acceptable limits for the loading of the network elements are typically:

- I_{max} for transmission lines (in Amps),
- the nominal apparent power S_r for the transformers (in MVA).

The total transfer capacity between two zones or countries can be found by looking at the sum of maximum generation shift for which security criteria are still satisfied in both interconnected countries and initial transaction values (base case exchange). The ENTSO-E procedure explains that if the whole physical generation shift between the two concerned countries or zones is reached and no security rule breaching has occurred, then no realistic limitations to the cross-border transmission capacity for the base case studied is found and TTC equals to the shift of available generators.

Some critical contingencies can be detected in the TTC calculation, but can be neglected in the following cases:

- if the reason for the detected critical contingency is not the real critical operational regime, but an imperfection of the network model employed for the analysis (for example, not modeled lower voltage network in one area, which actually mitigates the effect of the observed outage),
- if the system operator can make reasonable preventive and quick post-event measures, such as meshing of lower voltage networks, generation restrictions and re—dispatching,
- if a critical contingency is caused by an outage of an element with low probability of failure based on existing experience (for example an element operating for a few years without any unplanned outage),
- if critical contingency is electrically far away from the considered border (usually, this problem with high loading or overloading occurs in the base case and should be skipped if it is far from the border of interest).

2.6 Transmission Reliability Margin (TRM)

The TRM value is defined as the security margin that deals with uncertainties on the computed TTC values. It refers particularly to the:

- Unintended deviations of physical flows during operation due to the physical functioning of load-frequency control (LFC).
- Emergency exchanges between TSOs to deal with unexpected unbalanced situations in real time.
- Inaccuracies, e. g. in data collection and measurements.

In practice, the TRM values are typically agreed and fixed for a longer time period. It may be defined as a fixed figure (50, 100, 150 MW), or as a percentage of TTC.

TSOs often use (as well as SEE TSOs) one of the following two equations to determine the TRM values for different borders (in MW):

$$TRM = 100 \bullet N$$

$$TRM = 100 \bullet \sqrt{N}$$

N refers to the number of interconnection lines between two countries.

For example, if there are 4 interconnection lines between two countries (areas, zones), TRM may be defined within the range of 200 MW and 400 MW.

ENTSO-E’s procedure provides a basic guidance for determining TRM. However, it states that the definition of TRM is at the discretion each TSOs involved. It states that TRM values may be determined as:

$TRM_i = U_r + U_E$, or

$TRM_{ii} = \max(U_r, U_E)$

where:

U_r : statistical estimate based on historic data.
U_E : margin for common reserve and emergency exchanges.

TRM_i value is the worst case combination, that takes into account both statistical estimate and common reserve and emergency exchanges margin. TRM_{ii} value assumes that both uncertainty margins cannot happen simultaneously.

The other definition of TRM is related to the:

- unintended deviations due to primary control: P_{TRM1}
- unintended deviations due to power-frequency (secondary) control: P_{TRM2}
- common reserve and emergency exchanges to cope with unbalanced situations: P_{TRMe}
- inaccuracies in data collection and measurements: P_{TRMi}

Overall value of TRM may be defined as follows:

- $TRM_{pessimistic} = P_{TRM1} + P_{TRMe} + P_{TRMi}$
- $TRM_{optimistic} = \max(P_{TRM1}, P_{TRMe}) + P_{TRMi}$

2.7 Net Transfer Capacity (NTC)

NTC value is measured as the maximum exchange program between two areas compatible with security standards applicable at each system, while taking into account the technical uncertainties in future network conditions. NTC is defined as:

$$NTC = TTC - TRM$$

Maximum possible exchange between interconnected countries, areas or zones is defined for a studied time frame, by decreasing calculated Total Transfer Capacity value (TTC) for defined Transmission Reliability Margin (TRM). Expected generation and load patterns, base case operational situation and exchanges, security criteria, generation, network elements technical limits and uncertainties in computation are all taken into account.

The following figure presents a schematic illustration of how to determine NTC value. It defines two areas, A and B, with a base case exchange BCE (or $BCE^{A>B}$) in the direction of A to B. For this direction, maximum generation shift (increase of generation in A and decrease of generation in B), for which security criteria in both countries are fulfilled, is calculated as $\Delta E_{max}{}^{A>B}$. For the direction of B to A, maximum generation shift (increase of generation in B and decrease of generation in A), for which security criteria in both countries are fulfilled, is calculated as $\Delta E_{max}{}^{B>A}$. Transmission reliability margin $TRM^{A>B}$ and $TRM^{B>A}$ are usually equal and defined by a common agreement between two TSOs. NTC values for both directions are calculated as:

$NTC^{A>B} = BCE^{A>B} + \Delta E_{max}{}^{A>B} - TRM^{A>B}$ (for direction from A to B)

$NTC^{B>A} = -BCE^{A>B} + \Delta E_{max}{}^{B>A} - TRM^{B>A}$ (for direction from B to A)

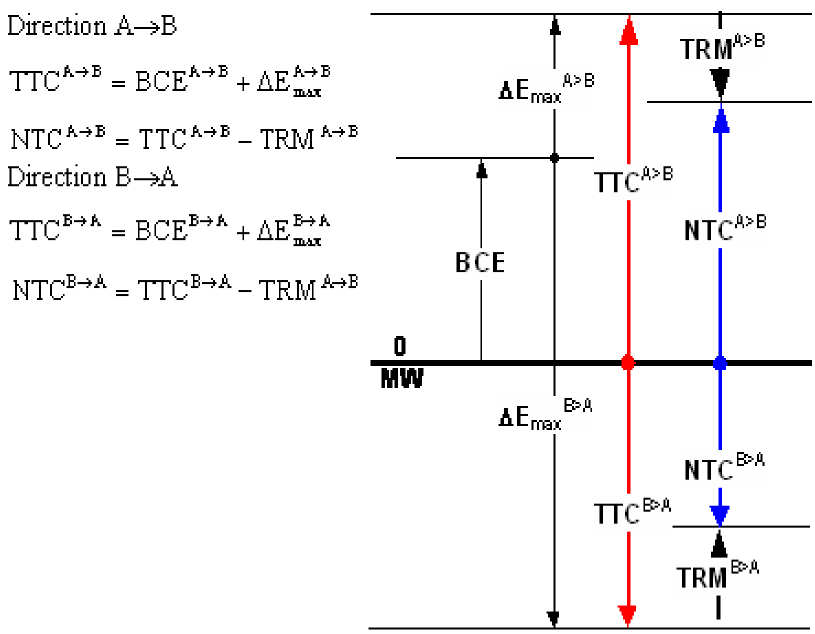


Figure 2.2 Net transfer capacities between two areas (A and B) and both directions

2.8 NTC results harmonization

Two neighboring TSOs should both typically calculate the NTCs for the same border/direction. The best method is to harmonize the results and check for issues (especially for problems encountered in other TSO's area). If the TSOs involved calculate different NTC values and cannot reach an agreement, then the usual rule is to use the lower value as the common NTC value.

2.9 Already Allocated Capacity (AAC)

The AAC (Already Allocated Capacity) value is part of the NTC values which represents capacity rights given to market participants at previous auction rounds (annual, monthly and daily).

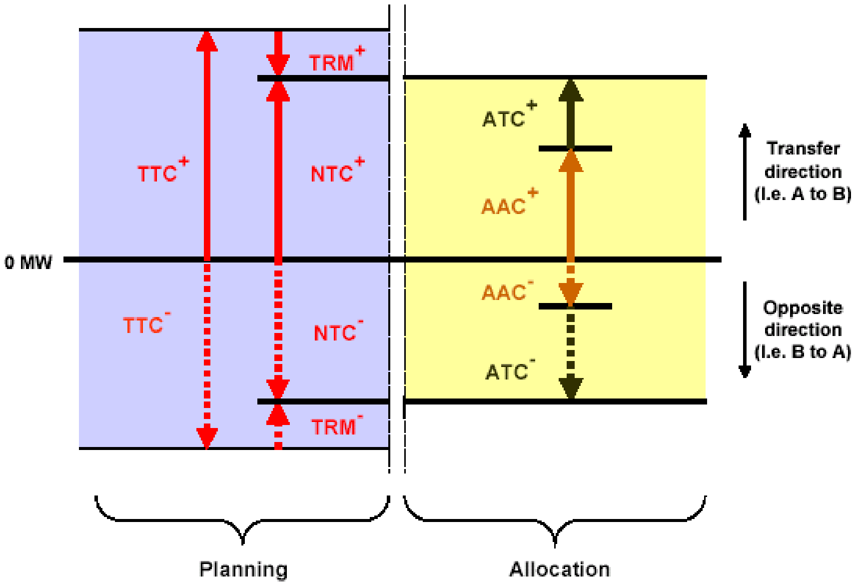


Figure 2.3 Net transfer capacities, already allocated capacities and available transmission capacity (*source ADMIE*)

2.10 Available Transmission Capacity (ATC)

The ATC (Available Transmission Capacity) is the part of NTC that remains available, after each phase of the allocation procedure, for further commercial activity.

$$ATC = NTC - AAC$$

TSOs or auction coordination offices may choose to allocate ATC. ATC based allocation methods:

- Define a single value of transmission capacity per border/direction, related to the network conditions in certain period (hour, day, week, month…), and allocate the transactions up to the size of the capacity.
- ATC based methods are suitable for not highly meshed systems, or medium meshed systems (radial areas, peninsula areas, etc.).

ENTSO-E publishes annual platform indicative (non-binding) NTC values. TSOs calculate these values, related to each border between interconnected power systems, using forecast models of the entire ENTSO-E region. TSOs calculate these NTC values for the base case winter and summer regime, and usually take into account the lower of these two values.

TSOs may determine the annual NTC value and offer it to the market participants as a yearly transfer capacity right. Each TSO involved will include an agreed and coordinated maintenance program, N-1 security criterion, and other uncertainties in the NTC calculations. Annual NTC values for a year are determined by the end of the prior year.

Country	Answer							
	Once a year		Twice a year		Monthly		Other	
Albania	✓		✓		✓		✗	
BiH	✗		✗		✓		✗	
Bulgaria	✗		✗		✓		✗	
Croatia	✗		✗		✓		✗	
Kosovo	✓		✗		✗		✗	
Macedonia	✗		✗		✓		✗	
Montenegro	✗		✗		✓		✗	
Romania	✓	firm ATC values for yearly auctions, determined in Y-1	✓	maximum seasonal indicative NTC values	✓	firm monthly NTC profiles with resolution down to week and day (depending on simultaneous & successive monthly maintenance programs	✓	NTC values updated for specific periods due to changes in maintenance programs
Serbia	✗		✗		✓		✗	
Turkey	✗		✗		✓		✗	

Figure 2.4 Calculation of the NTC values by the SEE TSOs

TSOs conduct cross-border capacity auctions about monthly. TSOs agree on monthly reference network models, which are used for the monthly NTC calculations. The countries whose models are exchanged and merged into a common regional model within this procedure are: Albania, BiH, Bulgaria, Croatia, Greece, Hungary, Austria, Macedonia, Romania, Slovenia, Serbia, Montenegro and Ukraine. If any of the above models is not available, the last available model/information is used (e.g. DACF: Day-Ahead Congestion Forecast files) – Source: „Methodology for the evaluation of the NTC values at the Greek interconnections", ADMIE.

TSOs calculate the NTC values on a monthly basis with a complete network for 10:30 CET (high tariff). They also do an additional monthly calculation and evaluation to determine the NTC value if one the critical lines is expected to be out of operation (forecasted monthly base case model takes into consideration a maintenance plan for that period) and in cases when there is something unexpected in the region. The parties should inform each other of any unplanned disconnections of transmission components in their own grid, provided that these disconnections have an essential impact on the grid security of other party.

Each TSO performs a security analysis and calculates the NTC values. Following the calculations, the TSOs exchange and harmonize the NTC values. If no agreement is reached, then the TSOs use the lower NTC value. After all monthly NTC calculations for imports/exports are completed, the monthly Available Transfer Capacity (ATC) for imports/exports that will be offered to the market is taken from the following formula:

$$ATC_{MONTHLY} = NTC_{MONTHLY} - AAC_{YEARLY\ RIGHT}$$

Where $ATC_{MONTHLY}$ is the Available Transfer Capacity for monthly auctions, $NTC_{MONTHLY}$ is the Net Transfer Capacity for monthly auctions and $AAC_{YEARLY\ RIGHT}$ is the Already Allocated Capacity from the yearly auctions.

The procedure for monthly capacity auctions related to month M in the Southeast Europe is as follows:

- At late M-2: all TSOs provide their national network models for the following month.
- At late M-2: One TSO (on circular basis) checks and merges all the models into the regional SEE model, and sends it to all TSOs.
- At early M-1: TSOs calculate NTCs on the basis of the common regional model, and harmonize results bilaterally.
- At mid M-1: TSOs organize NTC-based auctions for month M.

TSOs may also perform daily and intraday NTC calculations and auctions of remaining cross-border capacity. These calculations are based on day-ahead congestion forecast (DACF) models. Daily Available Transfer Capacity for imports/exports is taken from the following formula:

$$ATC_{DAILY} = NTC_{DAILY} - AAC_{NOTIFIED\ YEARLY\ RIGHT} - AAC_{NOTIFIED\ MONTHLY\ RIGHT}$$

Where ATC_{DAILY} is the Available Transfer Capacity for daily auction, NTC_{DAILY} is the Net Transfer Capacity for daily auction and $AAC_{NOTIFIED\ YEARLY\ RIGHT}$ is the Already Allocated Capacity from the yearly auction that has been notified and $AAC_{NOTIFIED\ MONTHLY\ RIGHT}$ is the Already Allocated Capacity from the monthly auction that has been notified.

2.11 Congestion management

Market participants who are interested in purchasing cross-border capacities will give their bids during the auction process. If a border is congested, meaning that an interest in its usage is larger than available transfer capacity related to that border (total amount of the requested reservation of network capacity exceeds the ATC), transfer capacity rights are allocated based on market participants' bids. TSOs may collect cross-border congestion management revenue, which may only be used in a pre-defined manner. Under EU legislation, TSOs must use the income derived from auctions for measures guaranteeing the availability of allocated capacity, decreasing the transmission and distribution tariffs, or for grid investments.

SEE TSOs use the congestion management revenues (see Figure 2.5) for different purposes. Some of them state that they use this revenue to construct new network elements needed for increasing NTC (Albania, Bulgaria, Macedonia, Montenegro, Romania, Serbia and Turkey). Some of them use it to upgrade existing network elements in order to increase NTC values (Albania, Macedonia, Montenegro, Romania, Serbia and Turkey). Albanian, Macedonian and Montenegrin TSOs use it to construct or upgrade network elements for other power system needs. Some TSOs use it for other purposes.

Country	Answer			
	Construction of new network elements needed for NTC increasing	Upgrading of existing network elements needed for NTC increasing	Construction/upgrading of network elements needed for other system needs	Other
Albania	✓	✓	✓	✓ the price of electricity
BiH	✗	✗	✗	✓ Relevant Transmission Company in B&H, not ISO B&H
Bulgaria	✓	✗	✗	✗
Croatia	✗	✗	✗	✗
Kosovo	✗	✗	✗	✓ EMS collect this revenue
Macedonia	✓	✓	✓	✓ for non-core business needs
Montenegro	✓	✓	✓	✗
Romania	✓	✓	✗	✓ price of electric energy transport
Serbia	✓	✓	✗	✗
Turkey	✓	✓	✗	✗

Figure 2.5 SEE TSOs answers on the question about congestion management usage

2.12 Composite NTC value

A composite NTC value is the NTC value calculated for a border between three or more TSOs. A composite NTC value is not necessarily the sum of bilateral NTC values. One border between several countries is identified and generation shift is applied to all generators on both sides of the border using this approach to calculate NTC. The interdependency of the loop flows (suitable for smaller power systems which exist in the SEE region) is taken into consideration during this calculation.

Generation is increased in one area by ΔE, usually proportional to its remaining capacity, while generation in the other area is decreased by the same amount (according to generation remaining capacity). When the security limit (usually N-1) is reached for both areas, the Total Transfer Capacity between the two areas is defined (TTC = BCE + ΔE). If the generation limit is reached in one area before a violation of the N-1 criteria, then additional generation will be taken into account through transits from neighboring countries.

The following values may be defined based on load flow calculations:

- Notified Transmission Flow (NTF) is the physical flow over the tie-lines between the considered areas observed in the base case model prior to any generation shift between the areas. Resulting from the Base Case Exchanges (BCE).
- The additional physical flow ΔFmax is the physical flow over the tie lines between the two areas, induced by the maximum generation shift ΔEmax.
- Total transfer Flow (TTF) is the net physical flow across the border associated with an exchange program of magnitude TTC, provided that no other exchanges have been modified from the base case (except the one between the two areas between which the TTC is calculated).

TTF = NTF + ΔFmax

NTC values are identified using power transfer distribution factors (PTDF). PTDF represents the portion of a power transfer that flows through a considered border. Power flow through the considered border may be calculated by multiplying PTDF and the amount of the power transfer:

$$\Delta F_{i,X} = PTDF_i * \Delta E_X$$

Where:

$\Delta F_{i,X}$: Physical flow over interconnection line *i* caused by generation shift ΔE_x.

$PTDF_i$: Power transfer distribution factor for interconnection line *i*

ΔE_X : Generation shift

For the maximum generation shift, from the base case exchange up to the total TTC limit, the total transfer flow over line *i* can be established for each interconnector as:

$$TTF_i = NTF_i + \Delta F_{i,TTC}$$

Where NTF_i is the base case load flow over line *i*.

Having in mind that:

$$\Delta E_{i,TTC} = \Delta F_{i,TTC}$$
$$TTC_i = BCE_i + \Delta E_{i,TTC}$$
$$TRM_{ALL} = 100\sqrt{N}$$
$$TRM_i = PTDF_i * TRM_{ALL}$$

NTC value related to interconnection line *i* is defined as:

$$NTC_i = TTC_i - TRM_i$$

Total NTC value is defined as:

$$NTC_{ALL} = \sum NTC_i$$

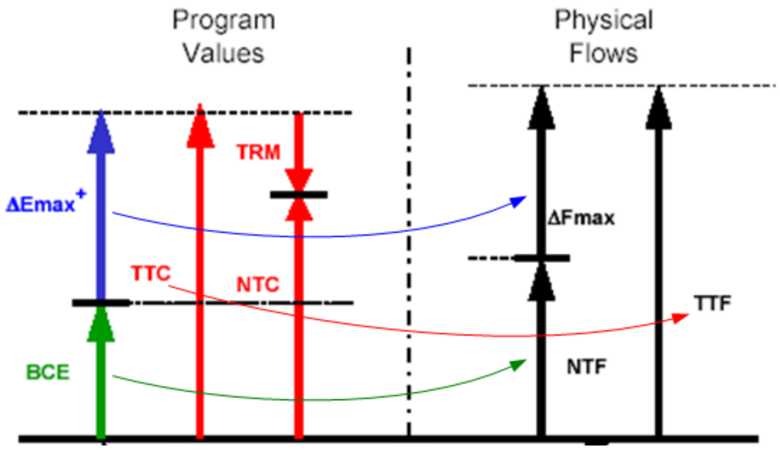


Figure 2.6 NTC calculation program base method and flow based method

Transelectrica remark:

In order to take into consideration the meshed nature of the interconnected network and the simultaneity of exchanges increase in the same direction, some partners in SEE calculate composite NTC values and then split these into the bilateral NTCs. The sum of these bilateral NTC values is equal to the composite NTC. For instance, a composite value is determined for simultaneous export from Romania and Bulgaria to Serbia and then split into bilateral NTC values. For Romania the sum of bilateral NTC values on its borders is equal to the composite NTC value in the Romanian interconnection interface (cumulative bilateral NTC values).

3. RELEVANT ENTSO-E ACTIVITIES

With the exception of Albania and Kosovo (KOSTT), all TSOs in the EU and surrounding countries are members of the European Network of Transmission System Operators for Electricity (ENTSO-E), which deals with technical and market aspects of transmission networks operation.

ENTSO-E plays an important role in establishing a common electricity market in Europe. Based on EU legislation, ENTSO-E has the right and obligation to identify planning and operational issues in the power transmission business in order to support a market-oriented and competitive European electricity market.

ENTSO-E's jurisdiction is extended to cross-border capacity allocation procedures and congestion management issues. ENTSO-E publishes the NTC values for different time-scales relevant for all European borders that have been agreed to TSOs.

ENTSO-E's activities are organized into three Committees: System Development; System Operations; and Market Committees. The System Operation Committee deals with, among other tasks, security of supply issues. The Market Committee's main task is to harmonize electricity market rules and promote a competitive internal electricity market. One of its key areas of work is market integration and congestion management. The Market Committee also prepares market-related network codes, such as the Capacity Allocation code, Congestion Management code and Forwards Capacity Allocation network code.

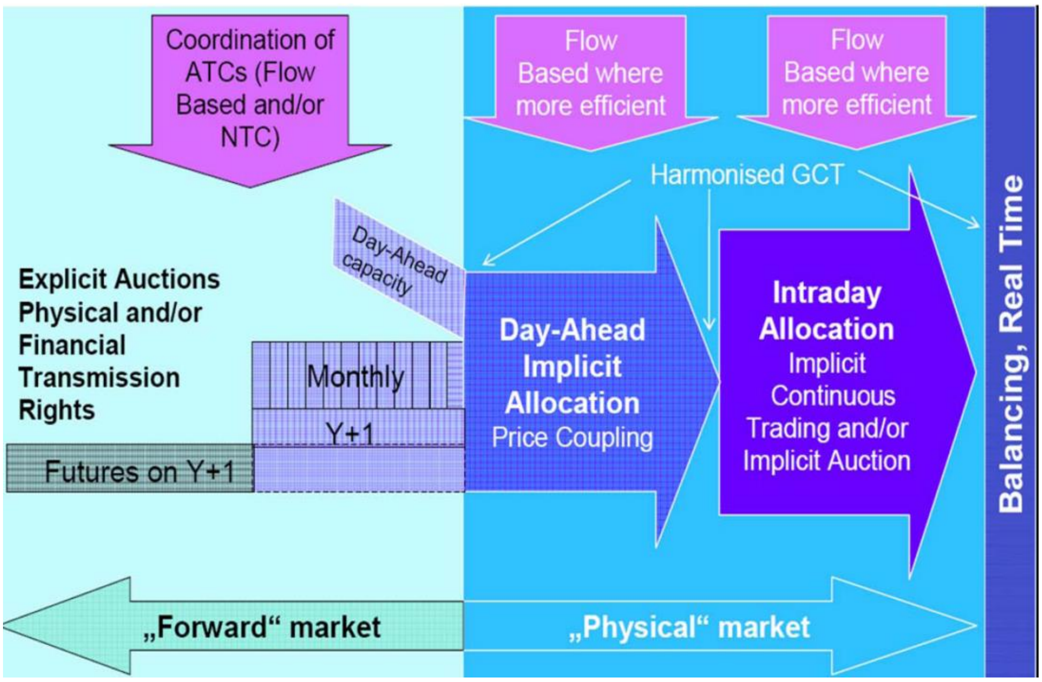


Figure 3.1 EU target model for the internal electricity market integration

The ENTSO-E Market Committee harmonizes the forward, day-ahead and intraday markets on the European level. Its recent activities include preparation of the following network codes:

1. Network Code on Capacity Allocation and Congestion Management (CACM).
2. Network Code on Forward Capacity Allocation (FCA).

The final version of the Network Code on Capacity Allocation and Congestion Management was submitted to the Agency for the Cooperation of Energy Regulators (ACER) and is now under the process of transformation into EU legislative. The final version of the Network Code on Forward Capacity Allocation was submitted to the ACER, and their response is expected soon.

According to the Network Code on Forward Capacity Allocation, each TSO for each Capacity Calculation Region shall ensure that Long Term Cross Zonal Capacity is calculated for each Forward Capacity Allocation, at least on annual and monthly timeframes. The Capacity Calculation Approach for the Long Term capacity calculation timeframes shall be based on either a Coordinated Net Transmission Capacity Approach or a Flow Based Approach. This network code also prescribes other aspects of annual and monthly cross-border capacity calculations, including the structure of a common grid models, determination of a reliability margin, generator shift keys, operational security limits and remedial actions. The network code promotes a coordinated capacity calculation process.

The Network Code on Capacity Allocation and Congestion Management sets common rules for Capacity Allocation and managing cross Bidding Zone congestion in the Day Ahead and Intraday Markets. It prescribes that TSOs have the obligation to use common grid model and promotes using the flow based approach for calculating capacity. It also defines more specifically how to determine transmission reliability margins, treat operational security constraints, generation shift keys and remedial actions.

Both network codes significantly impact the cross-border capacity calculations and capacity allocations for TSOs. Highly meshed and smaller systems, like those of the SEE region, should employ regional, coordinated and flow based approach for capacity calculations, due to the large interdependency of the load flows across different borders caused by individual market transactions.

In the following Chapters, published NTC values for all TSOs and respective borders, relating to different time frames, are presented for the 2012-2014 time period. All values are published at the ENTSO-E web site http://www.entsoe.net/.

NTC values shown in the tables and figures are indicative of annual NTC values agreed upon between adjacent TSOs, and refer to the January values. Monthly indicative NTC values are usually the same as the winter values (January value), except in some special cases.

MEPSO comment:
To give some additional explanations:
- These are indicative values and could differ from values published by the TSO and used for capacity allocation mechanism.
- Values used for capacity allocation can be found on TSO's web site, for MK: http://mepso.com.mk/en-us/Details.aspx?categoryID=92

3.1 Albania

The Albanian TSO (OST) shares national borders with Montenegro, Kosovo, Macedonia and Greece. There is no direct transmission line between Albania and Macedonia, so respective borders and directions of possible power exchanges are:

Border	Export (from Albania)	Import (to Albania)
Albania/Montenegro	AL>ME	ME>AL
Albania/Kosovo	AL>RS	RS>AL
Albania/Greece	AL>GR	GR>AL

The indicative annual NTC value for the Albanian/Greek border was set to a constant value of 250 MW in the observed time period. The same value is set for both power flow directions (from Albania to Greece and from Greece to Albania).

Table 3.1 Indicative annual NTC values for Albanian borders (January)

YEAR/BORDER	AL>GR	GR>AL	AL>RS	RS>AL	AL>ME	ME>AL
2012	250	250	210	100	NA	NA
2013	250	250	150	210	NA	NA
2014	250	250	50	50	NA	NA

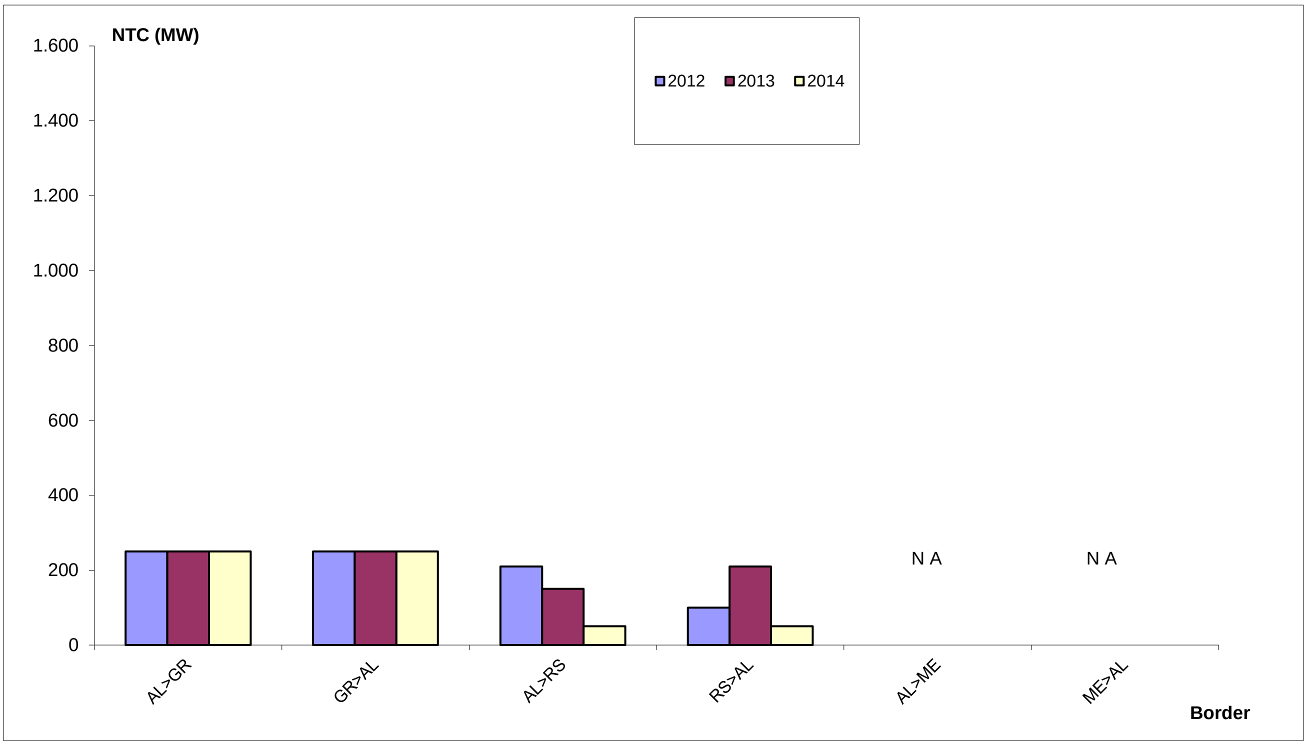


Figure 3.2 Indicative annual NTC values for Albania (2012-2014)

The indicative annual NTC value for the Albanian/Kosovan border was set to 210 MW for the Albania to Kosovo direction in 2012, but decreased in 2013 and 2014 to 150 MW and 50 MW respectively. In the opposite direction, the indicative NTC value was set to 100 MW in 2012, 210 MW in 2013 and 50 MW in 2014.

The indicative annual NTC values for the Albanian/Montenegrin border in the observed time frame have not been published on the ENTSO-E web site. For winter 2011 and summer 2010, these values were set to 200 MW for both directions.

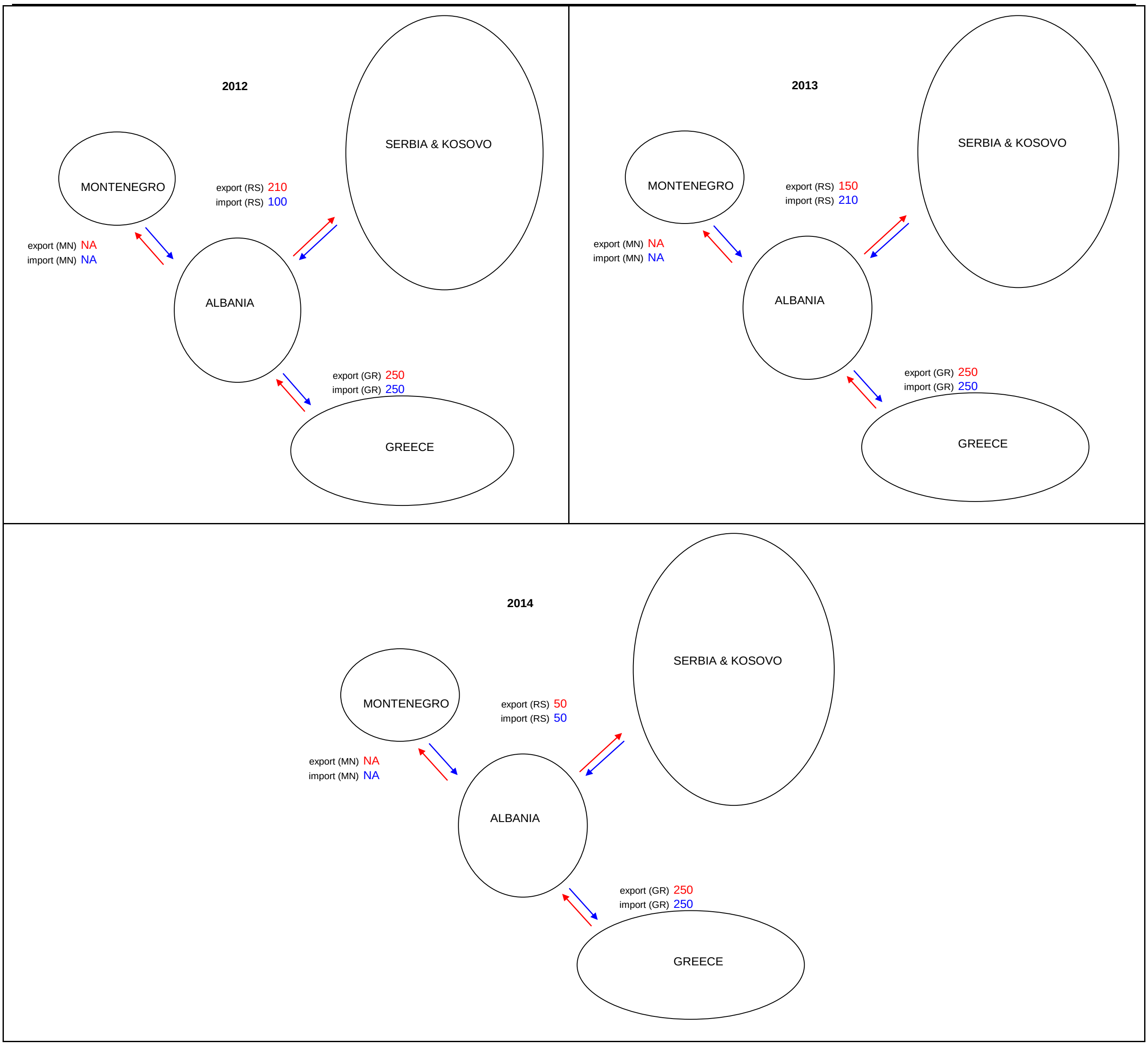


Figure 3.3 Graphical representation of the indicative annual NTC values for Albania

The estimated Month-ahead and Day-ahead NTC values for the Albanian borders, for the 2012-2014 time period, have not been published on the ENTSO-E web site.

3.2 Bosnia and Herzegovina

Bosnia and Herzegovina ISO (NOS BiH) shares national borders with Croatia, Montenegro and Serbia. The respective borders and directions of possible power exchanges are:

Border	Export (from BiH)	Import (to BiH)
BiH/Croatia	BA>HR	HR>BA
BiH/Montenegro	BA>ME	ME>BA
BiH/Serbia	BA>RS	RS>BA

The indicative annual NTC value for the Bosnian and Herzegovinian/Croatian border was set to a constant value of 400 MW in the observed time period. The same amount is set for both power flow directions (from BiH to Croatia and from Croatia to BiH).

Table 3.2 Indicative annual NTC values for Bosnia and Herzegovina borders (January)

YEAR/BORDER	*BA>RS*	*RS>BA*	*BA>HR*	*HR>BA*	*BA>ME*	*ME>BA*
2012	400	200	400	400	75	75
2013	300	150	400	400	200	200
2014	100	100	400	400	200	200

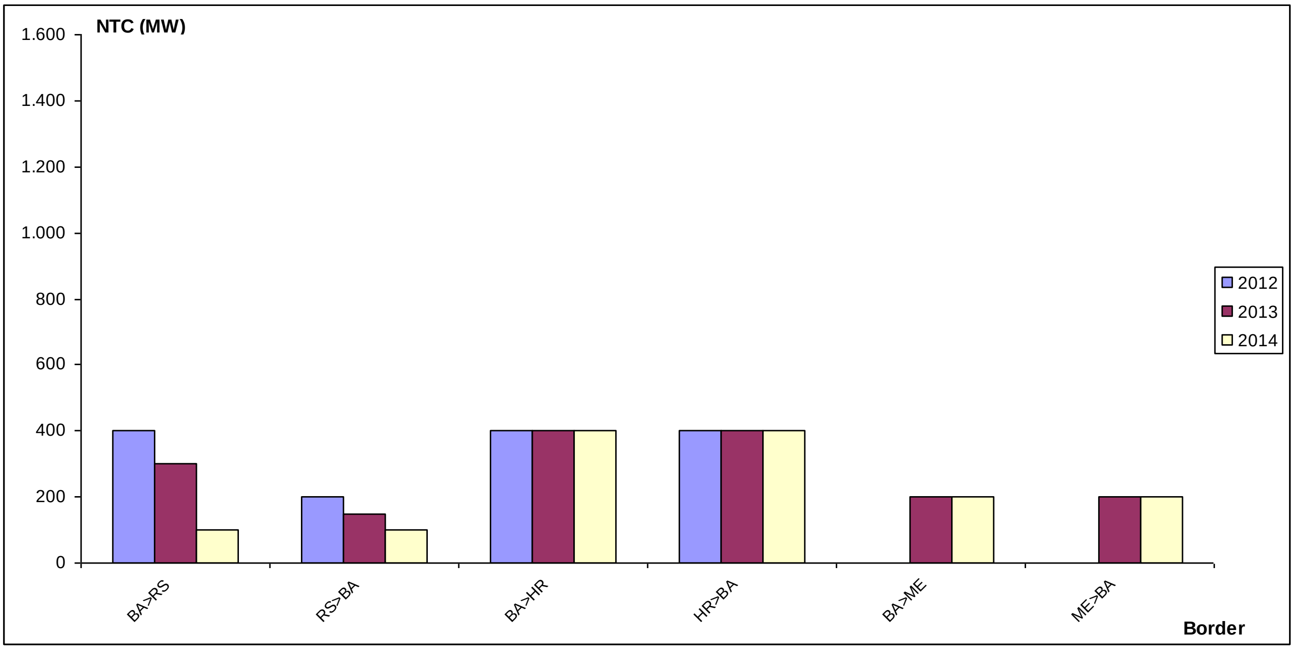


Figure 3.4 Indicative annual NTC values for Bosnia and Herzegovina (2012-2014)

The indicative annual NTC value for BiH/Serbian border was set to 400 MW for the BiH to Serbia direction in 2012, but decreased in 2013 and 2014 to 300 MW and 100 MW respectively. In the opposite direction, the indicative NTC value was set to 200 MW in 2012, 150 MW in 2013 and 100 MW in 2014.

The indicative annual NTC values for the BiH/Montenegrin border were set to 200 MW for both directions in 2013 and 2014. The value for 2012 was not published.

Estimated Month-ahead values for 2014 (January) are larger than the indicative annual NTC values and set to:

BiH/Croatia border	700 MW (for both directions)
BiH/Serbian border	600 MW (for both directions)
BiH/Montenegrin border	not available

Day-ahead values for January 2014 were equal to month-ahead values for the BA/HR and BA/RS borders, while day-ahead values for the BiH/Montenegrin border were defined to 500 MW (from BiH to Montenegro) and 400 MW (from Montenegro to BiH).

The indicative NTC values for winter 2011 and summer 2010 were higher than annual values for the 2012-2014 time period, set to 450 MW-600 MW (BA/HR), 350 MW-500 MW (BA/RS) and 400 MW (BA/ME) for directions of power export from BiH, and 550 MW-600 MW (BA/HR), 350 MW-450 MW (BA/RS) and 400 MW-450 MW (BA/ME) for directions of power import to BiH.

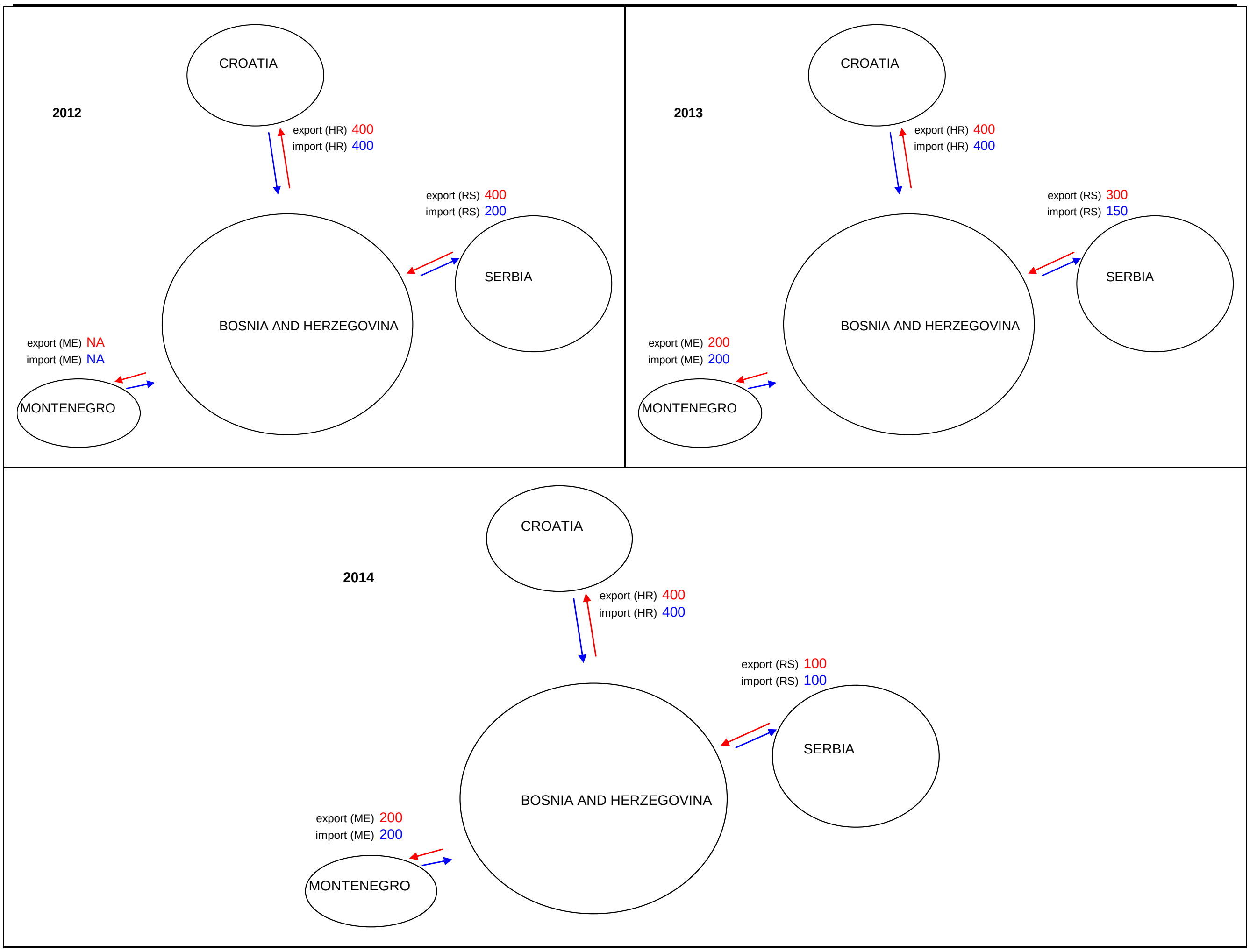


Figure 3.5 Graphical representation of the indicative annual NTC values for Bosnia and Herzegovina

3.3 Bulgaria

The Bulgarian TSO (ESO) shares national borders with Serbia, Romania, Turkey, Greece and Macedonia. The respective borders and directions of possible power exchanges are:

Border	Export (from Bulgaria)	Import (to Bulgaria)
Bulgaria/Greece	BG>GR	GR>BG
Bulgaria/Macedonia	BG>MK	MK>BG
Bulgaria/Serbia	BG>RS	RS>BG
Bulgaria/Romania	BG>RO	RO>BG
Bulgaria/Turkey	BG>TR	TR>BG

The indicative annual NTC value for the Bulgarian/Greek border was set to 250 MW in 2012, 350 MW in 2013 and 400 MW in 2014 for the Bulgaria to Greece direction, and 250 MW in 2012 and 2013 and 300 MW in 2014 for the Greece to Bulgaria direction.

Table 3.3 Indicative annual NTC values for Bulgarian borders (January)

YEAR/BORDER	*BG>GR*	*GR>BG*	*BG>RO*	*RO>BG*	*BG>MK*	*MK>BG*	*BG>RS*	*RS>BG*
2012	250	250	NA	NA	NA	NA	200	100
2013	350	250	NA	NA	NA	NA	200	150
2014	400	300	NA	NA	NA	NA	200	150

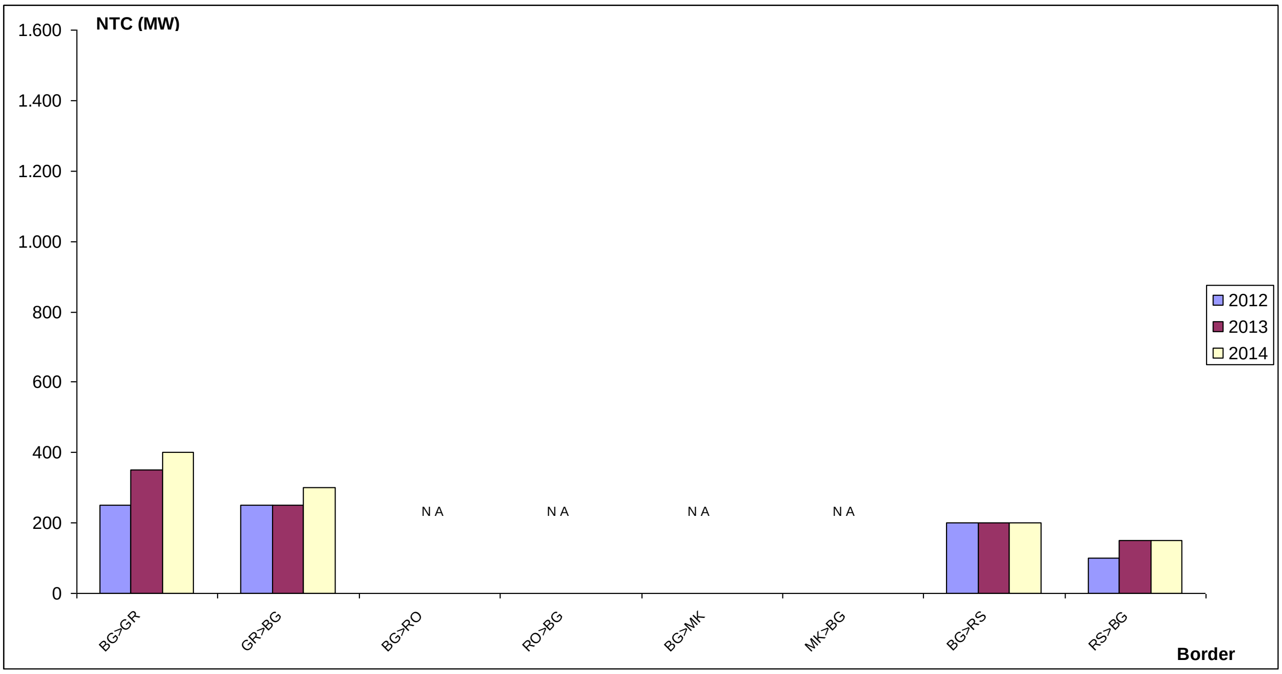


Figure 3.6 Indicative annual NTC values for Bulgaria (2012-2014)

The indicative annual NTC value for the Bulgarian/Serbian border was set to 200 MW in the observed time frame for the Bulgaria to Serbia direction, and 100 MW in 2012 and 150 MW in 2013 and 2014 for the Serbia to Bulgaria direction.

The indicative annual NTC values for the Bulgarian/Romanian border, as well as, month-ahead values for all Bulgarian borders were not published by ENTSO-E.

Day-ahead NTC values in January 2014 were set to:

Bulgaria/Greece border	250 MW (for both directions)
Bulgaria/Macedonia border	150 MW (for BG to MA direction) and 50 MW (for MA to BG direction)
Bulgaria/Serbia border	250 MW (for BG to RS direction) and 200 MW (for RS to BG direction)

The indicative NTC values for winter 2011 and summer 2010 were generally higher than annual values for the 2012-2014 time period, set to 550 MW-800 MW (BG/GR), 400 MW-600 MW (BG/RO), 400 MW-450 MW (BG/RS) and 400 MW-450 MW (BG/MK) for directions of power export from Bulgaria, and 100 MW-500 MW (BG/GR), 400 MW-600 MW (BG/RO), 100 MW-300 MW (BG/RS) and 50 MW-200 MW (BG/MK) for directions of power import to Bulgaria.

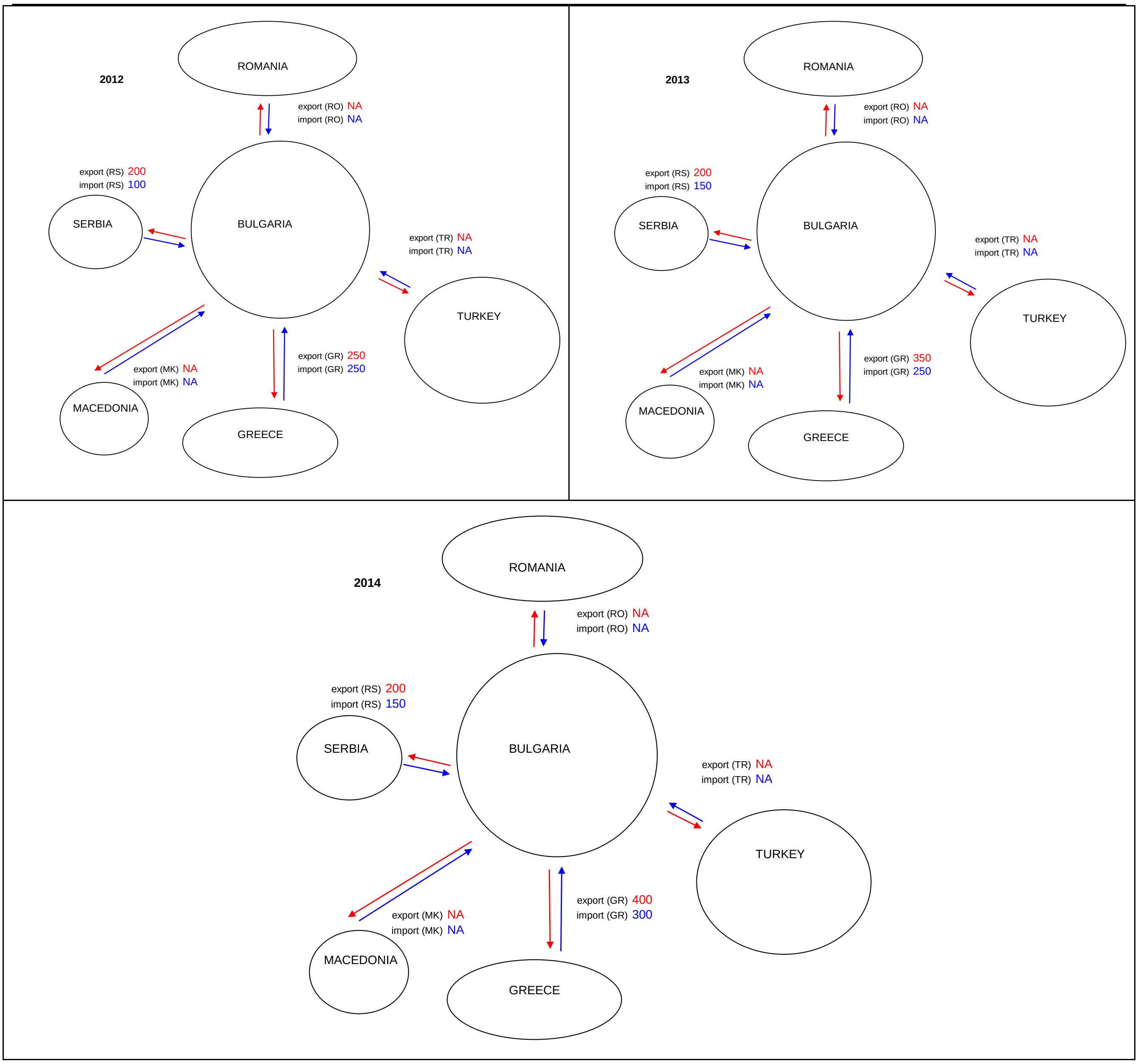


Figure 3.7 Graphical representation of the indicative annual NTC values for Bulgaria

3.4 Croatia

The Croatian TSO (HOPS) shares national borders with Serbia, Hungary, Bosnia and Herzegovina and Slovenia. The respective borders and directions of possible power exchanges are:

Border	Export (from Croatia)	Import (to Croatia)
Croatia/Slovenia	HR>SI	SI>HR
Croatia/Hungary	HR>HU	HU>HR
Croatia/Serbia	HR>RS	RS>HR
Croatia/Bosnia and Herzegovina	HR>BA	BA>HR

The indicative annual NTC value for the Croatian/Bosnian border was set to 400 MW for both directions over the considered time frame.

The indicative annual NTC value for the Croatian/Serbian border was set to 100 MW in the observed time frame for the Croatia to Serbia direction, and 200 MW in 2012, 150 MW in 2013 and 100 MW in 2014 for the Serbia to Croatia direction.

Table 3.4 Indicative annual NTC values for Croatian borders (January)

YEAR/BORDER	HR>BA	BA>HR	HR>RS	RS>HR	HR>HU	HU>HR	HR>SI	SI>HR
2012	400	400	100	200	600	700	600	800
2013	400	400	100	150	600	700	600	800
2014	400	400	100	100	600	700	600	800

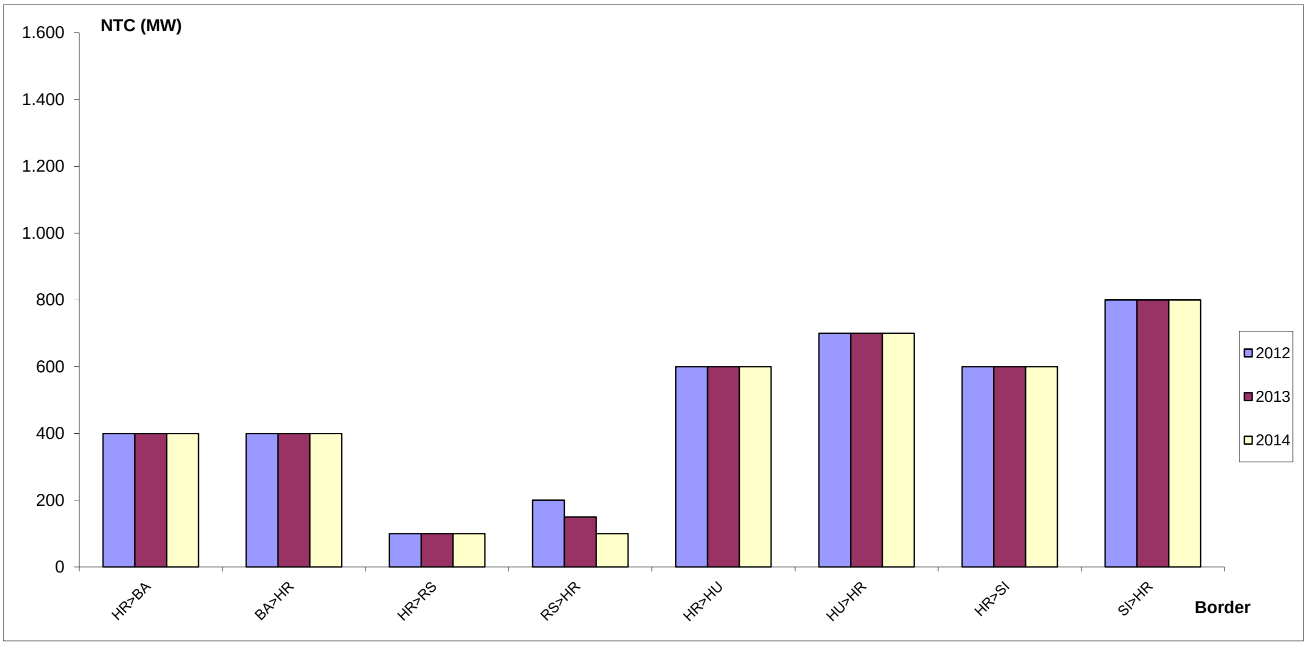


Figure 3.8 Indicative annual NTC values for Croatia (2012-2014)

The indicative annual NTC value for the Croatian/Hungarian border was set to 600 MW for direction from the Croatia to Hungary and 700 MW for the opposite direction, over the considered time frame.

Month-ahead NTC values for January 2014 were set to:

Croatia/BiH border	700 MW (for both directions)
Croatia/Hungary border	700 MW – 1200 MW (for HR to HU direction) and 600 MW – 1000 MW (for HU to HR direction)
Croatia/Serbia border	600 MW (for both directions)
Croatia/Slovenia border	1200 MW (for HR to SI direction) and 950 MW (for SI to HR direction)

Day-ahead NTC values in January 2014 were set to:

Croatia/BiH border	700 MW (for both directions)
Croatia/Hungary border	1000 MW (for HR to HU direction) and 1200 MW (for HU to HR direction)
Croatia/Serbia border	600 MW (for both directions)
Croatia/Slovenia border	1350 MW (for HR to SI direction) and 1150 MW (for SI to HR direction)

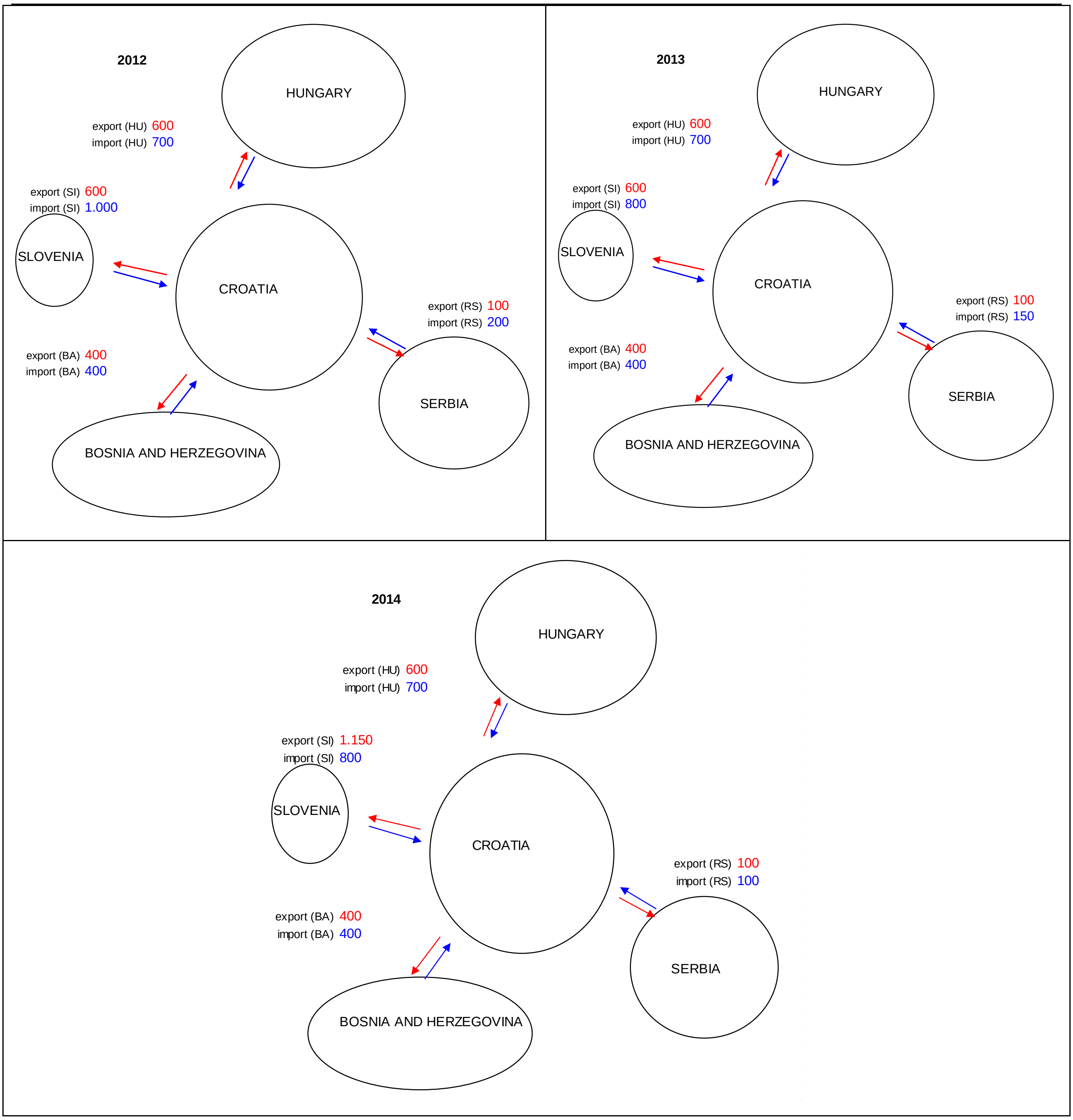


Figure 3.9 Graphical representation of the indicative annual NTC values for Croatia

3.5 Macedonia

The Macedonian TSO (MEPSO) shares national borders with Kosovo, Bulgaria, Greece and Albania. There is no direct transmission line between Macedonia and Albania, so respective borders and directions of possible power exchanges are:

Border	Export (from Macedonia)	Import (to Macedonia)
Macedonia/Kosovo	MK>RS	RS>MK
Macedonia/Bulgaria	MK>BG	BG>MK
Macedonia/Greece	MK>GR	GR>MK

Table 3.5 Indicative annual NTC values for Macedonian borders (January)

YEAR/BORDER	MK>BG	BG>MK	MK>RS	RS>MK	MK>GR	GR>MK
2012	NA	NA	250	250	150	300
2013	NA	NA	200	300	200	300
2014	NA	NA	100	150	250	350

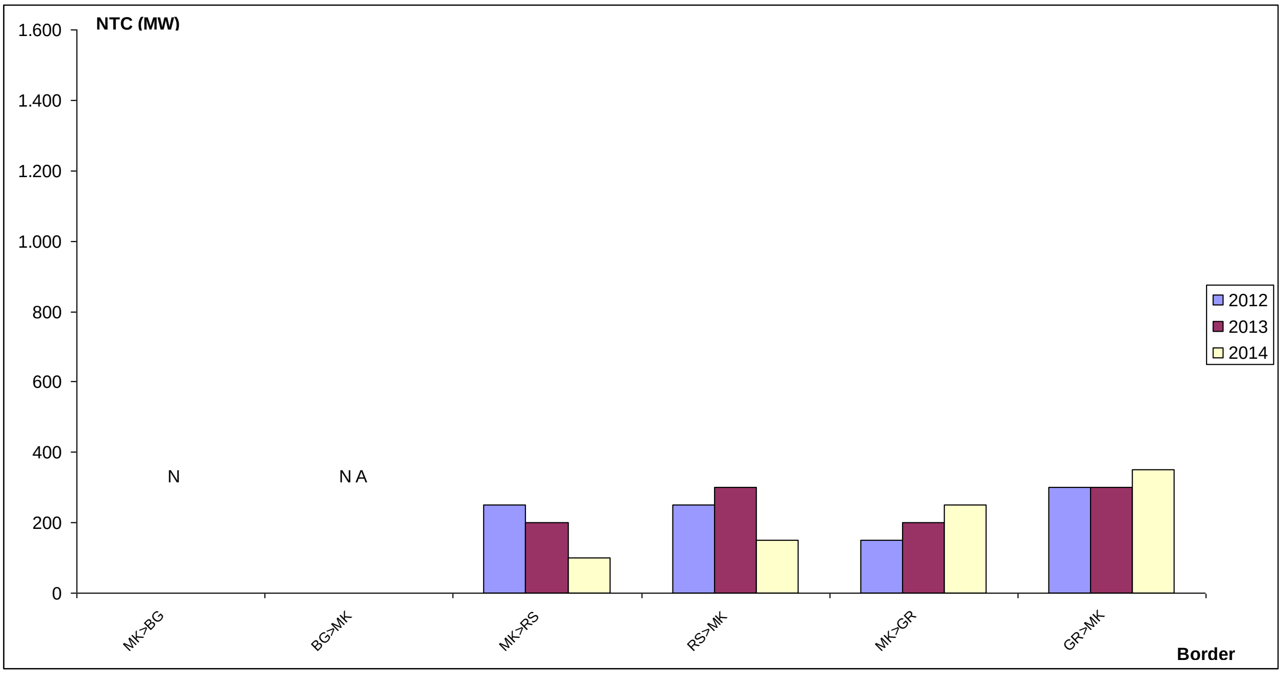


Figure 3.10 Indicative annual NTC values for Macedonia (2012-2014)

The indicative annual NTC value for the Macedonian/Kosovan border was set to 250 MW for both directions in 2012, 200 MW (MK to RS direction) and 300 MW (RS to Macedonia direction) in 2013, and 100 MW (MK to RS direction) and 150 MW (RS to Macedonia direction) in 2014.

The indicative annual NTC value for the Macedonian/Greek border was set to 150 MW for the MK to GR direction and 300 MW for the GR to MK direction in 2012, 200 MW (MK to GR direction) and 300 MW (Greece to Macedonia direction) in 2013, 250 MW (MK to GR direction) and 350 MW (GR to Macedonia direction) in 2014.

The indicative annual NTC values for the Macedonian/Bulgarian border, as well as month-ahead values for all Macedonian borders, were not published by ENTSO-E.

Day-ahead NTC values in January 2014 were set to:

Macedonia/Bulgaria border	50 MW (for MK to BG direction) and 150 MW (for BG to MK direction)
Macedonia/Greece border	170 MW (for MK to GR direction) and 350 MW (for GR to MK direction)
Macedonia/Kosovo border	250 MW (for MK to RS direction) and 700 MW (for RS to MK direction)

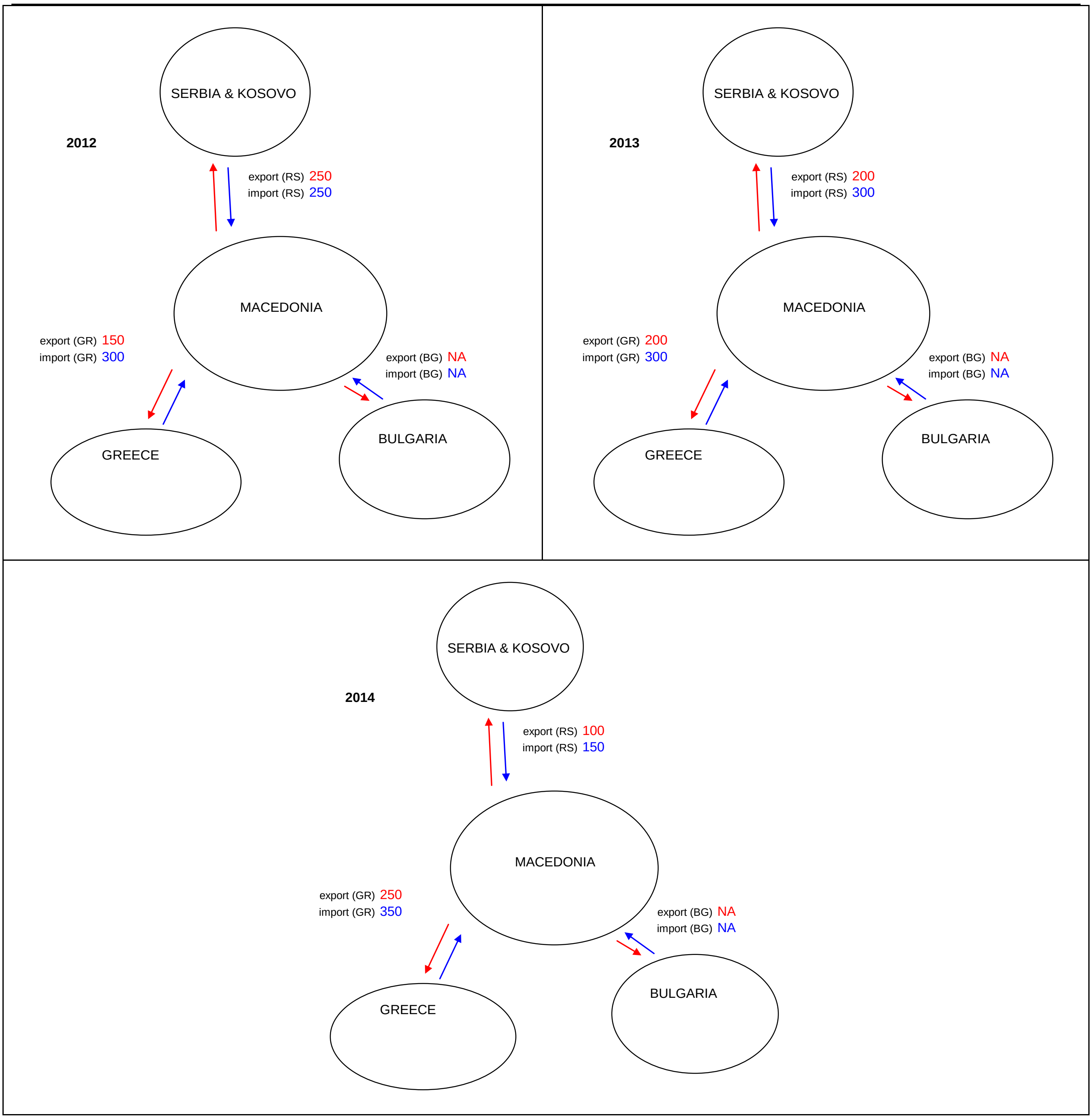


Figure 3.11 Graphical representation of the indicative annual NTC values for Macedonia

3.6 Montenegro

The Montenegrin TSO (CGES) shares national borders with Kosovo, Serbia, Bosnia and Herzegovina and Albania. The respective borders and directions of possible power exchanges are:

Border	Export (from Montenegro)	Import (to Montenegro)
Montenegro/Kosovo & Serbia	ME>RS	RS>ME
Montenegro/BiH	ME>BA	BA>ME
Montenegro/Albania	ME>AL	AL>ME

Table 3.6 Indicative annual NTC values for Montenegrin borders (January)

YEAR/BORDER	ME>AL	AL>ME	ME>BA	BA>ME	ME>RS	RS>ME
2012	NA	NA	NA	NA	400	300
2013	NA	NA	200	200	300	250
2014	NA	NA	200	200	200	200

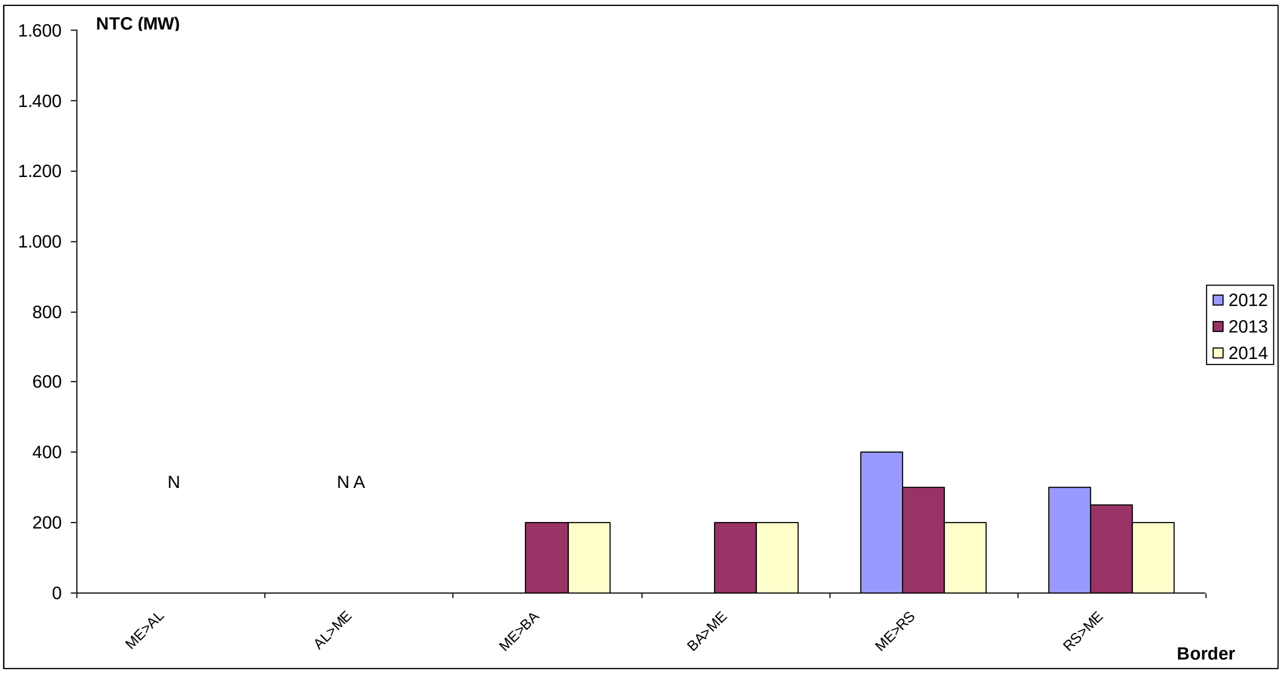


Figure 3.12 Indicative annual NTC values for Montenegro (2012-2014)

The indicative annual NTC value for the Montenegrin/Kosovan and Serbian border was set to 400 MW for the Montenegro to Kosovo and Serbia direction and 300 MW for the opposite direction in 2012, 300 MW (ME to RS direction) and 250 MW (RS to Montenegro direction) in 2013, and 200 MW for both directions in 2014.

The indicative annual NTC value for the Montenegrin/Bosnian and Herzegovinian border was set to 200 MW for both directions in 2013 and 2014

The indicative annual NTC values for the Montenegrin/Albanian border, as well as month-ahead values for all Montenegrin borders, were not published by ENTSO-E.

Day-ahead NTC values in January 2014 were set to:

Montenegro/BiH border	400 MW (for ME to BA direction) and 500 MW (for BA to ME direction)
Montenegro/Serbia & Kosovo border	600 MW (for ME to RS direction) and 700 MW (for RS to ME direction)

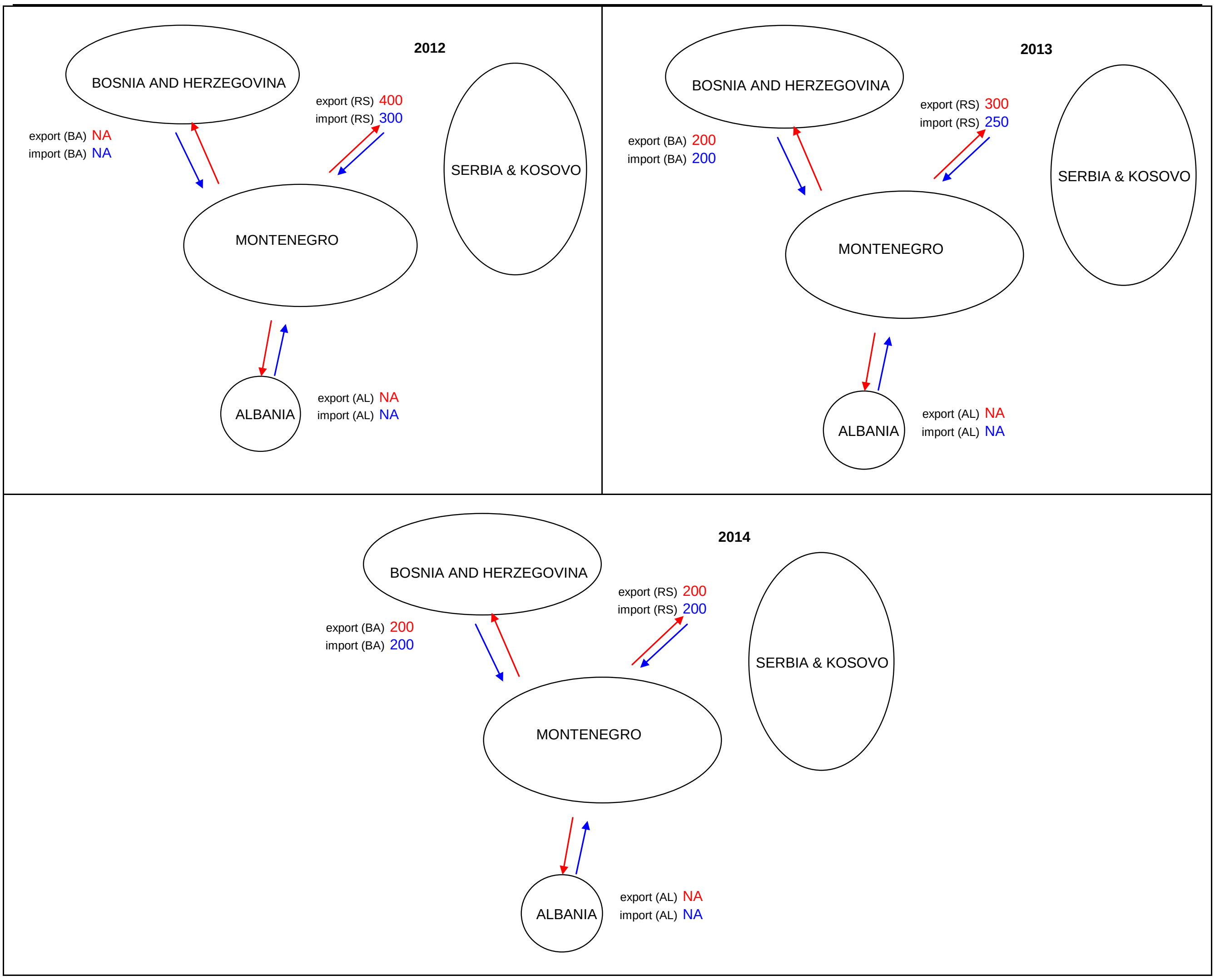


Figure 3.13 Graphical representation of the indicative annual NTC values for Montenegro

3.7 Romania

The Romanian TSO (Transelectrica) shares national borders with Serbia, Hungary, Ukraine, Moldova and Bulgaria. Since Moldova is operating in another synchronous zone, respective borders and directions of possible power exchanges are:

Border	Export (from Romania)	Import (to Romania)
Romania/Ukraine	RO>UA	UA>RO
Romania/Hungary	RO>HU	HU>RO
Romania/Serbia	RO>RS	RS>RO
Romania/Bulgaria	RO>BG	BG>RO

The indicative annual NTC value for the Romanian/Hungarian border was set to 200 MW for the direction from Romania to Hungary and 150 MW for the opposite direction in 2012 and 2014, and 250 MW for both directions in 2014.

The indicative annual NTC value for the Romanian/Serbian border was set to 250 MW for the direction from Romania to Serbia and 100 MW for the opposite direction in 2012, 250 MW for direction from Romania to

Serbia and 150 MW for the opposite direction in 2013, 150 MW and 100 MW for directions RO to RS and RS to RO respectively in 2014.

Table 3.7 Indicative annual NTC values for Romanian borders (January)

YEAR/BORDER	RO>RS	RS>RO	RO>HU	HU>RO	RO>BG	BG>RO	RO>UA	UA>RO
2012	250	100	200	150	NA	NA	NA	NA
2013	250	150	200	150	NA	NA	NA	NA
2014	150	100	250	250	NA	NA	NA	NA

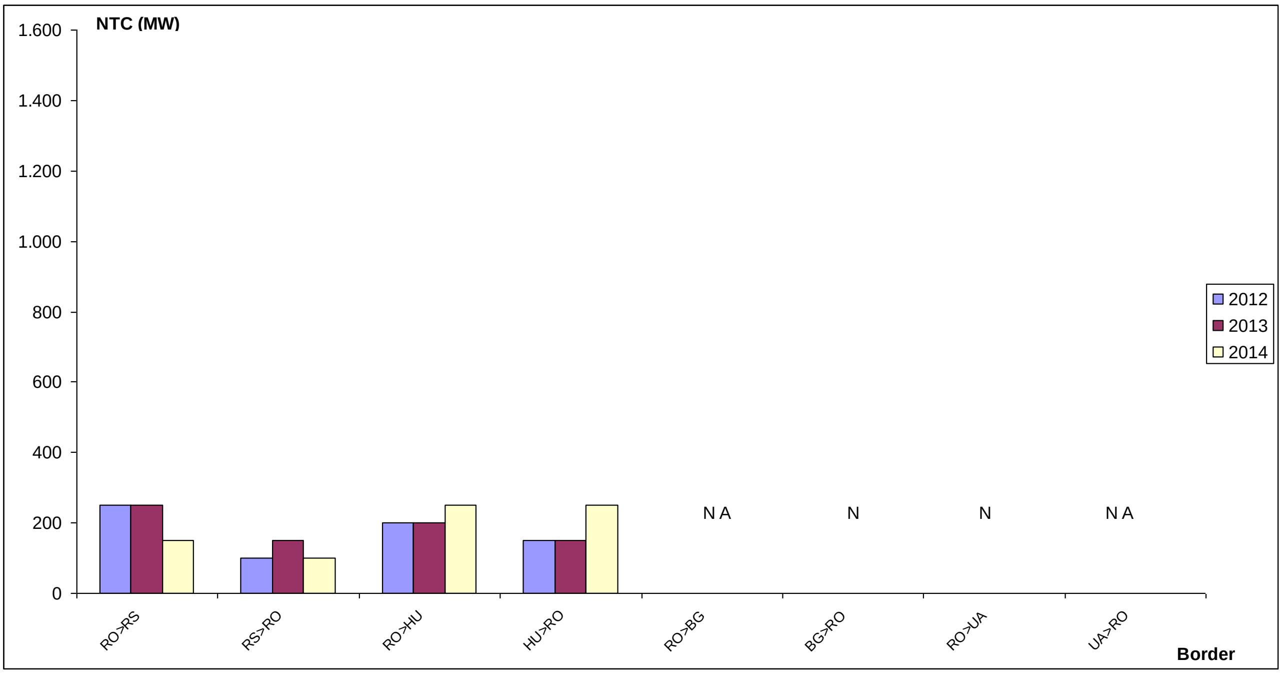


Figure 3.14 Indicative annual NTC values for Romania (2012-2014)

The indicative annual NTC values for the Romanian/Bulgarian and the Romanian/Ukraine border were not published by the ENTSO-E.

The month-ahead NTC values were also not published by the ENTSO-E.

The day-ahead NTC values in January 2014 were published for the Romania/Serbian border only, and set to 600 MW for the Romania to Serbia direction and 300 MW for the Serbia to Romania direction.

Transelectrica remark:

Romania seasonal and monthly NTCs vary from winter to summer due to:
- seasonal changes of protection settings in neighbor TN;
- increased maintenance scheduling in summer;
- seasonal evolution of deficit in some significant internal areas; seasonal evolution of partners exchanges, etc.

Please note that the SEE indicative yearly values were defined based on minimum values from the monthly firm NTC values in the previous year, so they indicate the reliable values in the next year for any maintenance schedules (not the maximum or average yearly values). Firm monthly NTC profiles, computed using monthly models (with resolution down to day and intra-month updating), are generally significantly higher.

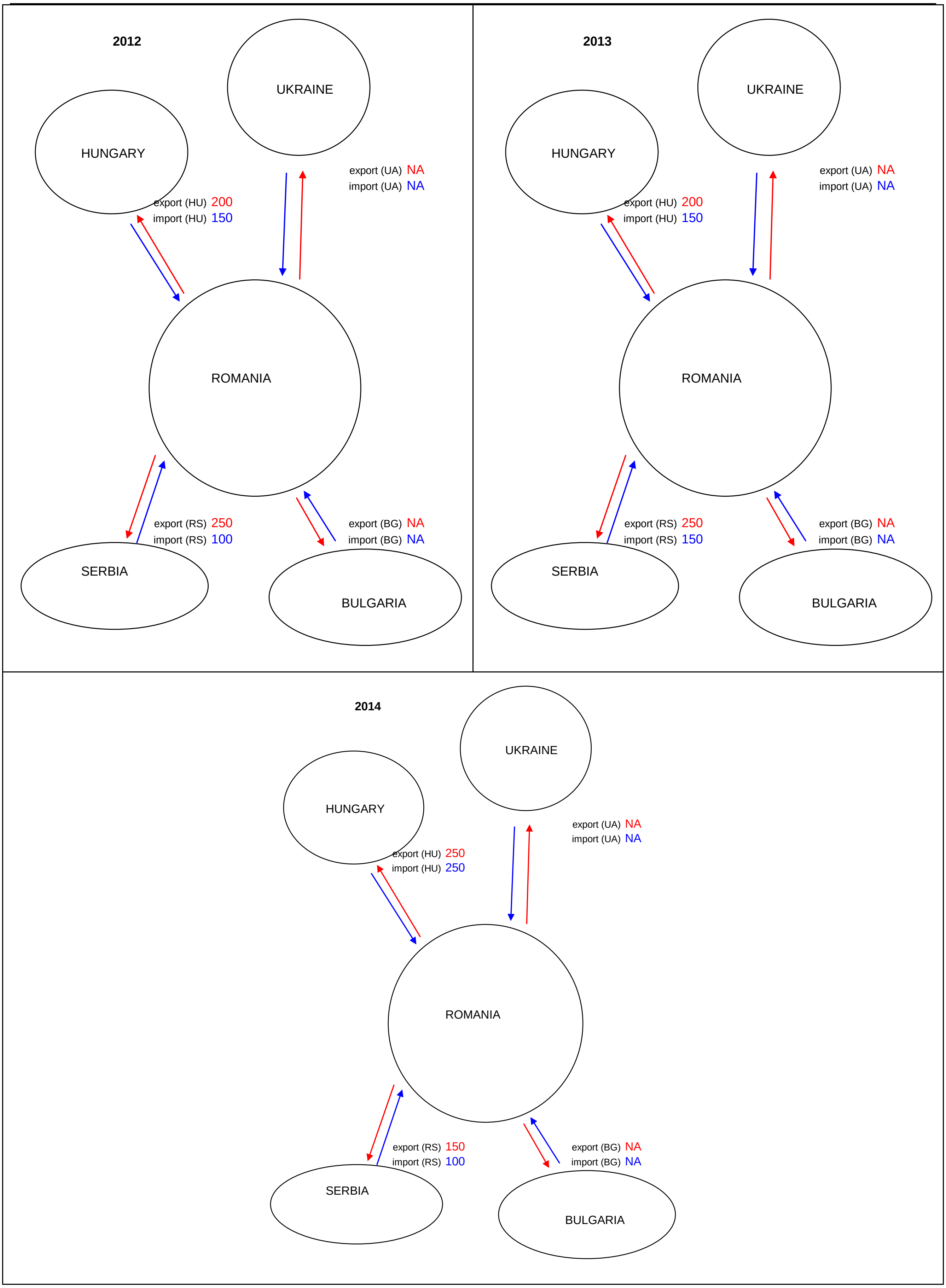


Figure 3.15 Graphical representation of the indicative annual NTC values for Romania

3.8 Serbia & Kosovo

The Serbian TSO (EMS) and the Kosovo TSO (KOSTT) share national borders with Albania, Bosnia and Herzegovina, Croatia, Hungary, Romania, Bulgaria, Macedonia and Montenegro. The respective borders and directions of possible power exchanges are:

Border	Export (from Serbia&Kosovo)	Import (to Serbia&Kosovo)
Serbia /Croatia	RS>HR	HR>RS
Serbia /Hungary	RS>HU	HU>RS
Serbia /Romania	RS>RO	RO>RS
Serbia /Bulgaria	RS>BG	BG>RS
Kosovo/Macedonia	RS>MK	MK>RS
Serbia & Kosovo/Montenegro	RS>ME	ME>RS
Kosovo/Albania	RS>AL	AL>RS
Serbia/Bosnia and Herzegovina	RS>BA	BA>RS

The indicative annual NTC value for the Kosovon/Albanian border for the direction from Kosovo to Albania was set to 100 MW in 2012, 210 MW in 2013 and 50 MW for 2014. For the opposite direction (from Albania to Kosovo), annual indicative NTC values were defined to be 210 MW in 2012, 150 MW in 2013 and 50 MW in 2014.

The indicative annual NTC values for the Serbian & Kosovan/Montenegrin border have gradually decreased for the Serbia & Kosovo direction to Montenegro, from 300 MW in 2012, 250 MW in 2013 to 200 MW in 2014. The same is true for the Montenegro to Serbia & Kosovo direction, where the NTC values have decreased from 400 MW in 2012 to 200 MW in 2014.

Table 3.8 Indicative annual NTC values (MW) for Serbia&Kosovo borders (January)

YEAR/BORDER	RS>AL	AL>RS	RS>ME	ME>RS	RS>BA	BA>RS	RS>BG	BG>RS
2012	100	210	300	400	200	400	100	200
2013	210	150	250	300	150	300	150	200
2014	50	50	200	200	100	100	150	200

YEAR/BORDER	HR>RS	RS>HR	RS>MK	MK>RS	RS>RO	RO>RS	RS>HU	HU>RS
2012	100	200	250	250	100	250	600	200
2013	100	150	300	200	150	250	700	200
2014	100	100	150	100	100	150	300	300

For Serbian/Bosnian and Herzegovinian border, indicative annual NTC values were set to 200 MW, 150 MW and 100 MW in observed time frame for the direction from Serbia to Bosnia and Herzegovina, and 400 MW, 300 MW and 100 MW for the opposite direction.

The indicative annual NTC values for the Serbian/Bulgarian border were set to 200 MW over considered time period for direction to Serbia. For the opposite direction, the NTC values were set to 100 MW in 2012 and 150 MW in 2013 and 2014.

Considering the Serbian/Croatian border, the NTC values the for direction to Croatia were set to 100 MW over the observed time period, while for the opposite direction, these values have gradually decreased from 200 MW in 2012 to 100 MW in 2014.

The net transfer capacities of 250 MW, 300 MW and 150 MW were defined for the Kosovan/Macedonian border for the direction to Macedonia and 250 MW, 200 MW and 100 MW for the direction to Kosovo.

The indicative NTC values for the Serbia/Romanian border were also limited to the maximum value of 250 MW (Romania to Serbia direction) in 2012 and 2013 but decreased to 150 MW in 2014, while for the opposite direction these values were set to 100 MW (2012 and 2014) and 150 MW (2013).

Observing the Serbia/Hungarian border, indicative NTC values were set to 600 MW in 2012, 700 MW in 2013 and 300 MW in 2014 for the direction from Serbia to Hungary and 200 MW (2012 and 2013) to 300 MW for the direction from Hungary to Serbia.

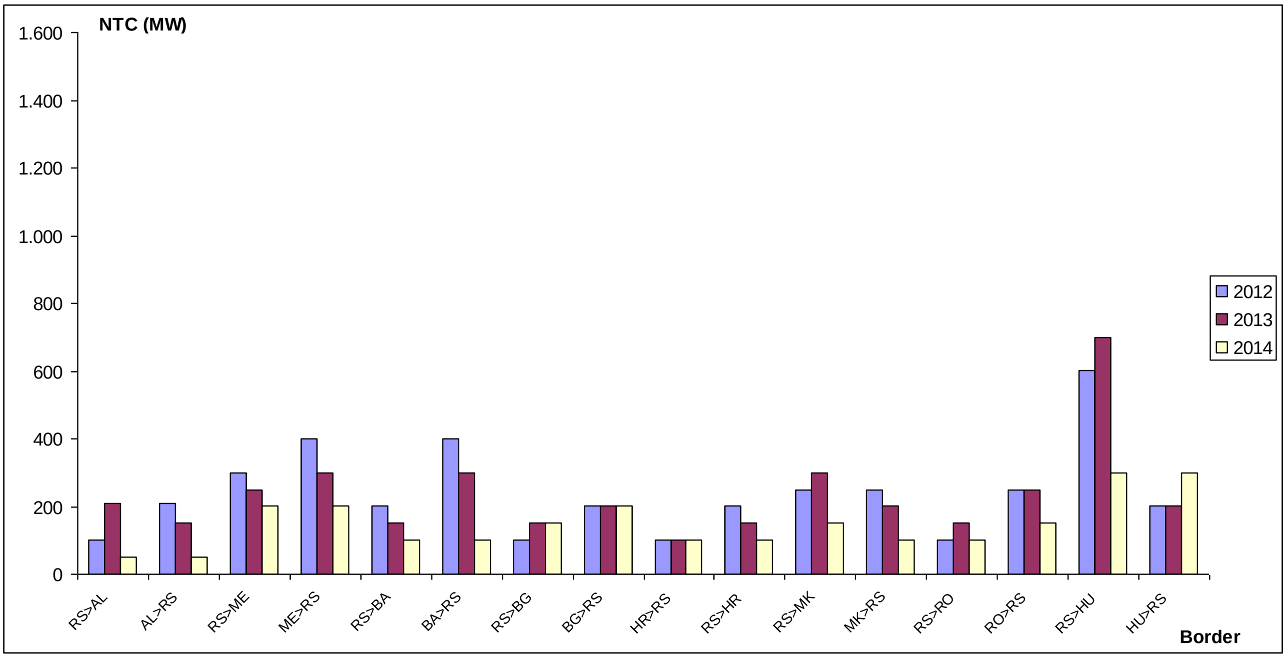


Figure 3.16 Indicative annual NTC values for Serbia & Kosovo (2012-2014)

The month-ahead NTC values are published for some Serbia & Kosovo borders and these values are significantly higher than the indicative annual values (referring to December 2013 and January 2014):

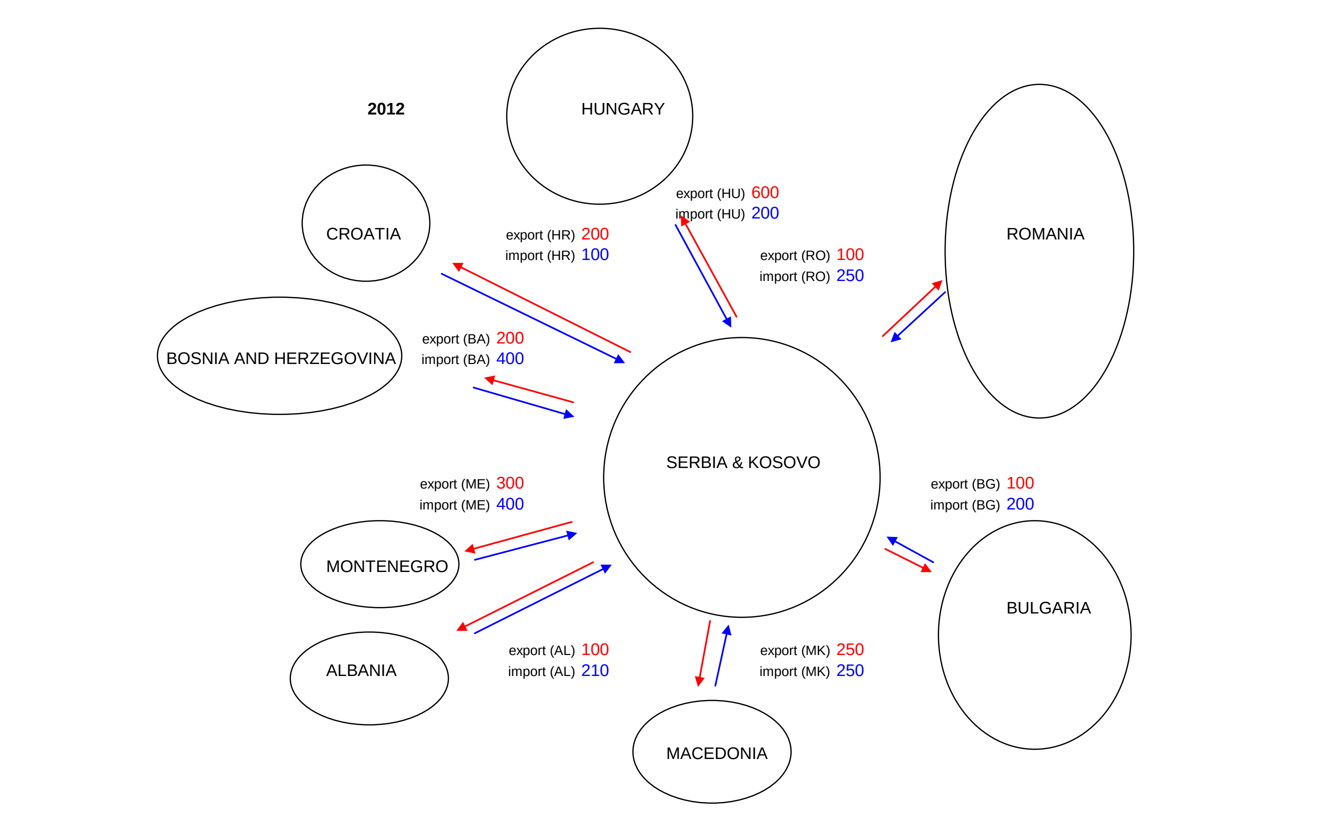
RS/BiH border	600 MW (for both directions)
RS/HR border	500 MW - 600 MW (for both directions)
RS/HU border	700 MW to 1000 MW (for Hungary to Serbia direction) and 800 MW – 1000 MW (for Serbia to Hungary direction)
RS/AL border	250 MW (for both directions)
RS/MK border	250 MW (for MK to RS direction) and 600 MW (for RS to MK direction)

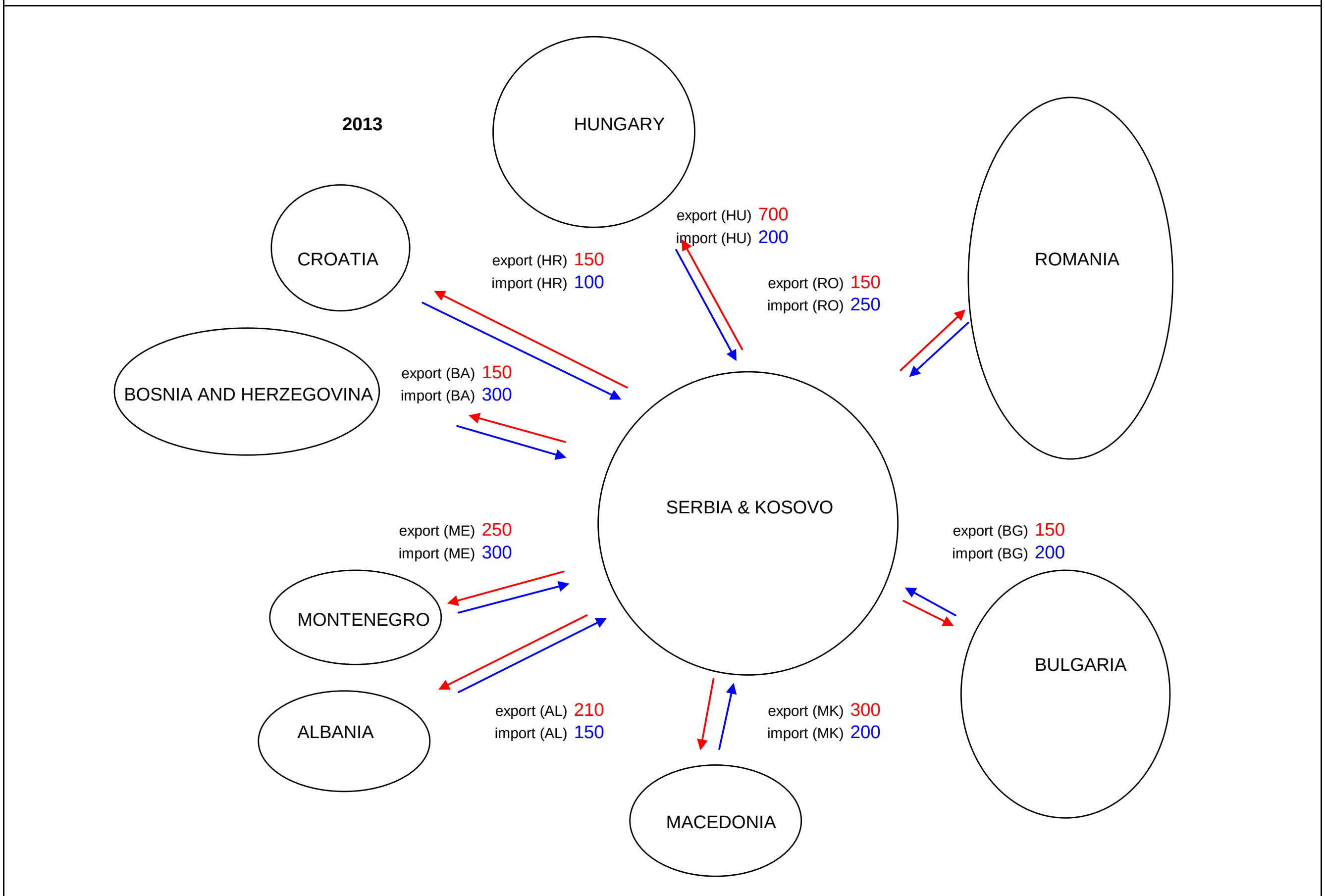
Day-ahead NTC values in January 2014 were also published for all Serbia & Kosovo borders:

Table 3.9 Day-ahead NTC values (MW) for Serbia & Kosovo borders (January 8, 2014, Wednesday)

BORDER	***RS>AL***	***AL>RS***	***RS>ME***	***ME>RS***	***RS>BA***	***BA>RS***	***RS>BG***	***BG>RS***
NTC (MW)	250	250	700	600	600	600	200	250

BORDER	***HR>RS***	***RS>HR***	***RS>MK***	***MK>RS***	***RS>RO***	***RO>RS***	***RS>HU***	***HU>RS***
NTC (MW)	600	600	700	250	300	600	800	700


2012
HUNGARY
CROATIA
ROMANIA
BOSNIA AND HERZEGOVINA
SERBIA & KOSOVO
MONTENEGRO
ALBANIA
BULGARIA
MACEDONIA
export (HU) 600
import (HU) 200
export (HR) 200
import (HR) 100
export (RO) 100
import (RO) 250
export (BA) 200
import (BA) 400
export (ME) 300
import (ME) 400
export (BG) 100
import (BG) 200
export (AL) 100
import (AL) 210
export (MK) 250
import (MK) 250


2013
HUNGARY
CROATIA
ROMANIA
BOSNIA AND HERZEGOVINA
SERBIA & KOSOVO
MONTENEGRO
ALBANIA
BULGARIA
MACEDONIA
export (HU) 700
import (HU) 200
export (HR) 150
import (HR) 100
export (RO) 150
import (RO) 250
export (BA) 150
import (BA) 300
export (ME) 250
import (ME) 300
export (BG) 150
import (BG) 200
export (AL) 210
import (AL) 150
export (MK) 300
import (MK) 200

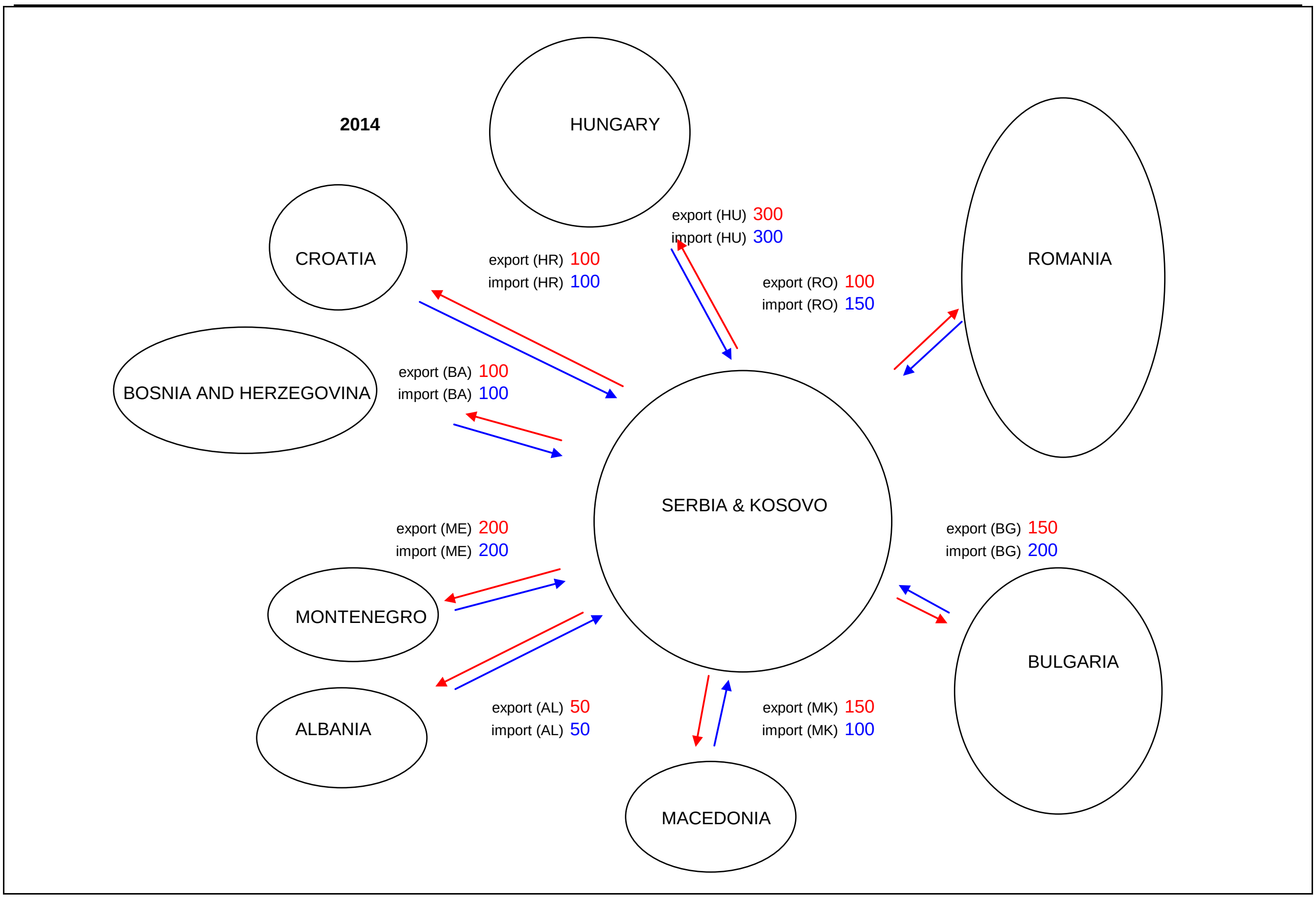


Figure 3.17 Graphical representation of the indicative annual NTC values for Serbia&Kosovo

3.9 Slovenia

The Slovenian TSO (ELES) shares national borders with Croatia, Hungary, Austria and Italy. There is no electrical connection between Slovenia and Hungary, so respective borders and directions of possible power exchanges are:

Border	Export (from Slovenia)	Import (to Slovenia)
Slovenia/Croatia	SI>HR	HR>SI
Slovenia/Austria	SI>AT	AT>SI
Slovenia/Italy	SI>I	I>SI

Table 3.10 Indicative annual NTC values for Slovenian borders (January)

YEAR/BORDER	SI>AT	AT>SI	SI>HR	HR>SI	SI>IT	IT>SI
2012	950	950	800	600	81	120
2013	950	950	800	600	79	120
2014	950	950	800	600	87	620

The indicative annual NTC value for the Slovenian/Austrian border was set to 950 MW for both directions in observed time frame.

The indicative annual NTC values for the Slovenian/Croatian border was set to be 800 MW for the Slovenia to Croatia direction, and 600 MW for the opposite direction.

The indicative annual NTC values for the Slovenian/Italian border were around 80 MW for the Slovenia to Italy direction, and 120 MW to 620 MW for the Italy to Slovenia direction. This is the only border in the region where load flows may be controlled by phase-shift transformers in Divaca (Slovenia) and Padriciano (Italy).

The month-ahead and day-ahead NTC values in January 2014 were similar to indicative annual NTC values for borders to Austria and Croatia, while the NTC values related to Italian border were increased up to 520 MW for Slovenia to Italy direction (month-ahead), and very variable on a daily level.

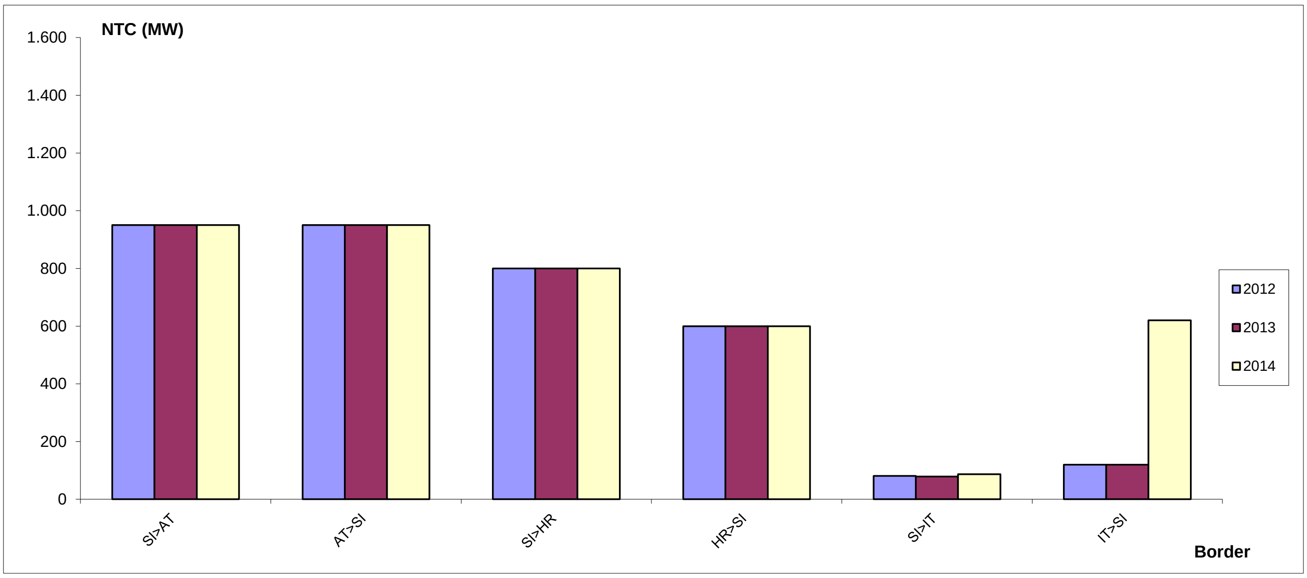


Figure 3.18 Indicative annual NTC values for Slovenia (2012-2014)

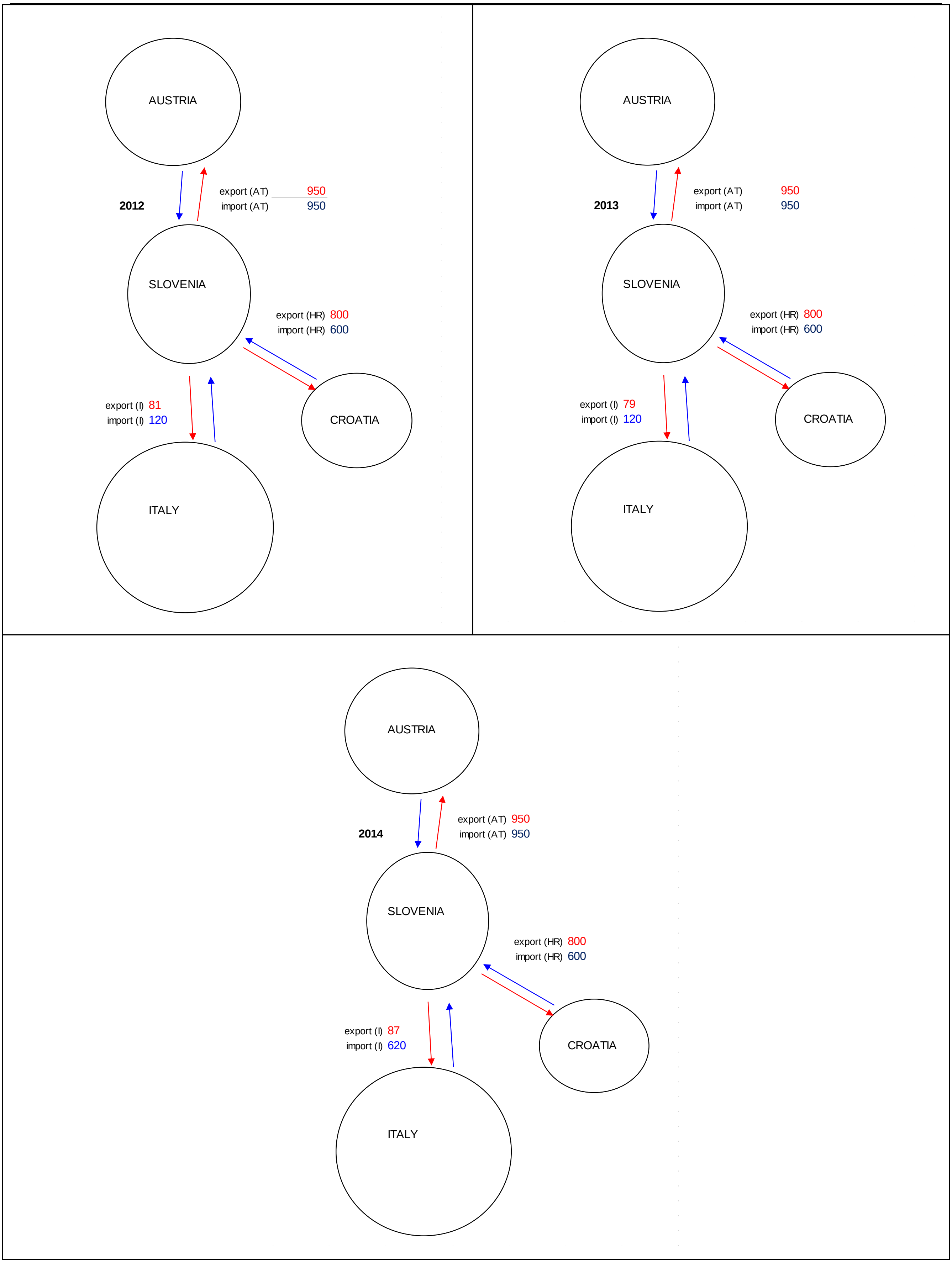


Figure 3.19 Graphical representation of the indicative annual NTC values for Slovenia

4. REGIONAL TRANSMISSION NETWORK MODEL

The network topology and operational conditions assumed in the model used to conduct this study correspond to the actual situation in the SEE network on January 14, 2012, at 12:40 pm. The model was prepared by the EKC – Belgrade in the PSS/E format. It was later used as the base case model for the NTC value calculations.

The PSS/E model of the SEE transmission network includes complete representation of 400 kV, 220 kV, 150 kV and 110 kV networks of:

Observed countries
Albania,
Bosnia and Herzegovina,
Bulgaria,
Croatia,
Macedonia,
Montenegro,
Romania,
Serbia and Kosovo (one area at the model with two separate zones),
Slovenia,
Turkey.

Surrounding countries
Greece,
Western Ukraine,
Hungary,
Austria, and
Italy.

The model is prepared, according to SECI standards previously used for short-term and long-term planning model preparation, with power plants modeled as groups of generators and unit transformers, and load modeled on 110 kV (150 kV) busbars.

The total load of observed countries in the model is around 57 GW (with Turkey) or 26 GW (without Turkey). Total generation was modeled to 56 GW within observed countries (including Turkey) or 25 GW (without Turkey), meaning that the observed region is importing around 2 GW.

Individual system loads vary from 0,5 GW (Montenegro) to 6,2 GW (Romania) and 20 GW (Turkey). The generation capacity of the region also varies between 0,25 GW (Montenegro) to 6,4 GW (Romania) and 31 GW (Turkey).

Within the model, the importing countries are Albania (imports 483 MW), Bosnia and Herzegovina (30 MW), Croatia (918 MW), Macedonia (335 MW), Montenegro (296 MW), Serbia and Kosovo (554 MW) and Slovenia (81 MW).

Exporting countries are Bulgaria (exports 846 MW), Romania (113 MW) and Turkey (81 MW).

The operational conditions and network element loadings in the base case (interconnection lines, internal networks) are presented for each SEE country in the following chapters. The presentation of individual countries' 400 kV and 220 kV interconnection lines is also given, along with their base case loading and modeled ratings. Finally, the comparison between individual interconnection line ratings and indicative annual NTC values is given.

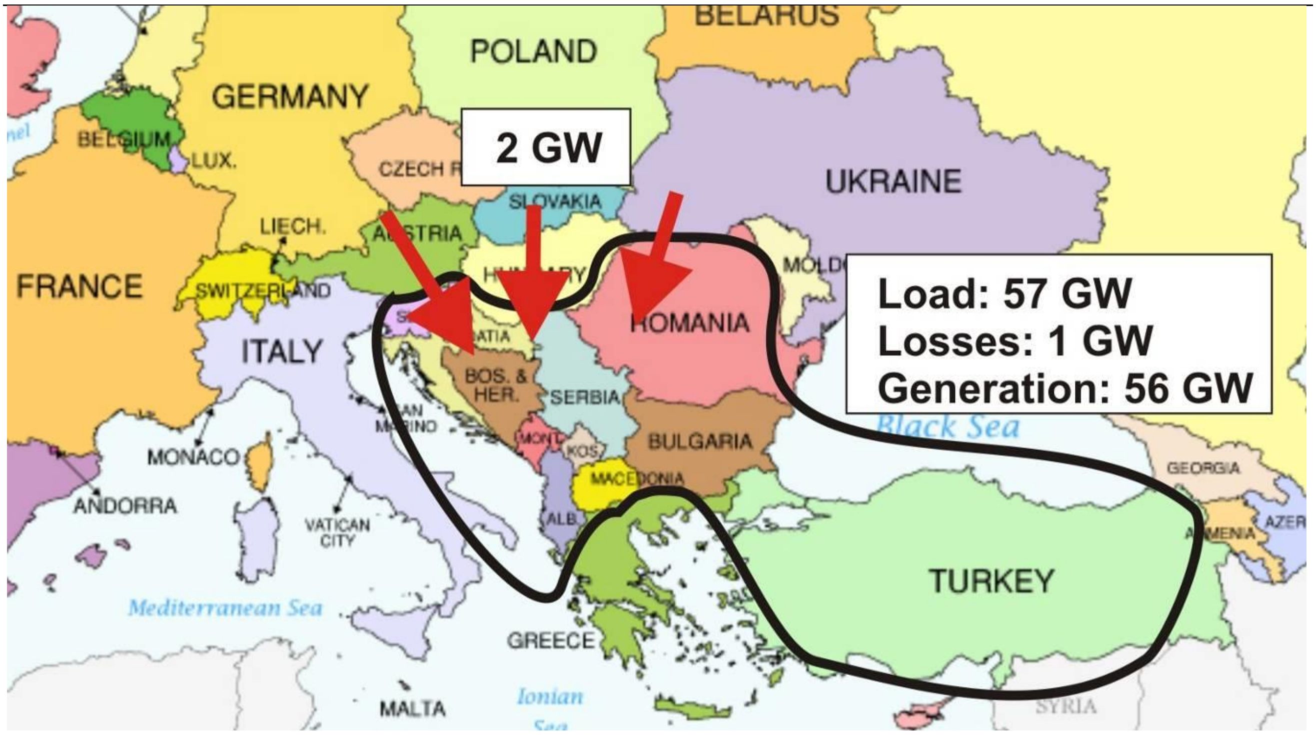


Figure 4.1 Power balance for the SEE region at the base case model in 2012

X-- AREA --X	FROM GENE-RATION	FROM IND GENERATN	TO IND MOTORS	TO LOAD	TO BUS SHUNT	TO GNE BUS DEVICES	TO LINE SHUNT	FROM CHARGING	TO LOSSES	-NET INTERCHANGE- TO TIE LINES	TO TIES + LOADS	DESIRED NET INT
10	672.6	0.0	0.0	1115.4	0.0	0.0	3.3	0.0	36.9	-483.0	-483.0	-483.0
AL	421.4	0.0	0.0	403.8	-70.7	0.0	17.9	357.1	357.8	69.8	69.8	
13	1680.1	0.0	0.0	1670.5	0.0	0.0	0.0	0.0	39.6	-30.1	-30.1	-30.0
BA	164.3	0.0	0.0	437.6	0.0	0.0	0.0	857.4	387.5	196.6	196.6	
14	6372.6	0.0	0.0	5393.0	0.0	0.0	16.8	0.0	116.7	846.1	846.1	846.0
BG	1024.6	0.0	0.0	1878.1	-57.7	0.0	151.1	2467.1	1542.0	-21.9	-21.9	
16	1292.5	0.0	0.0	2166.0	0.0	0.0	2.3	0.0	42.2	-918.0	-918.0	-918.0
HR	151.7	0.0	0.0	168.5	114.0	0.0	14.1	1209.4	402.1	662.4	662.4	
37	934.5	0.0	0.0	1246.7	0.0	0.0	1.7	0.0	21.1	-335.0	-335.0	-335.0
MK	238.0	0.0	0.0	369.3	0.0	0.0	7.6	354.2	204.2	11.1	11.1	
38	253.3	0.0	0.0	535.0	0.0	0.0	1.5	0.0	12.8	-296.0	-296.0	-296.0
ME	129.9	0.0	0.0	182.0	0.0	0.0	11.0	231.7	118.6	50.1	50.1	
44	6410.8	0.0	0.0	6283.7	0.0	0.0	81.4	0.0	112.6	-66.9	-66.9	-67.0
RO	-200.5	0.0	0.0	2380.3	290.8	0.0	225.4	4773.2	1564.0	112.2	112.2	
46	5761.3	0.0	0.0	6160.7	0.0	0.0	14.5	0.0	140.1	-554.0	-554.0	-554.0
RS	1317.0	0.0	0.0	1677.5	0.0	0.0	54.7	1485.5	1584.6	-514.4	-514.4	
49	1663.6	0.0	0.0	1794.1	0.0	0.0	7.9	0.0	22.6	-161.0	-161.0	-161.0
SI	-439.0	0.0	0.0	255.4	0.0	0.0	52.6	761.1	313.2	-299.1	-299.1	
54	31235.3	0.0	0.0	30376.2	0.0	0.0	0.0	0.0	778.1	81.0	81.0	81.0
TR	1709.5	0.0	0.0	3024.0	2945.9	0.0	0.0	13214.6	9094.8	-140.6	-140.6	
COLUMN	56276.6	0.0	0.0	56741.4	0.0	0.0	129.3	0.0	1322.8	-1917.0	-1917.0	-1917.0
TOTALS	4516.8	0.0	0.0	10776.4	3222.3	0.0	534.3	25711.3	15568.9	126.2	126.2	

Figure 4.2 Loads, generation and net interchanges of observed countries at the SEE PSS/E model for January 2012

4.1 Albania

The Albanian power system is modeled with the following operational conditions:

Generation: 672,6 MW
Load: 1115,4 MW
Losses: 36,9 MW
Net interchange: -483 MW (import)

Important parameters for the TTC values calculation are:

ΔE_{max}^{+} = 173 MW
(possible generation increase up to P_{max} of all modeled generators which are in operation)

In order to perform the NTC calculations for 2012 according to the ENTSO-E methodology possible generation shift in Albania was increased up to 780 MW at the model.

MAX (ΔE_{max}^{+}) = 2377,6 MW
(possible generation increase up to P_{max} of all modeled generators)

ΔE_{max}^{-} = 210,6 MW
(possible generation decrease up to P_{min} of all modeled generators which are in operation)

MAX (ΔE_{max}^{-}) = 1964,8 MW
(possible generation decrease up to P_{min} of all modeled generators)

In the base case, loadings of all network elements are within acceptable limits. Security criterion N-1 is not fulfilled in the base case for the Albanian network. The critical contingences comprise of some transformers at lines 220/110 kV, lines 220 kV and 110 kV. All critical lines are located in the Albanian internal network.

```
<----------- C O N T I N G E N C Y   E V E N T S ----------><--------- O V E R L O A D E D   L I N E S ----------> <- MVA(MW)FLOW ->
     <----------- MULTI-SECTION LINE GROUPINGS -----------> <------- F R O M -------> <--------- T O --------->CKT  PRE-CNT  POST-CNT  RATING  PERCENT
                                                           -----------------------------------------------CONTINGENCY SINGLE 102010-105060-104081(1)
OPEN LINE FROM BUS 102010 [AVDEJA2     220.00] TO BUS 105060 [AVDEJS51     110.00] TO BUS 104081 [AVDEJS_1     10.000] CKT 1
                                                           102010*AVDEJA2      220.00 3WNDTR AT-V.DEJA    WND 1 2       54.6     120.5     120.0     101.2
                                                           -----------------------------------------------CONTINGENCY SINGLE 102010-105065-104082(2)
OPEN LINE FROM BUS 102010 [AVDEJA2     220.00] TO BUS 105065 [AVDEJS52     110.00] TO BUS 104082 [AVDEJS_2     10.000] CKT 2
                                                           102010*AVDEJA2      220.00 3WNDTR AT-V.DEJA    WND 1 1       58.1     119.3     120.0     100.2
                                                           -----------------------------------------------------CONTINGENCY SINGLE 102045-102075(3)
OPEN LINE FROM BUS 102045 [ATIRA22     220.00] TO BUS 102075 [ARRAZH2      220.00] CKT 3
                                                           102047 ASHARR2      220.00 105272*ASHARR5      110.00 1       69.4     109.2     100.0     120.9
                                                           102050 AELBS12      220.00 102095*AFIER 2      220.00 1      118.7     223.0     269.4     102.7
                                                           105272 ASHARR5      110.00 105275*ARRAZB5      110.00 1       18.8     101.0      73.0     173.4
                                                           -----------------------------------------------------CONTINGENCY SINGLE 102050-102095(1)
OPEN LINE FROM BUS 102050 [AELBS12     220.00] TO BUS 102095 [AFIER 2      220.00] CKT 1
                                                           102045 ATIRA22      220.00 102075*ARRAZH2      220.00 3      202.4     318.6     269.4     129.8
                                                           -----------------------------------------------------CONTINGENCY SINGLE 105060-105070(1)
OPEN LINE FROM BUS 105060 [AVDEJS51    110.00] TO BUS 105070 [AVDVJT5      110.00] CKT 1
                                                           102010*AVDEJA2      220.00 3WNDTR AT-V.DEJA    WND 1 2       54.6     120.5     120.0     101.2
                                                           -----------------------------------------------------CONTINGENCY SINGLE 105065-105105(1)
OPEN LINE FROM BUS 105065 [AVDEJS52    110.00] TO BUS 105105 [AKOSMA5      110.00] CKT 1
                                                           102010*AVDEJA2      220.00 3WNDTR AT-V.DEJA    WND 1 1       58.1     119.6     120.0     100.4
                                                           -----------------------------------------------------CONTINGENCY SINGLE 105240-105270(1)
OPEN LINE FROM BUS 105240 [AKASH151    110.00] TO BUS 105270 [ATIRA25      110.00] CKT 1
                                                           102040*ATIRA12      220.00 3WNDTR AT-TIRANA1   WND 1 1       84.0     121.1     120.0     107.5
                                                           102040*ATIRA12      220.00 3WNDTR AT-TIRANA1   WND 1 2       84.0     121.1     120.0     107.5
                                                           -----------------------------------------------------CONTINGENCY SINGLE 105265-105270(1)
OPEN LINE FROM BUS 105265 [ASELIT5     110.00] TO BUS 105270 [ATIRA25      110.00] CKT 1
                                                           105265*ASELIT5      110.00 105272 ASHARR5      110.00 1       56.1      92.4      84.8     117.8
                                                           -----------------------------------------------------CONTINGENCY SINGLE 105275-105290(1)
OPEN LINE FROM BUS 105275 [ARRAZB5     110.00] TO BUS 105290 [ASHKZT5      110.00] CKT 1
                                                           105275 ARRAZB5      110.00 105290*ASHKZT5      110.00 2       46.2      85.3      73.0     122.0
                                                           -----------------------------------------------------CONTINGENCY SINGLE 105275-105290(2)
OPEN LINE FROM BUS 105275 [ARRAZB5     110.00] TO BUS 105290 [ASHKZT5      110.00] CKT 2
                                                           105275 ARRAZB5      110.00 105290*ASHKZT5      110.00 1       39.3      85.3      73.0     122.0
                                                           -----------------------------------------------CONTINGENCY SINGLE 105405-107350-108071(2)
OPEN LINE FROM BUS 105405 [AMARIN5     110.00] TO BUS 107350 [AMARIND      35.000] TO BUS 108071 [AMARIN_      6.3000] CKT 2
                                                           105405*AMARIN5      110.00 3WNDTR TR-MARINEZ   WND 1 1        5.2      10.4       7.5     143.2
                                                           -----------------------------------------------CONTINGENCY SINGLE 105405-107350-108071(1)
OPEN LINE FROM BUS 105405 [AMARIN5     110.00] TO BUS 107350 [AMARIND      35.000] TO BUS 108071 [AMARIN_      6.3000] CKT 1
                                                           105405*AMARIN5      110.00 3WNDTR TR-MARINEZ   WND 1 2        5.2      10.4       7.5     143.5
```

Figure 4.3 Base case overloading due to security criterion N-1 in the Albanian transmission network

The following figure presents the Albanian interconnection lines (400 kV – red, 220 kV – black) loadings (MW/Mvar) and the percentage of loading compared to a line rating. Interconnection lines are loaded in the base case at less than 21 % of their thermal ratings.

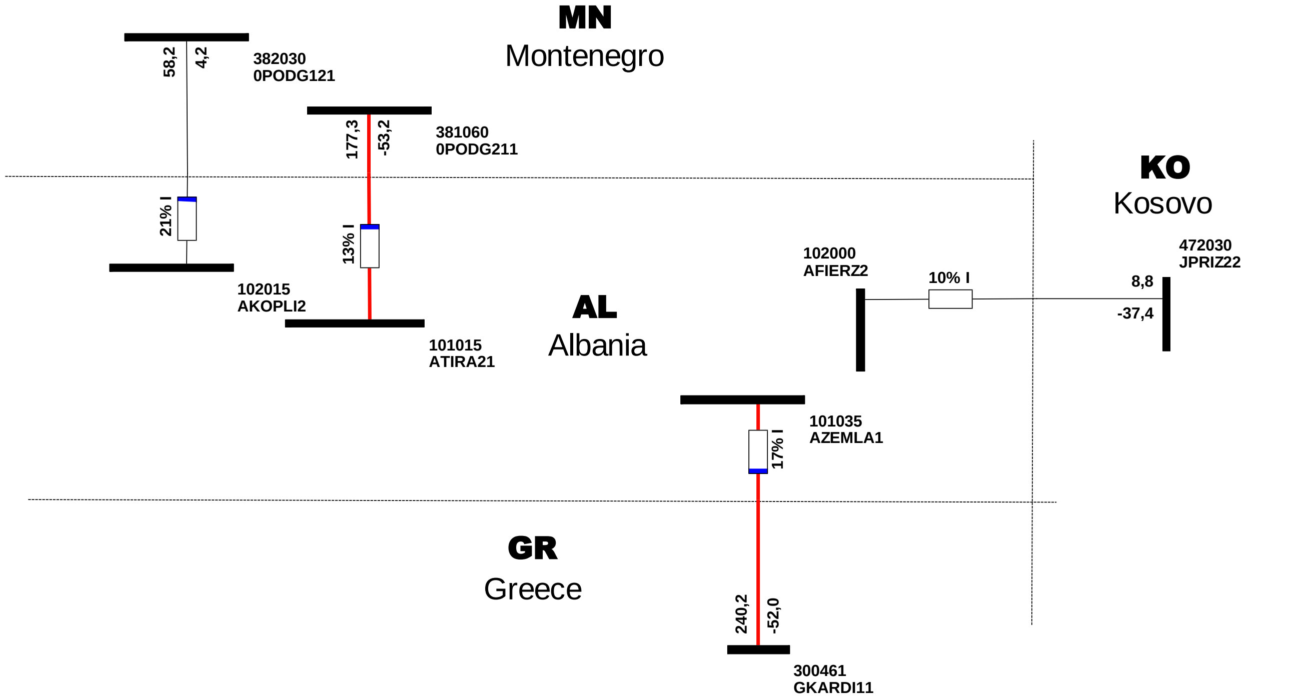


Figure 4.4 Albanian interconnection lines loading and percentage of loading in the base case

Currently, the Albanian transmission network is interconnected with neighboring power systems by two 400 kV and two 220 kV lines. The sum of their thermal ratings is 3304 MVA (around 3100 MW). Maximum transmission capacities over Albanian borders are:

Border	Number of 400 kV lines	Number of 220 kV lines	Total ratings (MVA / MW)
Albania/Montenegro	1	1	1628 / 1547
Albania/Kosovo	0	1	325 / 309
Albania/Greece	1	0	1350 / 1283
TOTAL	*2*	*2*	*3303 / 3139*

The theoretical limit of possible power exchanges over one border is the sum of all interconnection line ratings between two countries. Real NTC values will always be lower than the theoretical limit due to inequalities of interconnection line loadings (two lines cannot be loaded exactly on their thermal limit), N-1 security criterion and internal network overloading.

Table 4.1 Percentage of indicative annual NTC values for Albanian borders and total ratings of interconnection lines over these borders

NTC / THEORETICAL LIMIT (%)	*AL>GR*	*GR>AL*	*AL>RS*	*RS>AL*	*AL>ME*	*ME>AL*
2012	19	19	68	32	NA	NA
2013	19	19	49	68	NA	NA
2014	19	19	16	16	NA	NA

MEPSO remark:
Interconnection can not be loaded up to 100% of thermal rating. More relevant is to see comparison of real cross-border flows and declared NTCs.

Comparing Albanian interconnection lines ratings and the declared indicative annual NTC values in 2012 – 2014, one may notice that interconnection capacities at the Albanian/Greek border could be better employed, while interconnection capacity at the Albanian/Kosovan border could be used more significantly in 2012 and 2013, but poorly in 2014.

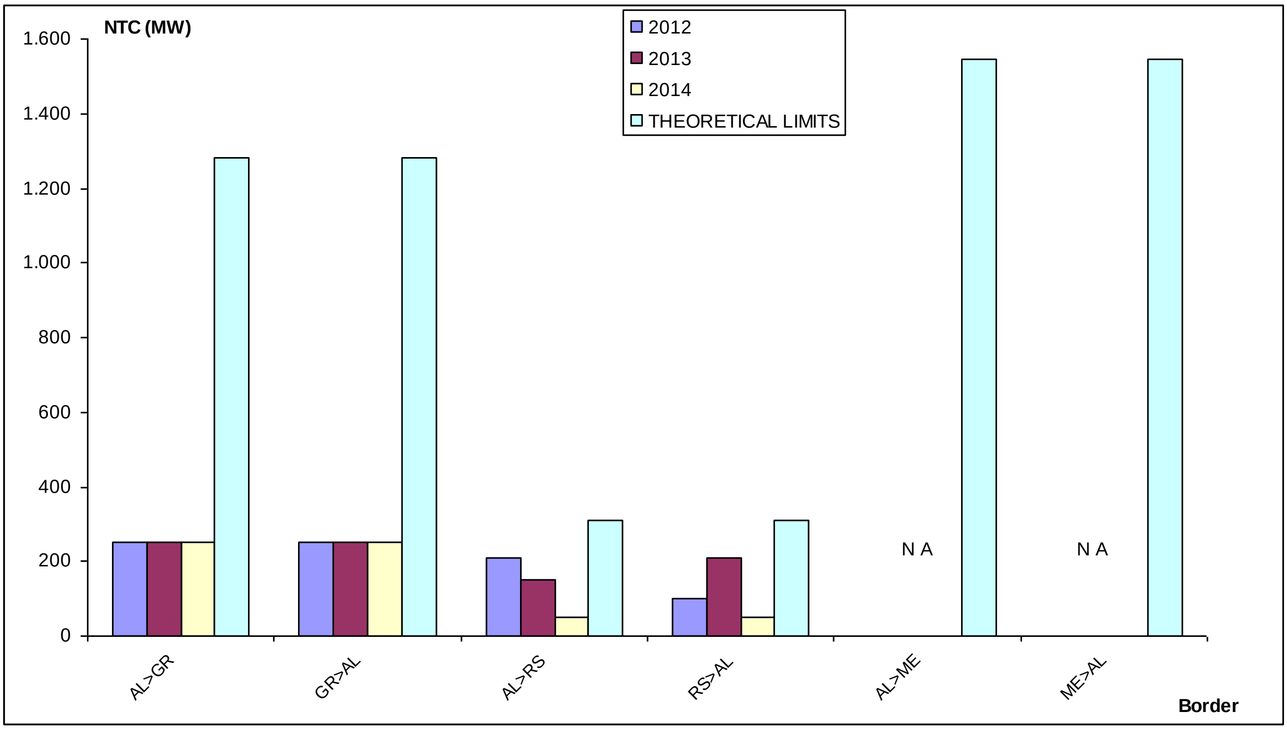


Figure 4.5 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Albania

4.2 Bosnia and Herzegovina

The Bosnian power system is modeled with the following operational conditions:

Generation: 1680,1 MW
Load: 1670,5 MW
Losses: 39,6 MW
Net interchange: -30,1 MW (import)

Important parameters for the TTC values calculation are:

ΔE_{max}^{+} = 449,2 MW
(possible generation increase up to P_{max} of all modeled generators which are in operation)

In order to perform the NTC calculations for 2015 according to the ENTSO-E methodology possible generation shift in BiH was increased up to 927 MW at the model.

MAX (ΔE_{max}^{+}) = 927 MW
(possible generation increase up to P_{max} of all modeled generators)

ΔE_{max}^{-} = 385,1 MW
(possible generation decrease up to P_{min} of all modeled generators which are in operation)

MAX (ΔE_{max}^{-}) = 1931,1 MW
(possible generation decrease up to P_{min} of all modeled generators)

In the base case, loadings of all network elements are within acceptable limits. Security criterion N-1 is fulfilled in the base case for the Bosnian network.

The following figure presents the Bosnian and Herzegovinian interconnection line (400 kV – red, 220 kV – black) loadings (MW/Mvar) and the percentage of loading compared to a line rating. The interconnection lines are loaded in the base case at less than 39 % of their thermal ratings.

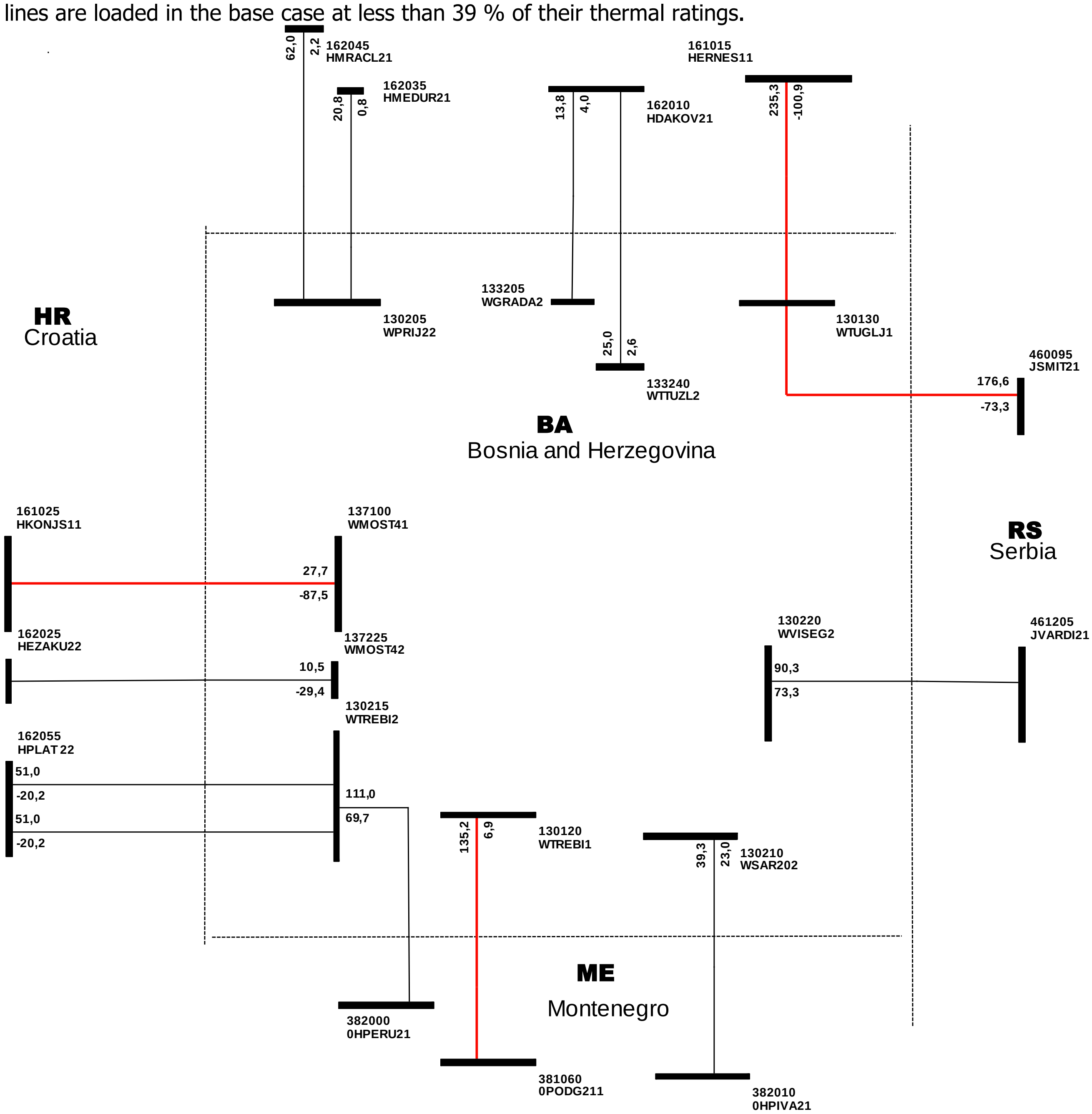


Figure 4.6 Bosnian interconnection lines loading and percentage of loading in the base case

Currently, the Bosnian transmission network is interconnected with neighboring power systems by four 400 kV lines and ten 220 kV lines. The sum of their thermal ratings is 9652 MVA (around 9200 MW). The maximum transmission capacities over BiH borders are:

Border	Number of 400 kV lines	Number of 220 kV lines	Total ratings (MVA / MW)
BiH/Montenegro	1	2	2845 / 2703
BiH/Serbia	1	1	1646 / 1564

BiH/Croatia	2	7	5161 / 4903
TOTAL	*4*	*10*	*9652 / 9170*

The theoretical limit of possible power exchanges over one border is the sum of all interconnection line ratings between two countries. Real NTC values will always be lower than theoretical limits due to inequalities of interconnection line loadings (two lines cannot be loaded exactly on their thermal limit), N-1 security criterion and internal network overloading.

Table 4.2 Percentage of indicative annual NTC values for Bosnian borders and total ratings of interconnection lines over these borders

NTC / THEORETICAL LIMIT (%)	*BA>RS*	*RS>BA*	*BA>HR*	*HR>BA*	*BA>ME*	*ME>BA*
2012	6	6	8	8	7	7
2013	19	10	8	8	7	7
2014	6	6	8	8	7	7

Comparing Bosnian interconnection line ratings and declared indicative NTC values in 2012 – 2014, one may notice that the interconnection capacities at all Bosnia and Herzegovina borders could be better employed, up to 8 % of theoretical limits in 2012 were declared, 19 % in 2013 and 8 % only in 2014.

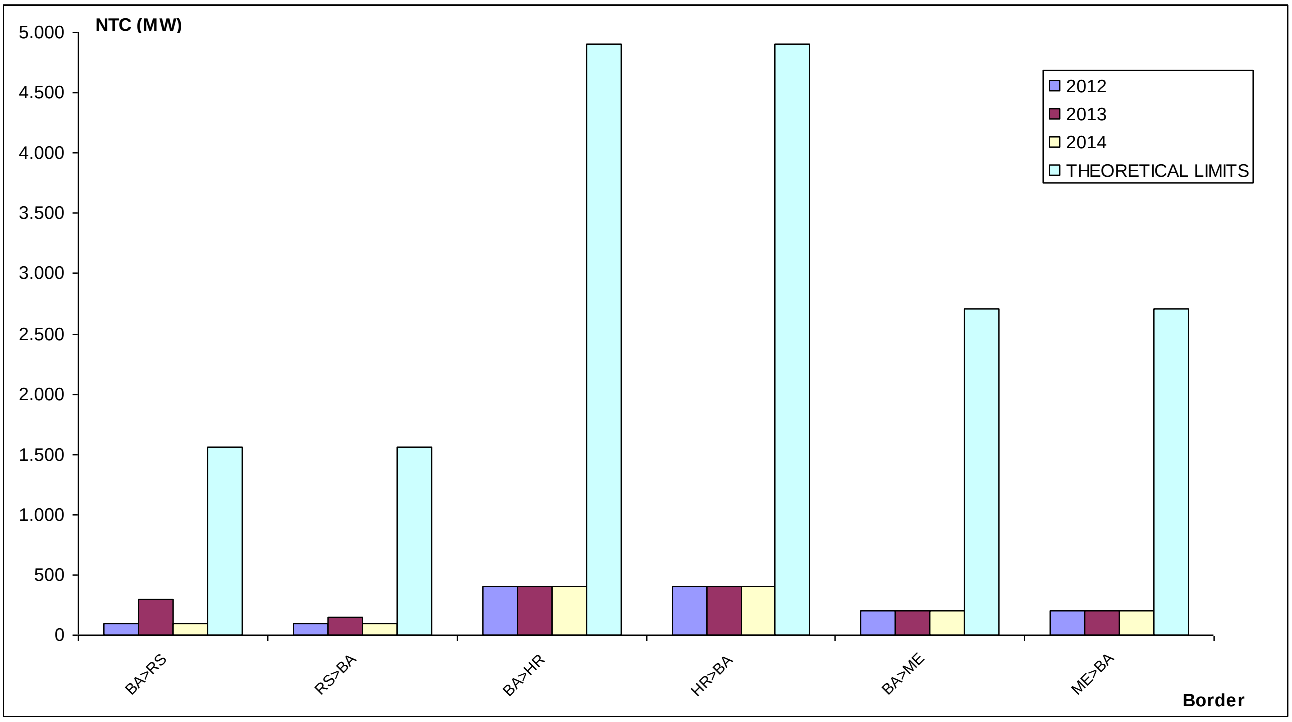


Figure 4.7 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Bosnia and Herzegovina

4.3 Bulgaria

The Bulgarian power system is modeled with the following operational conditions:

Generation: 6372,6 MW
Load: 5393,0 MW
Losses: 116,7 MW
Net interchange: 846,1 MW (export)

Important parameters for the TTC values calculation are:

ΔE_{max}^{+} = 1035,4 MW
(possible generation increase up to P_{max} of all modeled generators which are in operation)

MAX (ΔE_{max}^{+}) = 3669,2 MW
(possible generation increase up to P_{max} of all modeled generators)

ΔE_{max}^{-} = 3238,6 MW
(possible generation decrease up to P_{min} of all modeled generators which are in operation)

MAX (ΔE_{max}^{-}) = 9469,5 MW
(possible generation decrease up to P_{min} of all modeled generators)

In the base case, loadings of all network elements are within acceptable limits, except the following 110 kV line:

```
X--------- FROM BUS ----------X X---------- TO BUS -----------X
   BUS# X-- NAME --X BASKV  AREA   BUS# X-- NAME --X BASKV  AREA CKT LOADING  RATING PERCENT
 146265 VMIRKO5     110.00*   14 146380 VO_MIR5MT   110.00    14  1     52.3    49.9   104.8
```

The security criterion N-1 is not fulfilled in the base case for the Bulgarian network. The critical contingences comprise of some 400 kV and 110 kV lines. All critical contingences and critical lines are located in the Bulgarian internal network.

```
<----------- C O N T I N G E N C Y   E V E N T S ----------><--------- O V E R L O A D E D   L I N E S ----------> <- MVA(MW)FLOW ->
     <----------- MULTI-SECTION LINE GROUPINGS -----------> <------- F R O M -------> <---------- T O --------->CKT  PRE-CNT  POST-CNT  RATING  PERCENT
                                                            --------------------------------------------------------------------------BASE CASE
BASE CASE
                                                            146265*VMIRKO5     110.00 146380 VO_MIR5MT   110.00 1     55.8     55.8     49.9    104.8
                                                            ------------------------------------------------CONTINGENCY SINGLE 141000-149010(N0)
OPEN LINE FROM BUS 141000 [VAEC_41     400.00] TO BUS 149010 [VKOZL_N0    24.000] CKT N0
(BUS MISMATCH (MVA):    79.251    SYSTEM MISMATCH (MVA):    261.94    Iteration limit exceeded) *** NOT CONVERGED ***
                                                            ------------------------------------------------CONTINGENCY SINGLE 141000-149019(N9)
OPEN LINE FROM BUS 141000 [VAEC_41     400.00] TO BUS 149019 [VKOZL_N9    24.000] CKT N9
(BUS MISMATCH (MVA):    79.251    SYSTEM MISMATCH (MVA):    261.94    Iteration limit exceeded) *** NOT CONVERGED ***
                                                            -------------------------------------------------CONTINGENCY SINGLE 141045-141065(1)
OPEN LINE FROM BUS 141045 [VMAIZ11     400.00] TO BUS 141065 [VMAIZ61     400.00] CKT 1
                                                            141045 VMAIZ11     400.00 141060*VMAIZ51     400.00 1    314.3    638.2    519.0    118.0
                                                            ------------------------------------------------CONTINGENCY SINGLE 141065-149036(T6)
OPEN LINE FROM BUS 141065 [VMAIZ61     400.00] TO BUS 149036 [VMAIZ1T6    20.000] CKT T6
                                                            141045 VMAIZ11     400.00 141060*VMAIZ51     400.00 1    314.3    638.2    519.0    118.0
                                                            -------------------------------------------------CONTINGENCY SINGLE 145070-146395(1)
OPEN LINE FROM BUS 145070 [VARPEZ5     110.00] TO BUS 146395 [VO_PKU5     110.00] CKT 1
                                                            146080*VKRUMO5     110.00 146985 VSTKLA5     110.00 1     41.6     65.6     57.2    103.9
                                                            -------------------------------------------------CONTINGENCY SINGLE 145530-145680(1)
OPEN LINE FROM BUS 145530 [VDOBRI5     110.00] TO BUS 145680 [VG_TOS5     110.00] CKT 1
                                                            145535 VDOBRU5     110.00 147355*VVN_SE5     110.00 1     62.3    107.8     97.2    100.6
                                                            -------------------------------------------------CONTINGENCY SINGLE 145680-147315(1)
OPEN LINE FROM BUS 145680 [VG_TOS5     110.00] TO BUS 147315 [VVIDNO5     110.00] CKT 1
                                                            145535 VDOBRU5     110.00 147355*VVN_SE5     110.00 1     62.3    111.9     97.2    104.5
                                                            -------------------------------------------------CONTINGENCY SINGLE 146395-146985(1)
OPEN LINE FROM BUS 146395 [VO_PKU5     110.00] TO BUS 146985 [VSTKLA5     110.00] CKT 1
                                                            146080*VKRUMO5     110.00 146985 VSTKLA5     110.00 1     41.6     65.6     57.2    103.9
                                                            -------------------------------------------------CONTINGENCY SINGLE 146835-147315(1)
OPEN LINE FROM BUS 146835 [VSHABL5     110.00] TO BUS 147315 [VVIDNO5     110.00] CKT 1
                                                            145535 VDOBRU5     110.00 147355*VVN_SE5     110.00 1     62.3    112.1     97.2    104.7
```

Figure 4.8 Base case overloading due to security criterion N-1 in the Bulgarian transmission network

The following figure presents the Bulgarian interconnection lines (400 kV – red, 220 kV – black) loadings (MW/Mvar) and the percentage of loading compared to a line rating. Interconnection lines are loaded in the base case at less than 27 % of their thermal ratings.

Currently, the Bulgarian transmission network is interconnected with neighboring power systems by nine 400 kV lines. The sum of their thermal ratings is 13680 MVA (around 13000 MW). Maximum transmission capacities over Bulgarian borders are:

Border	Number of 400 kV lines	Number of 220 kV lines	Total ratings (MVA / MW)
Bulgaria/Romania	4	0	6725 / 6389
Bulgaria /Serbia	1	0	1310 / 1245
Bulgaria/Greece	1	0	1310 / 1245
Bulgaria/Macedonia	1	0	1310 / 1245

Bulgaria/Turkey	2	0	3025 / 2874
TOTAL	*9*	*0*	*13680 / 12998*

Comparing Bulgarian interconnection lines ratings and declared indicative NTC values in 2012 – 2014, one may notice that interconnection capacities at all Bulgarian borders could be better employed, up to 20 % of theoretical limits in 2012 were declared, 28 % in 2013 and up to 32 % in 2014.

Table 4.3 Percentage of indicative annual NTC values for Bulgarian borders and total ratings of interconnection lines over these borders

NTC / THEORETICAL LIMIT (%)	BG>GR	GR>BG	BG>RO	RO>BG	BG>MK	MK>BG	BG>RS	RS>BG
2012	20	20	-	-	-	-	16	8
2013	28	20	-	-	-	-	16	12
2014	32	24	-	-	-	-	16	12

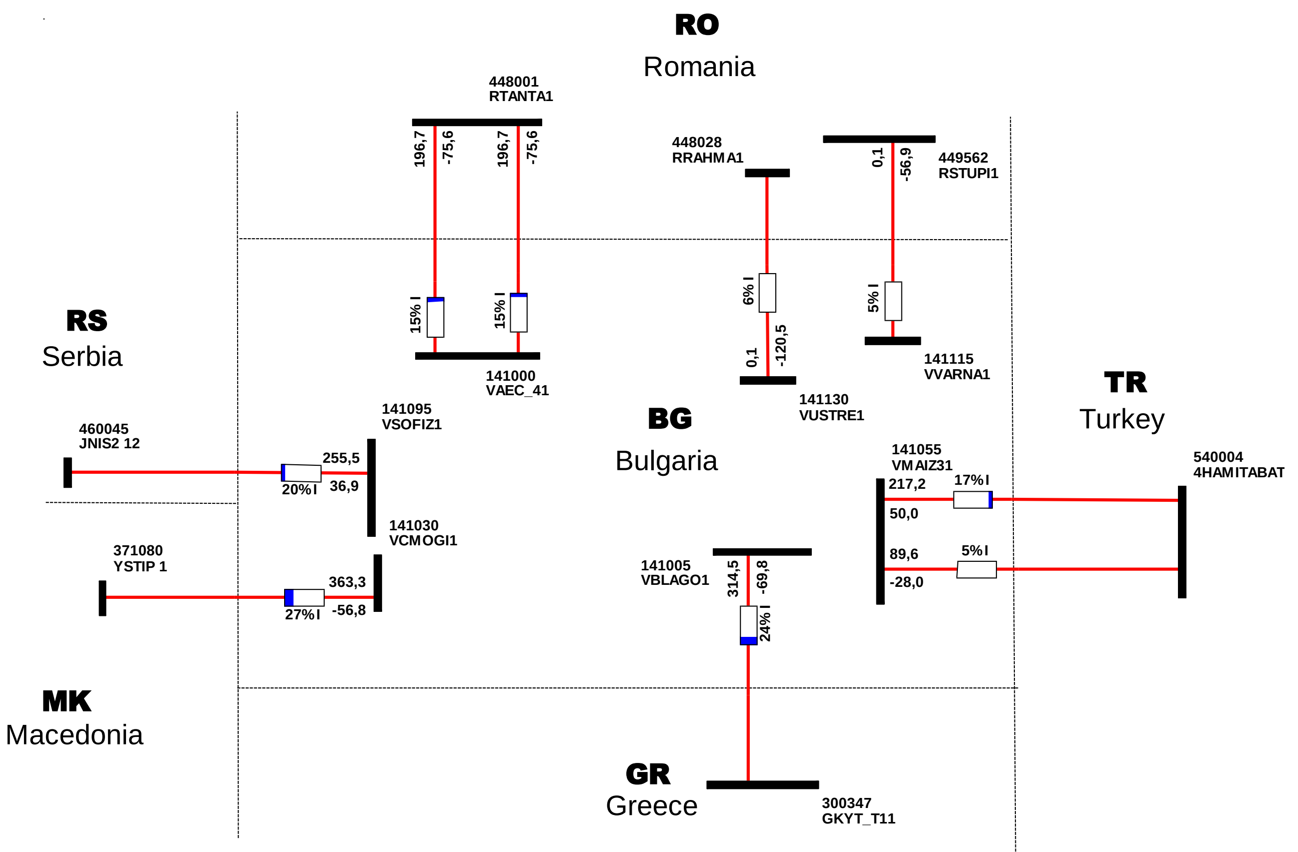


Figure 4.9 Bulgarian interconnection lines loading and percentage of loading in the base case

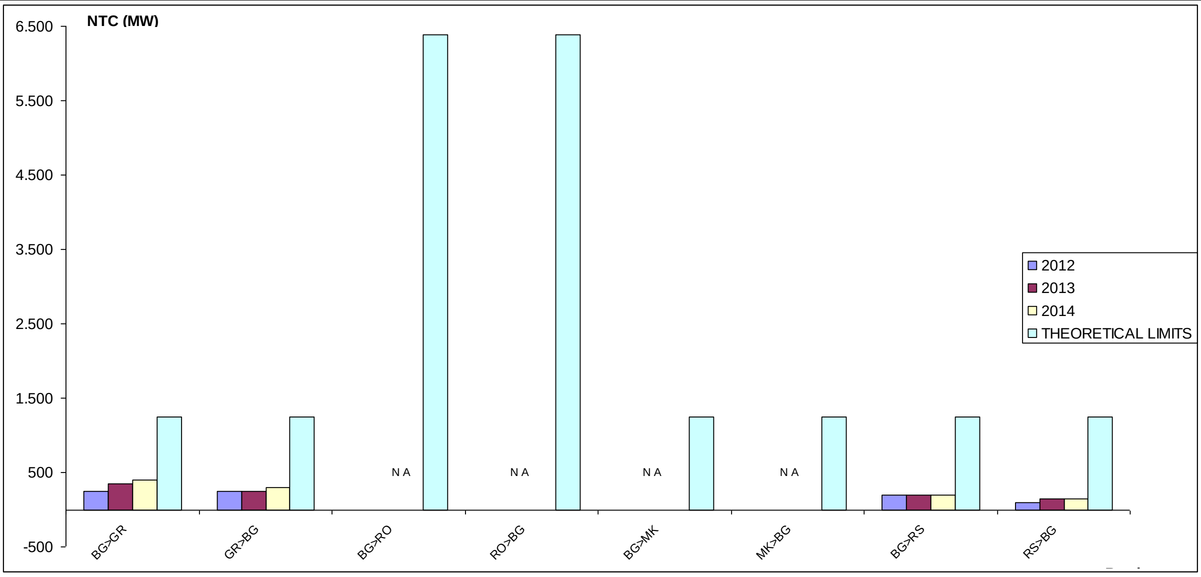


Figure 4.10 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Bulgaria

4.4 Croatia

The Croatian power system is modeled with the following operational conditions:

Generation: 1292,5 MW
Load: 2166,0 MW
Losses: 42,2 MW
Net interchange: -918 MW (import)

Important parameters for the TTC values calculation are:

ΔE_{max}^{+} = 525,6 MW
(possible generation increase up to P_{max} of all modeled generators which are in operation)

MAX (ΔE_{max}^{+}) = 1938,5 MW
(possible generation increase up to P_{max} of all modeled generators)

ΔE_{max}^{-} = 680,3 MW
(possible generation decrease up to P_{min} of all modeled generators which are in operation)

MAX (ΔE_{max}^{-}) = 2218,2 MW
(possible generation decrease up to P_{min} of all modeled generators)

The base case loadings of all network elements are within acceptable limits, and security criterion N-1 is fulfilled.

The following figure presents Croatian interconnection line (400 kV – red, 220 kV – black) loadings (MW/Mvar) and the percentage of loading compared to a line rating. Interconnection lines are loaded in the base case at less than 51 % of their thermal ratings.

Currently, the Croatian transmission network is interconnected with neighboring power systems by ten 400 kV lines and nine 220 kV lines (circuits). The sum of their thermal ratings is 12994 MVA (around 12300 MW). Maximum transmission capacities over Croatian borders are:

Border	Number of 400 kV lines	Number of 220 kV lines	Total ratings (MVA / MW)
Croatia/BiH	2	7	4054 / 3851
Croatia/Serbia	1	0	1030 / 979
Croatia/Slovenia	3	2	3790 / 3601
Croatia/Hungary	4	0	4120 / 3914
TOTAL	*10*	*9*	*12994 / 12345*

Comparing Croatian interconnection line ratings and declared indicative NTC values in 2012 – 2014, one may notice that interconnection capacities at all Croatian borders could be better employed, up to 28 % of theoretical limits in 2012 were declared, 22 % in 2013 and up to 37 % in 2014.

Table 4.4 Percentage of indicative annual NTC values for Croatian borders and total ratings of interconnection lines over these borders

NTC / THEORETICAL LIMIT (%)	***HR>BA***	***BA>HR***	***HR>RS***	***RS>HR***	***HR>HU***	***HU>HR***	***HR>SI***	***SI>HR***
2012	10	10	10	20	15	18	17	28
2013	10	10	10	15	15	18	17	22
2014	10	10	10	10	15	18	17	37

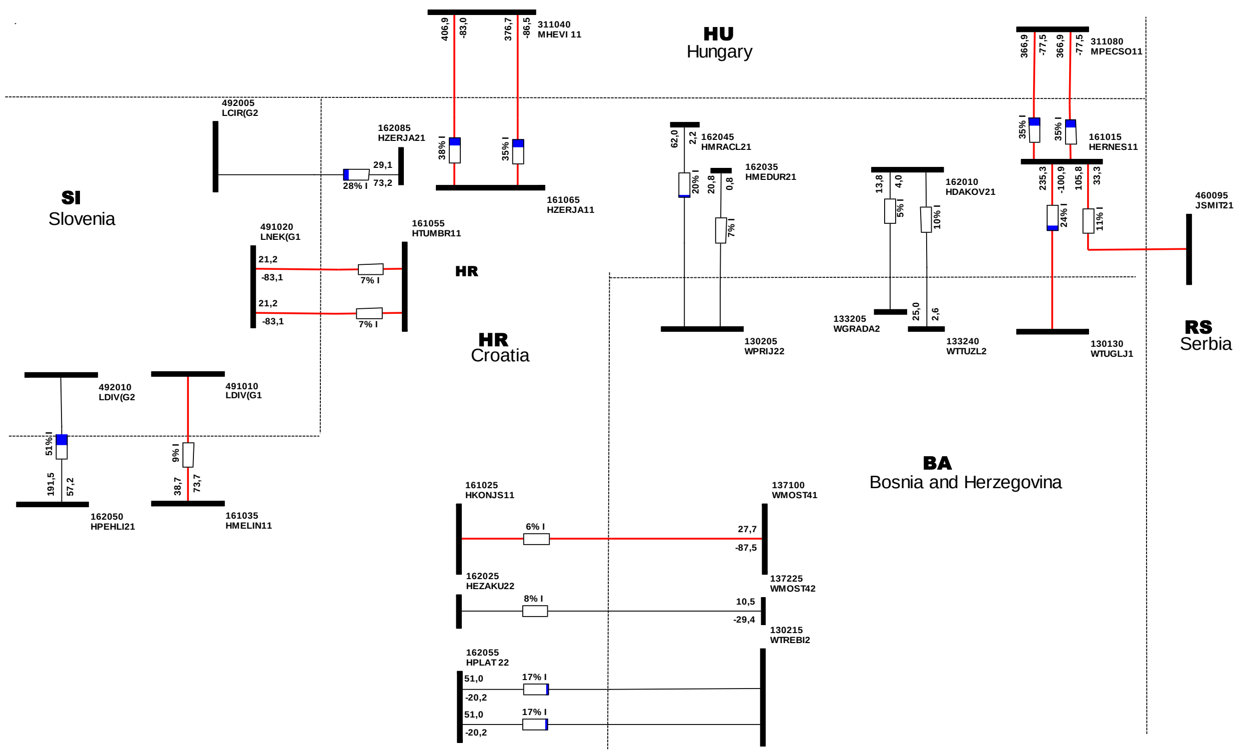


Figure 4.11 Croatian interconnection lines loading and percentage of loading in the base case

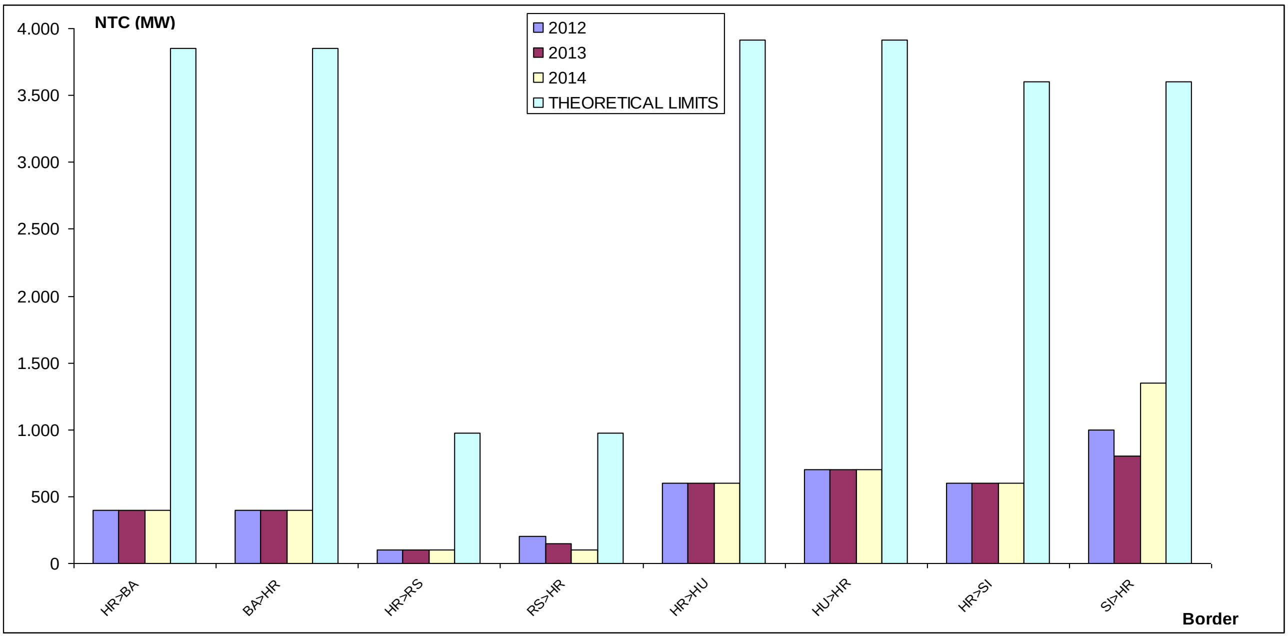


Figure 4.12 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Croatia

4.5 Macedonia

The Macedonian power system is modeled with the following operational conditions:

Generation: 934,5 MW
Load: 1246,7 MW
Losses: 21,1 MW
Net interchange: 335,0 MW (import)

Important parameters for the TTC values calculation are:

ΔE_{max}^{+} = 137,3 MW
(possible generation increase up to P_{max} of all modeled generators which are in operation)

In order to perform the NTC calculations for 2015 according to the ENTSO-E methodology possible generation shift in Macedonia was increased up to 900 MW at the model.

MAX (ΔE_{max}^{+}) = 981 MW
(possible generation increase up to P_{max} of all modeled generators)

ΔE_{max}^{-} = 432,5 MW
(possible generation decrease up to P_{min} of all modeled generators which are in operation)

MAX (ΔE_{max}^{-}) = 978,5 MW
(possible generation decrease up to P_{min} of all modeled generators)

In the base case, loadings of all network elements are within acceptable limits. Security criterion N-1 is not fulfilled in the base case for Macedonian network. The critical contingences comprise of some 110 kV lines, located within the Macedonian internal network. All identified contingencies could be resolved with corrective dispatching actions.

```
<----------- C O N T I N G E N C Y   E V E N T S ----------><--------- O V E R L O A D E D   L I N E S ----------> <- MVA(MW)FLOW ->
     <----------- MULTI-SECTION LINE GROUPINGS ----------->  <------- F R O M -------> <--------- T O --------->CKT  PRE-CNT  POST-CNT  RATING  PERCENT
                                                             ------------------------------------------------------CONTINGENCY SINGLE 375020-375025(1)
OPEN LINE FROM BUS 375020 [YBITOL51    110.00] TO BUS 375025 [YBITOL52    110.00] CKT 1
                                                             375020*YBITOL51    110.00 375025 YBITOL52    110.00 2      83.2    151.0    123.0    117.8
                                                             ------------------------------------------------------CONTINGENCY SINGLE 375020-375025(2)
OPEN LINE FROM BUS 375020 [YBITOL51    110.00] TO BUS 375025 [YBITOL52    110.00] CKT 2
                                                             375020*YBITOL51    110.00 375025 YBITOL52    110.00 1      83.2    151.0    123.0    117.8
                                                             ------------------------------------------------------CONTINGENCY SINGLE 375020-375035(1)
OPEN LINE FROM BUS 375020 [YBITOL51    110.00] TO BUS 375035 [YBITOL54    110.00] CKT 1
(BUS MISMATCH (MVA):   3.6883    SYSTEM MISMATCH (MVA):   33.223    Blown up) *** NOT CONVERGED ***
                                                             -----------------------------------------------------CONTINGENCY SINGLE 375050-375335(F1)
OPEN LINE FROM BUS 375050 [YCBLOH51    110.00] TO BUS 375335 [YDUMMY51    110.00] CKT F1
                                                             375055 YCBLOH52    110.00 375340*YDUMMY52    110.00 F2    100.3    184.2    157.0    111.7
                                                             375055*YCBLOH52    110.00 375410 YTETO 5     110.00 F2    100.5    185.0    156.0    112.4
                                                             375330*YSK 4 5     110.00 375340 YDUMMY52    110.00 B4     99.8    182.7    157.0    111.7
                                                             -----------------------------------------------------CONTINGENCY SINGLE 375050-375410(F1)
OPEN LINE FROM BUS 375050 [YCBLOH51    110.00] TO BUS 375410 [YTETO 5     110.00] CKT F1
                                                             375055 YCBLOH52    110.00 375340*YDUMMY52    110.00 F2    100.3    183.7    157.0    111.5
                                                             375055*YCBLOH52    110.00 375410 YTETO 5     110.00 F2    100.5    184.5    156.0    112.2
                                                             375330*YSK 4 5     110.00 375340 YDUMMY52    110.00 B4     99.8    182.3    157.0    111.5
                                                             -----------------------------------------------------CONTINGENCY SINGLE 375055-375340(F2)
OPEN LINE FROM BUS 375055 [YCBLOH52    110.00] TO BUS 375340 [YDUMMY52    110.00] CKT F2
                                                             375050 YCBLOH51    110.00 375335*YDUMMY51    110.00 F1     87.7    183.5    157.0    111.0
                                                             375050*YCBLOH51    110.00 375410 YTETO 5     110.00 F1     87.9    184.3    156.0    111.7
                                                             375310*YSK 1A5     110.00 375335 YDUMMY51    110.00 B3     86.8    180.3    157.0    111.1
                                                             -----------------------------------------------------CONTINGENCY SINGLE 375055-375410(F2)
OPEN LINE FROM BUS 375055 [YCBLOH52    110.00] TO BUS 375410 [YTETO 5     110.00] CKT F2
                                                             375050 YCBLOH51    110.00 375335*YDUMMY51    110.00 F1     87.7    183.1    157.0    110.9
                                                             375050*YCBLOH51    110.00 375410 YTETO 5     110.00 F1     87.9    183.9    156.0    111.6
                                                             375310*YSK 1A5     110.00 375335 YDUMMY51    110.00 B3     86.8    180.0    157.0    110.9
                                                             -----------------------------------------------------CONTINGENCY SINGLE 375310-375335(B3)
OPEN LINE FROM BUS 375310 [YSK 1A5     110.00] TO BUS 375335 [YDUMMY51    110.00] CKT B3
                                                             375055 YCBLOH52    110.00 375340*YDUMMY52    110.00 F2    100.3    184.2    157.0    111.7
                                                             375055*YCBLOH52    110.00 375410 YTETO 5     110.00 F2    100.5    185.0    156.0    112.4
                                                             375330*YSK 4 5     110.00 375340 YDUMMY52    110.00 B4     99.8    182.7    157.0    111.7
                                                             -----------------------------------------------------CONTINGENCY SINGLE 375330-375340(B4)
OPEN LINE FROM BUS 375330 [YSK 4 5     110.00] TO BUS 375340 [YDUMMY52    110.00] CKT B4
                                                             375050 YCBLOH51    110.00 375335*YDUMMY51    110.00 F1     87.7    183.5    157.0    111.1
                                                             375050*YCBLOH51    110.00 375410 YTETO 5     110.00 F1     87.9    184.3    156.0    111.8
                                                             375310*YSK 1A5     110.00 375335 YDUMMY51    110.00 B3     86.8    180.3    157.0    111.1
```

Figure 4.13 Base case overloading due to security criterion N-1 in the Macedonian transmission network

The following figure presents Macedonian interconnection line (400 kV – red, 220 kV – black) loadings (MW/Mvar) and the percentage of loading compared to a line rating. Interconnection lines are loaded in the base case at less than 29 % of their thermal ratings.

Currently, the Macedonian transmission network is interconnected with neighboring power systems by four 400 kV lines. The sum of their thermal ratings is 4248 MVA (around 4000 MW). Maximum transmission capacities over Macedonian borders are:

Border	Number of 400 kV lines	Number of 220 kV lines	Total ratings (MVA / MW)
Macedonia/Bulgaria	1	0	1218 / 1157
Macedonia /Kosovo(&)Serbia	1	0	1310 / 1245
Macedonia/Greece	2	0	1720 / 1634
TOTAL	*4*	*0*	*4248 / 4036*

Table 4.5 Percentage of indicative annual NTC values for Macedonian borders and total ratings of interconnection lines over these borders

NTC / THEORETICAL LIMIT (%)	***MK>BG***	***BG>MK***	***MK>RS***	***RS>MK***	***MK>GR***	***GR>MK***
2012	NA	NA	22	22	9	18
2013	NA	NA	17	26	12	18
2014	NA	NA	9	13	15	21

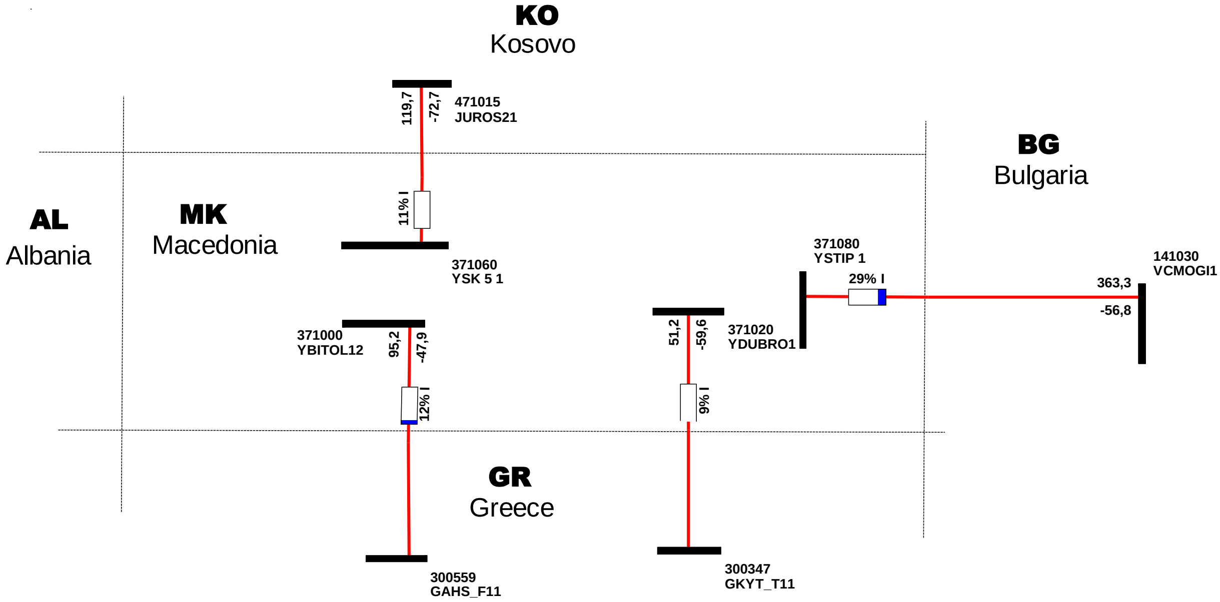


Figure 4.14 Macedonian interconnection lines loading and percentage of loading in the base case

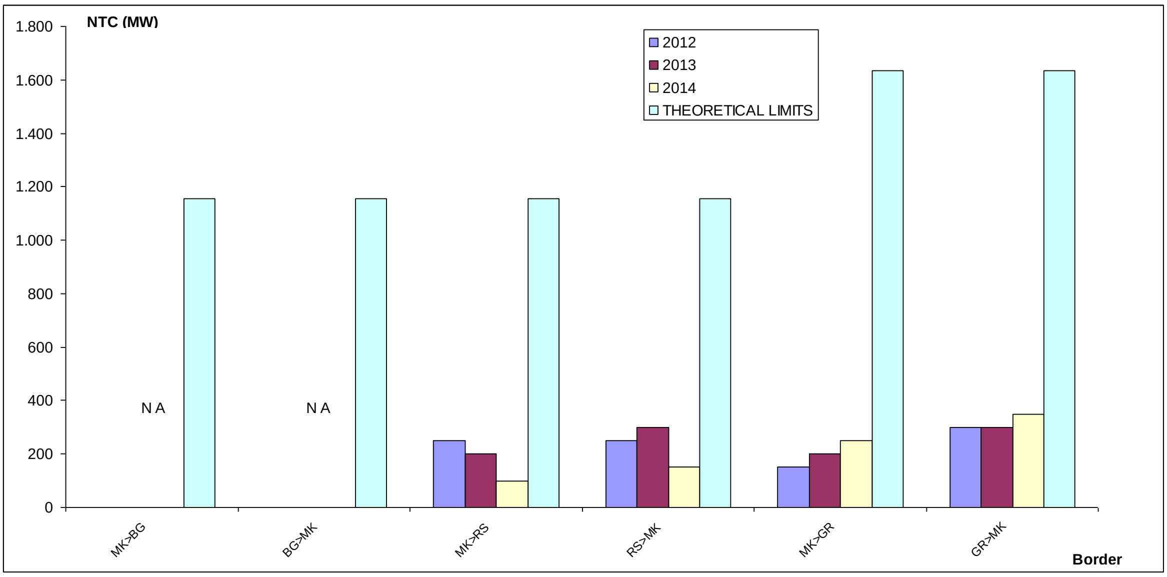


Figure 4.15 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Macedonia

4.6 Montenegro

The Montenegrin power system is modeled with the following operational conditions:

Generation: 253,3 MW
Load: 525,0 MW
Losses: 12,8 MW
Net interchange: -296,0 MW (import)

Important parameters for the TTC values calculation are:

ΔE_{max}^{+} = 30,2 MW
(possible generation increase up to P_{max} of all modeled generators which are in operation)

In order to perform the NTC calculations for 2015 according to the ENTSO-E methodology possible generation shift in Montenegro was increased up to 1100 MW at the model (by adding equivalent generation and load of the same amount at the 400 kV network node Podgorica 2).

MAX (ΔE_{max}^{+}) = 620,7 MW
(possible generation increase up to P_{max} of all modeled generators)

ΔE_{max}^{-} = 117,3 MW
(possible generation decrease up to P_{min} of all modeled generators which are in operation)

MAX (ΔE_{max}^{-}) = 433,0 MW
(possible generation decrease up to P_{min} of all modeled generators)

In the base case loadings of all network elements are within acceptable limits. Security criterion N-1 is fulfilled in the base case.

The following figure presents Montenegrin interconnection line (400 kV – red, 220 kV – black) loadings (MW/Mvar) and the percentage of loading compared to a line rating. Interconnection lines are loaded in the base case at less than 46 % of their thermal ratings.

Currently, the Montenegrin transmission network is interconnected with neighboring power systems by three 400 kV lines and five 220 kV lines. The sum of their thermal ratings is 5742 MVA (around 5450 MW). Maximum transmission capacities over Montenegrin borders are:

Border	Number of 400 kV lines	Number of 220 kV lines	Total ratings (MVA / MW)
Montenegro/BiH	1	2	2041 / 1939
Montenegro/Kosovo&Serbia	1	2	2041 / 1939
Montenegro/Albania	1	1	1660 / 1577
TOTAL	*3*	*5*	*5742 / 5455*

Table 4.6 Percentage of indicative annual NTC values for Montenegrin borders and total ratings of interconnection lines over these borders

NTC / THEORETICAL LIMIT (%)	***ME>AL***	***AL>ME***	***ME>BA***	***BA>ME***	***ME>RS***	***RS>ME***
2012	NA	NA	NA	NA	21	15
2013	NA	NA	10	10	15	13
2014	NA	NA	10	10	10	10

Comparing Montenegrin interconnection lines ratings and declared indicative NTC values in 2012 – 2014, one may notice that interconnection capacities at all Montenegrin borders could be better employed, up to 21 % of theoretical limits in 2012 were declared, 15 % in 2013 and up to 10 % in 2014.

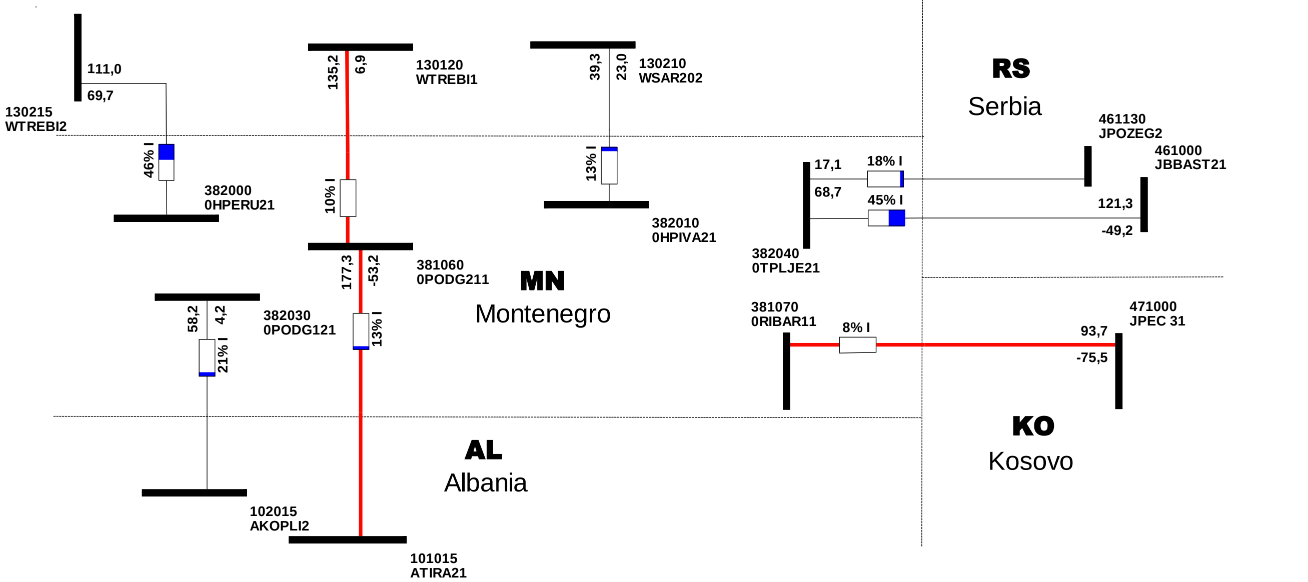


Figure 4.16 Montenegrin interconnection lines loading and percentage of loading in the base case

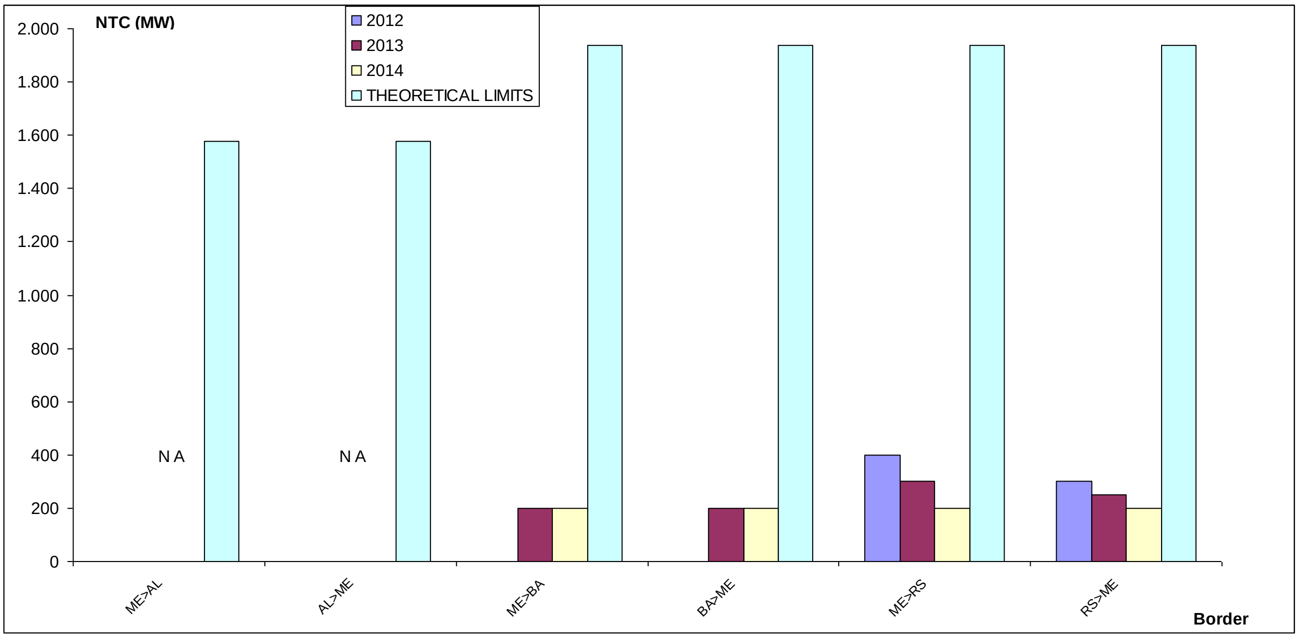


Figure 4.17 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Montenegro

4.7 Romania

The Romanian power system is modeled with the following operational conditions:

Generation: 6410,8 MW
Load: 6283,7 MW
Losses: 112,6 MW
Net interchange: -66,9 MW (import)

Important parameters for the TTC values calculation are:

ΔE_{max}^{+} = 3115,2 MW
(possible generation increase up to P_{max} of all modeled generators which are in operation)

MAX (ΔE_{max}^{+}) = 13956,6 MW
(possible generation increase up to P_{max} of all modeled generators)

ΔE_{max}^{-} = 1914,6 MW
(possible generation decrease up to P_{min} of all modeled generators which are in operation)

MAX (ΔE_{max}^{-}) = 12473,5 MW
(possible generation decrease up to P_{min} of all modeled generators)

In the base case loadings of all network elements are within acceptable limits. Security criterion N-1 is not fulfilled in the base case for Romanian network. The critical contingences comprise two 220/110 transformers kV within the Romanian internal network.

```
<----------- C O N T I N G E N C Y   E V E N T S ----------><--------- O V E R L O A D E D   L I N E S ----------> <- MVA(MW)FLOW ->
     <----------- MULTI-SECTION LINE GROUPINGS -----------> <------- F R O M -------> <--------- T O --------->CKT  PRE-CNT  POST-CNT  RATING  PERCENT
                                                            ------------------------------------------------------CONTINGENCY SINGLE 448400-448911(1)
OPEN LINE FROM BUS 448400 [RTIRGO5B    110.00] TO BUS 448911 [RTIRGO22    220.00] CKT 1
                                                            448400 RTIRGO5B     110.00 448911*RTIRGO22    220.00 2     103.7    215.5    200.0    105.4
                                                            ------------------------------------------------------CONTINGENCY SINGLE 448400-448911(2)
OPEN LINE FROM BUS 448400 [RTIRGO5B    110.00] TO BUS 448911 [RTIRGO22    220.00] CKT 2
                                                            448400 RTIRGO5B     110.00 448911*RTIRGO22    220.00 1     103.7    215.5    200.0    105.4
```

Figure 4.18 Base case overloading due to security criterion N-1 in the Romanian transmission network

The following figure presents Romanian interconnection line (400 kV – red, 220 kV – black) loadings (MW/Mvar) and the percentage of loading compared to a line rating. Interconnection lines are loaded in the base case at less than 38 % of their thermal ratings.

Currently, the Romanian transmission network is interconnected with neighboring power systems by eight 400 kV lines. One line to Bulgaria is permanently out of operation (Issaccea – Varna), as well as one line to Moldova. The sum of interconnection lines', which are in operation, thermal ratings is 9364 MVA (around 8900 MW). Maximum transmission capacities over Romanian borders are:

Border	Number of 400 kV lines	Number of 220 kV lines	Total ratings (MVA / MW)
Romania/Bulgaria	4	0	4370 / 4151
Romania /Serbia	1	0	1204 / 1144
Romania/Hungary	2	0	2586 / 2457
Romania/Ukraine	1	0	1204 / 1144
TOTAL	*8*	*0*	*9364 / 8896*

Table 4.7 Percentage of indicative annual NTC values for Romanian borders and total ratings of interconnection lines over these borders

NTC / THEORETICAL LIMIT (%)	RO>RS	RS>RO	RO>HU	HU>RO	RO>BG	BG>RO	RO>UA	UA>RO
2012	22	9	8	6	NA	NA	NA	NA
2013	22	13	8	6	NA	NA	NA	NA
2014	13	9	10	10	NA	NA	NA	NA

Transelectrica comment:
Table 4.7 does not indicate the degree of usage of Romanian interconnection capacities during the year, only the lowest maximum usage that could be had in some topologies with very low firm NTC values.

Comparing Romanian interconnection lines ratings and declared indicative NTC values in 2012 – 2014, one may notice that interconnection capacities at all Romanian borders could be better employed, up to 22 % of theoretical limits in 2012 and 2013, and up to 13 % in 2014.

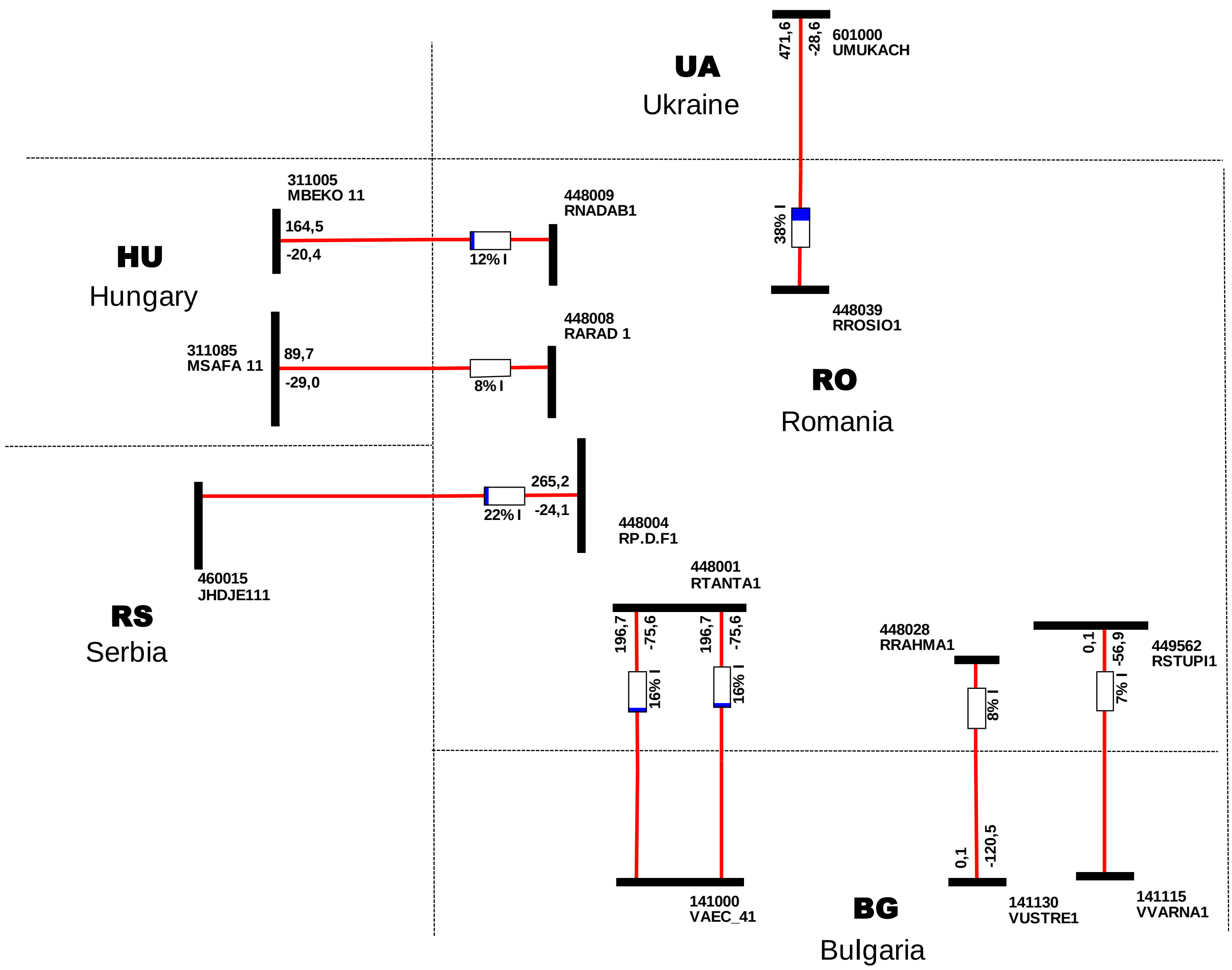


Figure 4.19 Romanian interconnection lines loading and percentage of loading in the base case

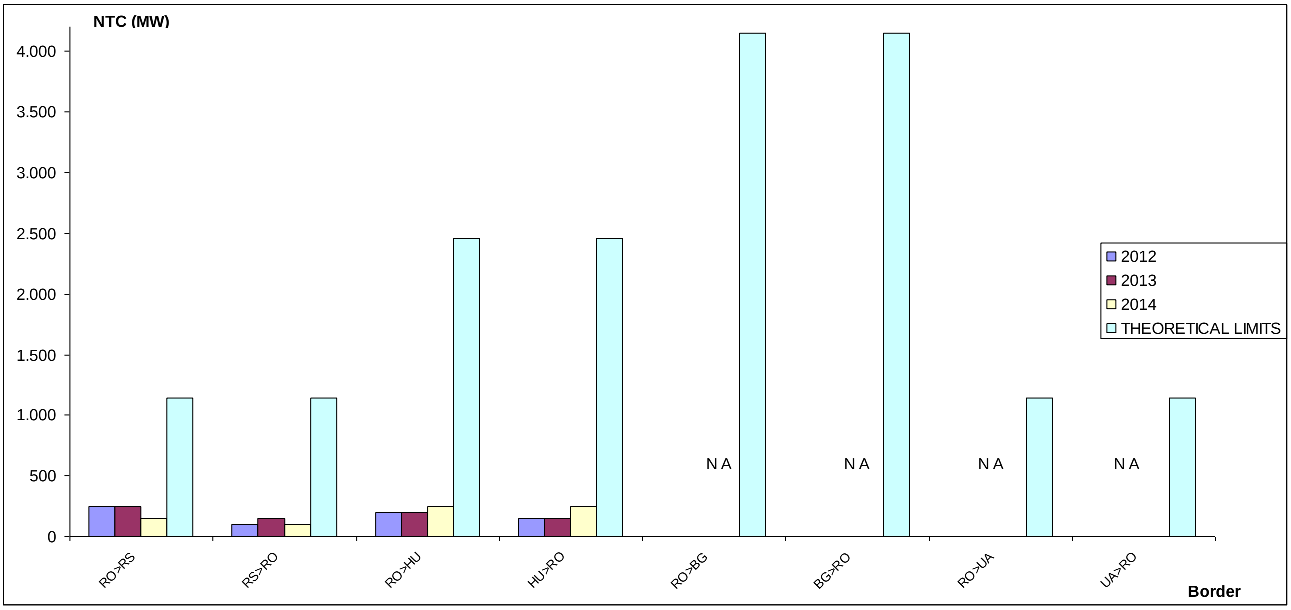


Figure 4.20 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Romania

Transelectrica comment: Figure 4.20 has no relevance for yearly usage.

4.8 Serbia & Kosovo

The Serbian & Kosovan power systems are modeled with the following operational conditions:

Generation: 5761,3 MW
Load: 6160,7 MW
Losses: 140,1 MW
Net interchange: -554,0 MW (import)

Important parameters for the TTC values calculation are:

ΔE_{max}^{+} = 908,6 MW
(possible generation increase up to P_{max} of all modeled generators which are in operation)

MAX (ΔE_{max}^{+}) = 1135,2 MW
(possible generation increase up to P_{max} of all modeled generators)

ΔE_{max}^{-} = 1475,1 MW
(possible generation decrease up to P_{min} of all modeled generators which are in operation)

MAX (ΔE_{max}^{-}) = 4422,8 MW
(possible generation decrease up to P_{min} of all modeled generators)

In the base case, loadings of all network elements are within acceptable limits. Security criterion N-1 is not fulfilled in the base case for Serbian and Kosovo network. The critical contingences comprise of 400/110 kV and 220/110 kV transformers and 220 kV and 110 kV lines within the Serbian internal network, as well as 110 kV lines in the network of Kosovo.

The following figure presents the Serbian and Kosovan interconnection line (400 kV – red, 220 kV – black) loadings (MW/Mvar) and the percentage of loading compared to a line rating. Interconnection lines are loaded in the base case at less than 37 % of their thermal ratings.

Currently, the Serbian & Kosovan transmission networks are interconnected with neighboring power systems by seven 400 kV lines and four 220 kV lines. The sum of interconnection lines thermal ratings is 10568 MVA (around 10000 MW). Maximum transmission capacities over Serbian borders are:

Border	Number of 400 kV lines	Number of 220 kV lines	Total ratings (MVA / MW)
Serbia/Bulgaria	1	0	1330 / 1264
Serbia /Romania	1	0	1244 / 1185
Serbia/Hungary	1	0	1330 / 1264
Serbia/Croatia	1	0	1330 / 1264
Serbia/BiH	1	1	1627 / 1546
Serbia&Kosovo/Montenegro	1	2	2117 / 2011
Kosovo/Albania	0	1	274 / 261
Kosovo/Macedonia	1	0	1316 / 1251
TOTAL	*7*	*4*	*10568 / 10046*

Comparing Serbia and Kosovo interconnection lines ratings and declared indicative NTC values in 2012 – 2014, one may notice that interconnection capacities at the Kosovan/Albanian border were used significantly in 2013 but not as extensively in 2014. Interconnection capacities at other borders appear to be used in very low portions of their theoretical values, except the Serbia to Hungary direction in 2012 and 2013. NTC values (exact or indicative) are determined, among other things, by taking into consideration existing ratings of internal lines.

```
<----------- C O N T I N G E N C Y   E V E N T S ----------><--------- O V E R L O A D E D   L I N E S ----------> <- MVA(MW)FLOW ->
     <----------- MULTI-SECTION LINE GROUPINGS -----------> <------- F R O M -------> <--------- T O --------->CKT  PRE-CNT  POST-CNT  RATING  PERCENT
                                                            ------------------------------------------------CONTINGENCY SINGLE 460070-462945-465085(1)
OPEN LINE FROM BUS 460070 [JPANC211    400.00] TO BUS 462945 [JPANC251    110.00] TO BUS 465085 [JPANC2_2    10.000] CKT 1
                                                            460070*JPANC211     400.00 3WNDTR              WND 1 2     182.1    301.6    300.0    101.7
                                                            ------------------------------------------------CONTINGENCY SINGLE 460070-462950-465090(2)
OPEN LINE FROM BUS 460070 [JPANC211    400.00] TO BUS 462950 [JPANC252    110.00] TO BUS 465090 [JPANC2_3    10.000] CKT 2
                                                            460070*JPANC211     400.00 3WNDTR              WND 1 1     179.3    300.9    300.0    101.5
                                                            -------------------------------------------------------CONTINGENCY SINGLE 461010-461045(1)
OPEN LINE FROM BUS 461010 [JBGD1721    220.00] TO BUS 461045 [JBGD8 21    220.00] CKT 1
                                                            461020*JBGD1723     220.00 3WNDTR              WND 1 3     154.1    417.9    250.0    168.8
                                                            462095*JBGD145      110.00 462100 JBGD155     110.00 1       5.4    239.2    110.1    228.4
                                                            462095 JBGD145      110.00 462160*JBGD2851    110.00 1      25.8    207.5    170.3    129.9
                                                            462100*JBGD155      110.00 462115 JBGD1752    110.00 1      37.6    277.2    120.0    238.9
                                                            462110*JBGD1751     110.00 462190 JBGD365     110.00 1      75.0    157.4    150.5    112.4
                                                            462115*JBGD1752     110.00 3WNDTR              WND 2 3     152.1    397.3    250.0    161.4
                                                            462160 JBGD2851     110.00 462190*JBGD365     110.00 1      63.3    170.0    153.6    118.6
                                                            -------------------------------------------------------CONTINGENCY SINGLE 461020-461050(1)
OPEN LINE FROM BUS 461020 [JBGD1723    220.00] TO BUS 461050 [JBGD8 22    220.00] CKT 1
                                                            462095 JBGD145      110.00 462100*JBGD155     110.00 1       5.4    150.1    110.1    137.1
                                                            462095*JBGD145      110.00 462160 JBGD2851    110.00 1      25.8    180.2    170.3    105.4
                                                            462110 JBGD1751     110.00 462190*JBGD365     110.00 1      75.0    232.3    150.5    151.1
                                                            462160*JBGD2851     110.00 462190 JBGD365     110.00 1      63.3    219.8    153.6    140.9
                                                            ------------------------------------------------CONTINGENCY SINGLE 461020-462115-465190(3)
OPEN LINE FROM BUS 461020 [JBGD1723    220.00] TO BUS 462115 [JBGD1752    110.00] TO BUS 465190 [JBGD17_3    10.000] CKT 3
                                                            462095 JBGD145      110.00 462100*JBGD155     110.00 1       5.4    149.9    110.1    136.9
                                                            462095*JBGD145      110.00 462160 JBGD2851    110.00 1      25.8    180.1    170.3    105.2
                                                            462110 JBGD1751     110.00 462190*JBGD365     110.00 1      75.0    232.1    150.5    151.0
                                                            462160*JBGD2851     110.00 462190 JBGD365     110.00 1      63.3    219.7    153.6    140.7
                                                            ------------------------------------------------CONTINGENCY SINGLE 461035-462205-465210(2)
OPEN LINE FROM BUS 461035 [JBGD5 21    220.00] TO BUS 462205 [JBGD5 51    110.00] TO BUS 465210 [JBGD5 _2    10.000] CKT 2
                                                            461035*JBGD5 21     220.00 3WNDTR              WND 1 1     130.0    170.4    150.0    111.7
                                                            462205*JBGD5 51     110.00 3WNDTR              WND 2 1     128.3    167.5    150.0    106.8
                                                            ------------------------------------------------CONTINGENCY SINGLE 461040-462205-465220(2)
OPEN LINE FROM BUS 461040 [JBGD5 22    220.00] TO BUS 462205 [JBGD5 51    110.00] TO BUS 465220 [JBGD5 _4    10.000] CKT 2
                                                            461035*JBGD5 21     220.00 3WNDTR              WND 1 1     130.0    215.5    150.0    142.3
                                                            462205*JBGD5 51     110.00 3WNDTR              WND 2 1     128.3    210.6    150.0    136.1
                                                            ------------------------------------------------CONTINGENCY SINGLE 461195-463390-465305(1)
OPEN LINE FROM BUS 461195 [JVALJ321    220.00] TO BUS 463390 [JVALJ351    110.00] TO BUS 465305 [JVALJ3_1    10.000] CKT 1
                                                            463375*JVALJ151     110.00 463395 JVALJ352    110.00 1      53.8     96.0     91.5    101.8
                                                            ------------------------------------------------CONTINGENCY SINGLE 461195-463395-465310(2)
OPEN LINE FROM BUS 461195 [JVALJ321    220.00] TO BUS 463395 [JVALJ352    110.00] TO BUS 465310 [JVALJ3_2    10.000] CKT 2
                                                            463375 JVALJ151     110.00 463390*JVALJ351    110.00 1      60.0     94.8     91.5    101.8
                                                            -------------------------------------------------------CONTINGENCY SINGLE 462070-462165(1)
OPEN LINE FROM BUS 462070 [JBGD1 5     110.00] TO BUS 462165 [JBGD3 51    110.00] CKT 1
                                                            462125*JBGD195      110.00 462170 JBGD3 52    110.00 1      66.1    138.4    137.2    104.0
                                                            -------------------------------------------------------CONTINGENCY SINGLE 462125-462170(1)
OPEN LINE FROM BUS 462125 [JBGD195     110.00] TO BUS 462170 [JBGD3 52    110.00] CKT 1
                                                            462070*JBGD1 5      110.00 462165 JBGD3 51    110.00 1      72.8    138.2    137.2    104.2
                                                            -------------------------------------------------------CONTINGENCY SINGLE 462525-462945(1)
OPEN LINE FROM BUS 462525 [JKACAR5     110.00] TO BUS 462945 [JPANC251    110.00] CKT 1
                                                            462025*JALIBU5      110.00 462950 JPANC252    110.00 1      49.6    121.0    110.5    125.3
                                                            462025 JALIBU5      110.00 463445*JVRSA15     110.00 1      29.6     90.2    110.5    105.3
                                                            -------------------------------------------------------CONTINGENCY SINGLE 462775-462820(1)
OPEN LINE FROM BUS 462775 [JNIS1 52    110.00] TO BUS 462820 [JNIS8 5     110.00] CKT 1
                                                            462770*JNIS1 51     110.00 462800 JNIS2 52    110.00 2      37.2     79.2     76.2    108.0
                                                            -------------------------------------------------------CONTINGENCY SINGLE 462795-462820(1)
OPEN LINE FROM BUS 462795 [JNIS2 51    110.00] TO BUS 462820 [JNIS8 5     110.00] CKT 1
                                                            462770*JNIS1 51     110.00 462800 JNIS2 52    110.00 2      37.2     83.6     76.2    114.2
                                                            -------------------------------------------------------CONTINGENCY SINGLE 475020-475025(2)
OPEN LINE FROM BUS 475020 [JDJAK15     110.00] TO BUS 475025 [JDJAK25     110.00] CKT 2
                                                            475105 JPEJA15      110.00 475110*JPEJA25     110.00 1      33.7     95.0    114.3    100.1
                                                            475105*JPEJA15      110.00 475115 JPEJA252    110.00 1      82.9    146.4    139.7    124.3
                                                            -------------------------------------------------------CONTINGENCY SINGLE 475105-475106(1)
OPEN LINE FROM BUS 475105 [JPEJA15     110.00] TO BUS 475106 [JPEJA1D1    35.000] CKT 1
                                                            475105*JPEJA15      110.00 3WNDTR              WND 1 2      22.6     52.3     40.0    141.6
                                                            -------------------------------------------------------CONTINGENCY SINGLE 475105-475115(1)
OPEN LINE FROM BUS 475105 [JPEJA15     110.00] TO BUS 475115 [JPEJA252    110.00] CKT 1
                                                            475015*JDECAN5      110.00 475020 JDJAK15     110.00 1      22.3    110.1    114.3    118.5
                                                            475015 JDECAN5      110.00 475110*JPEJA25     110.00 1       8.1     81.9     83.8    127.3
                                                            475020*JDJAK15      110.00 475025 JDJAK25     110.00 2      58.3    155.4    114.3    154.8
```

Figure 4.21 Base case overloading due to security criterion N-1 in the Serbian transmission network

Table 4.8 Percentage of indicative annual NTC values for Serbian and Kosovo borders and total ratings of interconnection lines over these borders

NTC / THEORETICAL LIMIT (%)	RS>AL	AL>RS	RS>ME	ME>RS	RS>BA	BA>RS	RS>BG	BG>RS
2012	38	81	15	20	13	26	8	16
2013	81	58	12	15	10	19	12	16
2014	19	19	10	10	6	6	12	16

NTC / THEORETICAL LIMIT (%)	HR>RS	RS>HR	RS>MK	MK>RS	RS>RO	RO>RS	RS>HU	HU>RS
2012	8	16	20	20	8	21	47	16
2013	8	12	24	16	13	21	55	16
2014	8	8	12	8	8	13	24	24

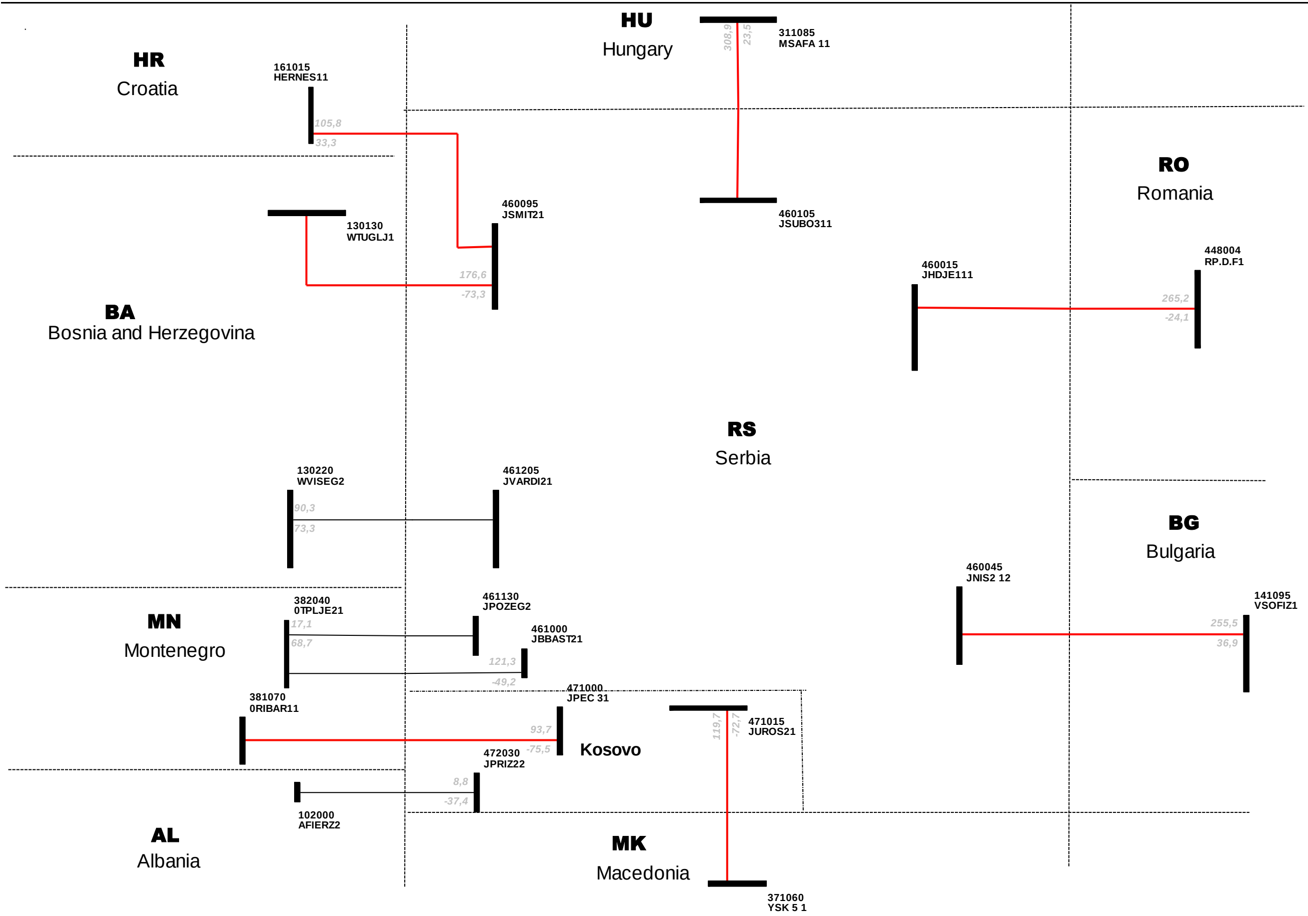


Figure 4.22 Serbian & Kosovan interconnection lines loading and percentage of loading in the base case

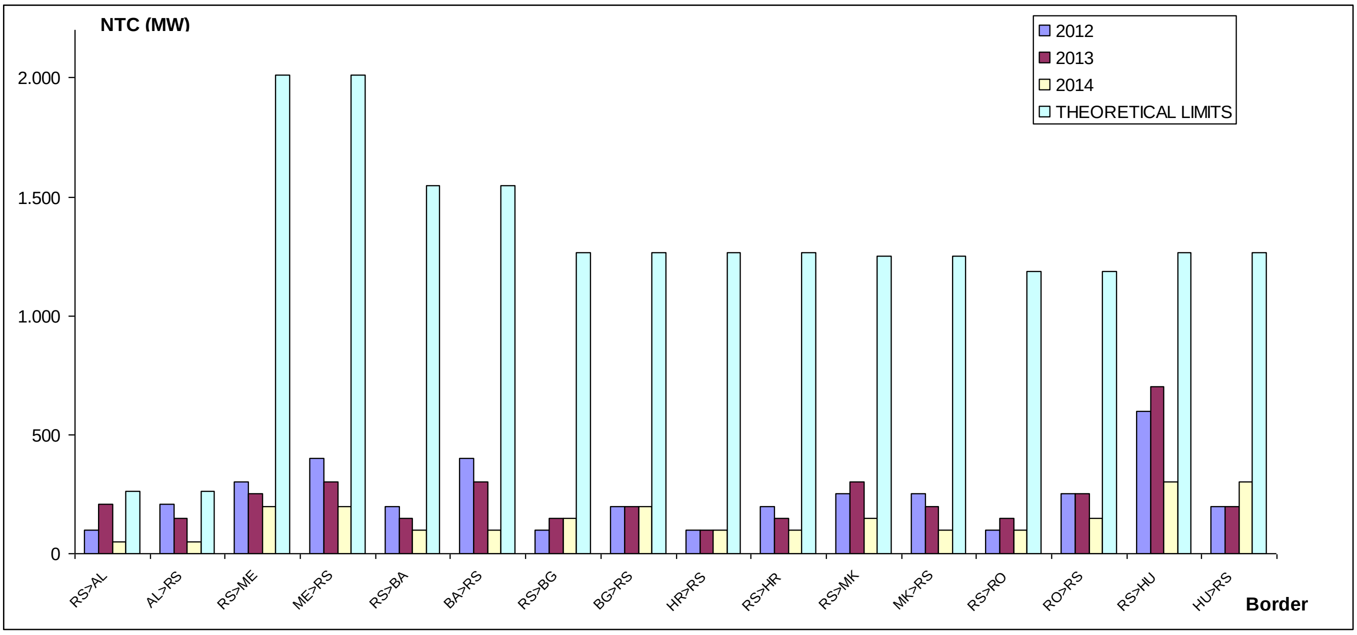


Figure 4.23 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Serbia &Kosovo

4.9 Slovenia

The Slovenian power system is modeled with the following operational conditions:

Generation: 1663,6 MW
Load: 1794,1 MW
Losses: 22,6 MW
Net interchange: -161,1 MW (import)

Important parameters for the TTC values calculation are:

ΔE_{max}^{+} = 1598,5 MW
(possible generation increase up to P_{max} of all modeled generators which are in operation)

MAX (ΔE_{max}^{+}) = 4450,1 MW
(possible generation increase up to P_{max} of all modeled generators)

ΔE_{max}^{-} = 920,6 MW
(possible generation decrease up to P_{min} of all modeled generators which are in operation)

MAX (ΔE_{max}^{-}) = 5263,7 MW
(possible generation decrease up to P_{min} of all modeled generators)

In the base case, loadings of all network elements are within acceptable limits. Security criterion N-1 is fulfilled in the base case.

The following figure presents Slovenian interconnection line (400 kV – red, 220 kV – black) loadings (MW/Mvar) and the percentage of loading compared with a line rating. Interconnection lines are loaded in the base case at less than 81 % of their thermal ratings.

Currently, the Slovenian transmission network is interconnected with neighboring power systems by six 400 kV lines and four 220 kV lines. The sum of their thermal ratings is 9457 MVA (around 9000 MW). Maximum transmission capacities over Slovenian borders are:

Border	Number of 400 kV lines	Number of 220 kV lines	Total ratings (MVA / MW)
Slovenia/Austria	2	1	3011 / 2860
Slovenia/Croatia	3	2	4210 / 4000
Slovenia/Italy	1	1	2236 / 2125
TOTAL	*6*	*4*	*9457 / 8985*

Table 4.9 Percentage of indicative annual NTC values for Slovenian borders and total ratings of interconnection lines over these borders

NTC / THEORETICAL LIMIT (%)	*SI>AT*	*AT>SI*	*SI>HR*	*HR>SI*	*SI>IT*	*IT>SI*
2012	33	33	25	15	10	8
2013	33	23	20	15	13	8
2014	33	33	34	15	11	31

Comparing Slovenian interconnection lines ratings and declared indicative NTC values in the 2012 – 2014 time period, one may notice that interconnection capacities at all Slovenian borders could be better employed, up to 34 % of theoretical limits were declared in the 2012-2014 time period.

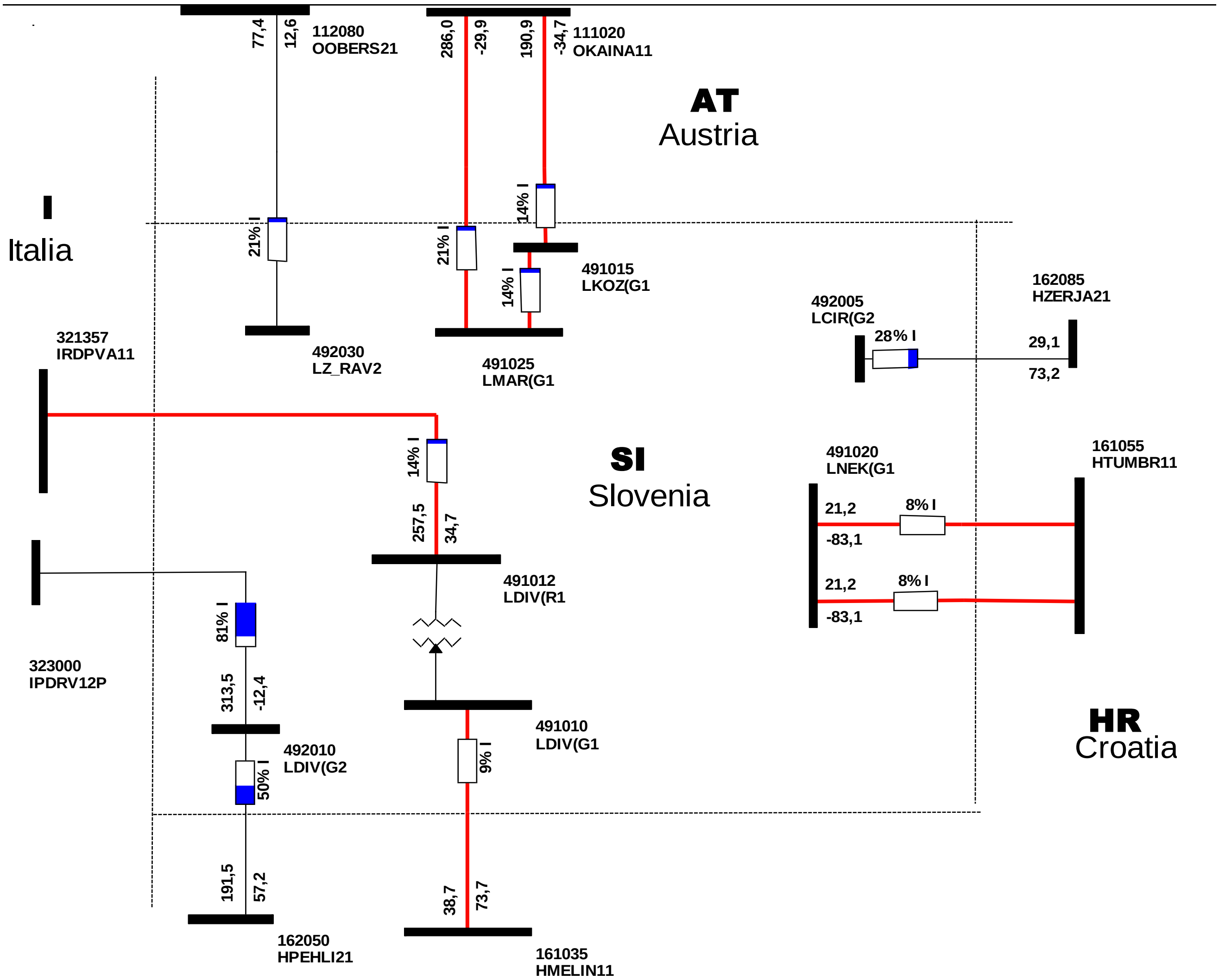


Figure 4.24 Slovenian interconnection lines loading and percentage of loading in the base case

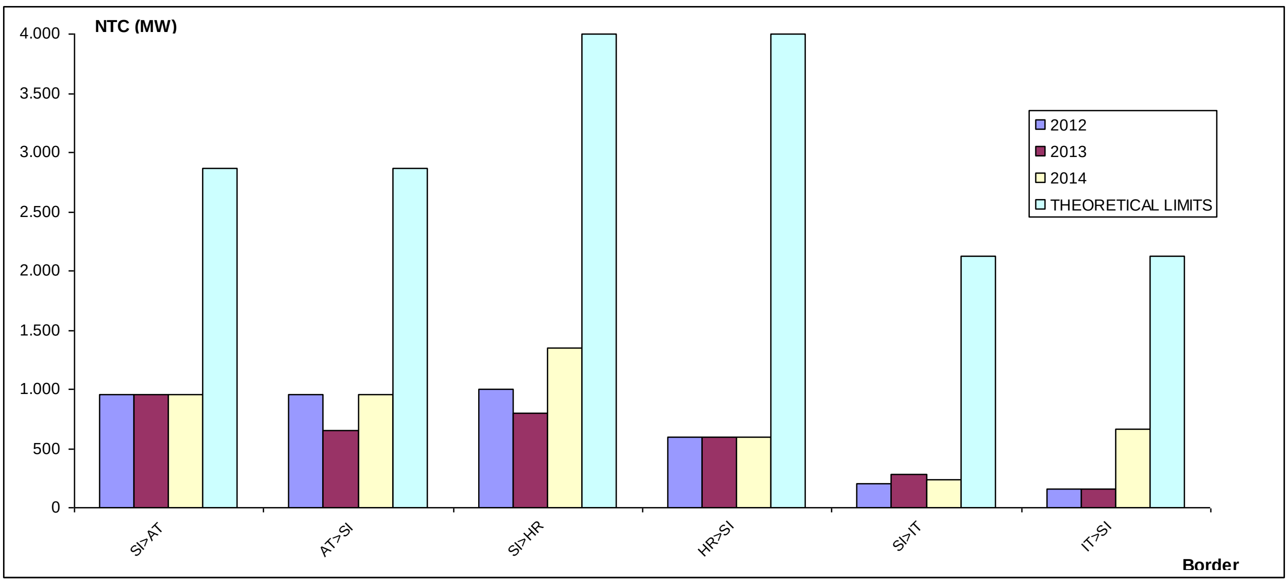


Figure 4.25 Indicative annual NTC values for time period 2012-2014 and theoretical limits for Slovenia

4.10 Turkey

The Turkish power system is modeled with the following operational conditions:

Generation: 31235,3 MW
Load: 30376,2 MW
Losses: 778,1 MW
Net interchange: 81,0 MW (export)

Important parameters for the TTC values calculation are:

ΔE_{max}^{+} = 8982 MW
(possible generation increase up to P_{max} of all modeled generators which are in operation)

MAX (ΔE_{max}^{+}) = 81292 MW
(possible generation increase up to P_{max} of all modeled generators)

ΔE_{max}^{-} = 31269 MW
(possible generation decrease up to P_{min} of all modeled generators which are in operation)

MAX (ΔE_{max}^{-}) = 160867 MW
(possible generation decrease up to P_{min} of all modeled generators)

In the base case, two 400/154 kV transformers and two 154 kV lines are overloaded.

```
X--------- FROM BUS ----------X X---------- TO BUS -----------X
   BUS# X-- NAME --X BASKV  AREA   BUS# X-- NAME --X BASKV  AREA CKT LOADING  RATING PERCENT
 542103 4SINCAN     400.00    54 542107 SINCAN_B    154.00*   54  1    154.5   150.0   103.0
 542103 4SINCAN     400.00*   54 542107 SINCAN_B    154.00    54  2    262.0   250.0   104.8
 544240 BATMAN1     154.00    54 544345 BISMIL      154.00*   54  1    205.9   180.0   114.4
 544534 BERKE-H     154.00    54 544535 BERKE-H_B   154.00*   54  1    267.9   250.0   107.2
```

Security criterion N-1 is not fulfilled in the base case.

The following figure presents Turkish interconnection line (400 kV – red, 220 kV – black) loadings (MW/Mvar) and the percentage of loading compared to a line rating. Interconnection lines are loaded in the base case at less than 18 % of their thermal ratings.

Currently, the Turkish transmission network is interconnected with ENTSO-E countries by three 400 kV lines. The sum of their thermal ratings is 5787 MVA (around 5500 MW). Maximum transmission capacities over western Turkish borders are:

Border	Number of 400 kV lines	Number of 220 kV lines	Total ratings (MVA / MW)
Turkey/Bulgaria	2	0	3609 / 3429
Turkey/Greece	1	0	2178 / 2069
TOTAL	*3*	*0*	*5787 / 5498*

Power exchanges to and from Turkey are still limited by the ENTSO-E because of a trial operation.

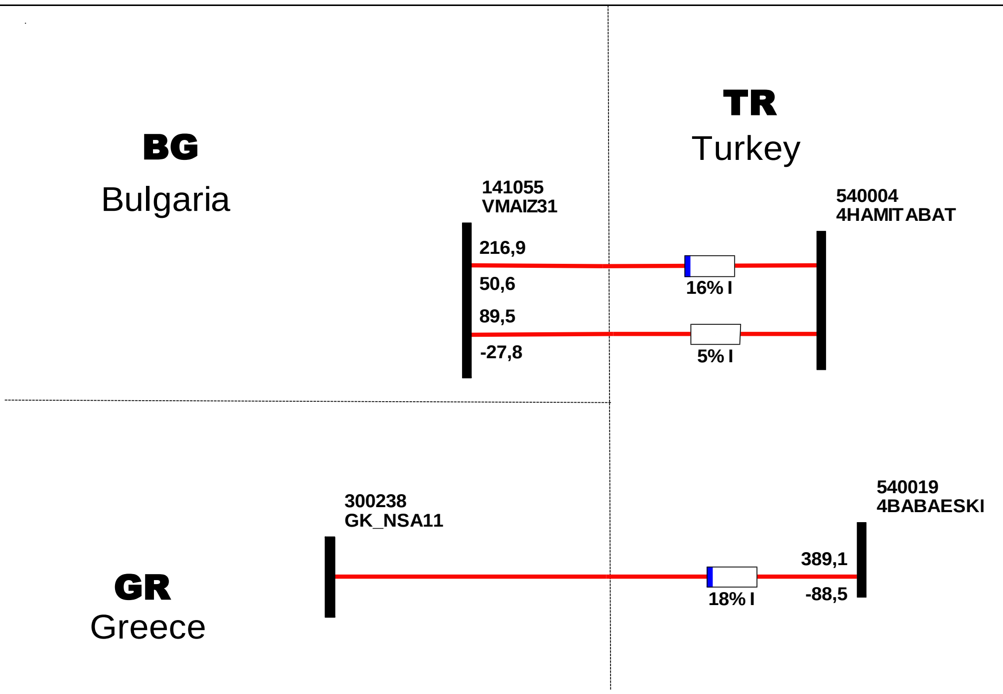


Figure 4.26 Turkish interconnection lines loading and percentage of loading in the base case

5. CALCULATION OF THE NTC VALUES USING LOAD FLOW AND N-1 ANALYSES

The NTC values were calculated using previously described PSS/E models and the ENTSO-E methodology. The calculations were performed by increasing generation in one country and decreasing generation by the same amount in another country, with proportional increase/decrease of generation depending on the generator's engagement in the base case and maximum and minimum power output of each generator.

For power systems (countries) with a small amount of possible generation increase, additional generators that were initially out of operation were included in the model with engagement close to 0 MW (in order to be included into generation shift).

In order to compute TTC values for each SEE border, the Python program was prepared in order to automatically produce final results based on the proportional increase of production in one area and proportional decrease of production in another area. The program initially uses a 200 MW generation shift. But, when transmission limits are found (network overloading), the program automatically decreases generation shift steps until the final result is reached with 1 MW precision.

TTC values may be computed with respect to all 400 kV, 220 kV and 110 (154 kV) network elements in one or more areas, or may be computed evaluating only 400 kV and 220 kV networks, or even individual contingences. Computations were performed observing outages of all 110 kV – 400 kV network elements and monitoring the following elements:

1. all 400 kV, 220 kV, 110 kV network elements and tie-lines,
2. all 400 kV and 220 kV network elements and 400 kV and 220 kV tie-lines,
3. 400 kV and 220 kV tie-lines only.

TSOs usually perform the NTC calculations observing 400 kV and 220 kV network elements only, but calculations within this study were performed in order to identify possible critical network elements which limit power exchanges, so three types of calculations have been conducted. It should stressed that some TSOs in take into consideration 110 kV network elements while performing the NTC calculations. The NTC computation only monitoring tie-lines (neglecting what happens within internal networks) was performed in order to identify areas of network limiting elements (cross-border interconnection lines or somewhere in the internal networks).

Critical contingences and overloading in the base case were neglected. TTC calculation stops when a contingency causing the first new overloading in a network is detected. Overloading in the base case was especially significant in Albania, Serbia, Macedonia and Bulgaria (see Chapters 4.1, 4.3, 4.5 and 4.8).

A composite NTC calculation, used in practice by several SEE TSOs, was not used in this study. Hence, the results of this study may be different for these countries because they employ a different NTC calculation methodology (EMS latter stated that it is its practice to use composite NTC calculation because of the loop flows and if the NTC on borders with Serbia's neighbouring countries was calculated with different methodology than the results obtained can not be comperable with NTC values calculated by EMS in previous preiod).

NTC values were computed for each side of a border, meaning that two possible NTC values may be calculated for one border. TSOs evaluate contingencies and monitor network elements in one area, then evaluate contingences and monitor network elements in the other area. The final NTC value is defined as the lower value of the two.

NTC values were computed as TTC minus TRM values. TRM values for all SEE borders were calculated by multiplying 100 by the second square-root of the number of 400 kV and 220 kV interconnection lines related to an observed border (EMS later confirmed that it determine the TRM value differently, providing another reason why some results obtained in this study cannot be compared to values calculated by EMS).

NTC values are related to contingencies in the evaluated country only for borders consisting of one observed country and one surrounding country (SI-I, SI-AT, HR-HU, RS-HU, RO-UA, RO-HU, BG-GR, TU-GR, MK-GR, AL-GR). Contingences in Italy, Austria, Hungary, Ukraine and Greece were not analyzed. In a real situation, the NTC values for these borders may be lower because of network limitations in the surrounding countries.

Transelectrica comment:
For Romania (and others) the bilateral NTC values calculated without taking in consideration their interdependence in composite interfaces (such as the national system interface) are non-aggregable and will not furnish an indication regarding the simultaneous usage on all borders and the total exchange capacity in the system interconnection interface.

5.1 The NTC computation with all network elements 400 kV, 220 kV and 110 kV monitored

The results of the NTC computation in this scenario are presented in the following table (Table 5.1). Outages of all 400 kV, 220 kV, 110 kV (and 154 kV) network elements were evaluated, and all network elements of the same voltage levels were monitored. The computation stops when the first new overloading in a network occurs (with base case overloading neglected).

The next table (Table 5.2) summarizes the ENTSO-E data related to the indicative annual NTC values in 2012. Computed NTC values are generally higher than indicative annual NTC values published by the ENTSO-E. The reasons for this may be as follows:

1. Computed values refer to only one operational situation and there were other more restrictive operational situations that were not analyzed in this study.
2. Indicative annual NTC values were probably computed using the worst expected power system operating condition, possibly with at least one additional line in maintenance.
3. Nominated NTC values may have been additionally decreased, in relation to to computation results, in order to take different uncertainties into account.
4. Some TSOs defined security criterion or contingency lists to include exceptional types of contingencies (loss of double circuit line, single busbar, several generation units etc.).
5. In some countries, TRM values were most likely defined on a higher level than assumed here.
6. Different methodology was used.
7. Some NTC values may have decreased due to contingencies and critical network elements in surrounding countries, etc.

According to the PSS/E modeling calculations, when monitoring the 400 kV, 220 kV, and 110 (154) kV networks for critical elements that limit cross-border transaction, NTC values lower than 300 MW were observed in the following borders:

Albania/Montenegro	(ME to AL direction)
Albania/Kosovo	(both directions)
BiH/Serbia	(BA to RS direction)
Bulgaria/Macedonia	(both directions)
Bulgaria/Romania	(BG to RO direction)
Bulgaria/Turkey	(both directions)
Bulgaria/Greece	(BG to GR direction)
Serbia/Bulgaria	(both directions)
Greece/Macedonia	(GR to MK direction)

Observing ENTSO-E data on indicative annual NTC values for the SEE borders, NTC values lower than 300 MW were defined for the following borders and directions:

Kosovo/Albania	(both directions)
Albania/Greece	(both directions)

Bulgaria/Serbia	(both directions)
Bulgaria/Greece	(both directions)
Croatia/Serbia	(both directions)
Macedonia/Kosovo	(both directions)
Macedonia/Greece	(MK to GR direction)
Romania/Hungary	(both directions)
Serbia/Romania	(both directions)
Slovenia/Italy	(both directions)

Figure 5.1 Borders with small cross-border capacity (NTC < 300 MW, based on calculations using PSS/E model in 2012, and evaluating all network elements 400 kV, 220 kV and 110 kV)

Figure 5.2 Borders with small cross-border capacity (NTC < 300 MW, based on the ENTSO-E data on indicative annual NTC values for 2012)

Table 5.1 The NTC values for existing network model with all network elements 400 kV, 220 kV and 110 kV monitored

	Export																
Import	**AL**	**BA**	**BG**	**HR**	**MK**	**ME**	**RO**	**RS**	**SI**		**IT**	**AT**	**HU**	**UA**	**TR**	**GR**
AL		-	-	-	-	291	-	109	-		-	-	-	-	-	340
BA	-		-	775	-	789	-	473	-		-	-	-	-	-	-
BG	-	-		-	282	-	1014	132	-		-	-	-	-	0	331
HR	-	380	-		-	-	-	443	344		-	-	1811	-	-	-
MK	-	-	267	-		-	-	320	-		-	-	-	-	-	212
ME	383	639	-	-	-		-	303	-		-	-	-	-	-	-
RO	-	-	0	-	-	-		474	-		-	-	1256	1119	-	-
RS	178	0	161	669	441	311	830		-		-	-	872	-	-	-
SI	-	-	-	1009	-	-	-	-			893	1502	-	-	-	-
IT	-	-	-	-	-	-	-	-	674			n.a.	-	-	-	500
AT	-	-	-	-	-	-	-	-	482		n.a.		n.a.	-	-	-
HU	-	-	-	789	-	-	681	489	-		-	n.a.		n.a.	-	-
UA	-	-	-	-	-	-	442	-	-		-	-	n.a.		-	-
TR	-	-	170	-	-	-	-	-	-		-	-	-	-		913
GR	360	-	219	-	755	-	-	-	-		500	-	-	-	410	

Table 5.2 The indicative annual NTC values for 2012 published by the ENTSO-E

	Export															
Import	**AL**	**BA**	**BG**	**HR**	**MK**	**ME**	**RO**	**RS**	**SI**		**IT**	**AT**	**HU**	**UA**	**TR**	**GR**
AL		-	-	-	-	NA	-	100	-		-	-	-	-	-	250
BA	-		-	400	-	NA	-	200	-		-	-	-	-	-	-
BG	-	-		-	NA	-	NA	100	-		-	-	-	-	NA	250
HR	-	400	-		-	-	-	200	1000		-	-	700	-	-	-
MK	-	-	NA	-		-	-	250	-		-	-	-	-	-	300
ME	NA	NA	-	-	-		-	300	-		-	-	-	-	-	-
RO	-	-	NA	-	-	-		100	-		-	-	150	NA	-	-
RS	210	400	200	100	250	400	250		-		-	-	200	-	-	-
SI	-	-	-	600	-	-	-	-			160	950	-	-	-	-
IT	-	-	-	-	-	-	-	-	203			-	-	-	-	500
AT	-	-	-	-	-	-	-	-	950		-		-	-	-	-
HU	-	-	-	600	-	-	200	600	-		-	-		-	-	-
UA	-	-	-	-	-	-	NA	-	-		-	-	-		-	-
TR	-	-	NA	-	-	-	-	-	-		-	-	-	-		-
GR	250	-	250	-	150	-	-	-	-		500	-	-	-	-	

5.2 The NTC computation with all network elements 400 kV and 220 kV monitored

The results of the NTC computation in this scenario are presented in the following table (Table 5.3). Outages of all network elements (400 kV, 220 kV, 110 kV (and 154 kV)) were evaluated, and all network elements of the 220 kV and 400 kV voltage levels were monitored (lines 400 kV, lines 220 kV, transformers 400/220 kV, 400/110 kV, 220/110 kV, tie-lines). 110 kV and 154 kV Networks were excluded from observations, meaning that eventual overloading in the 110 (154) kV network was neglected. The computed NTC values do not include potentially critical elements in the 110 (154) kV networks, assuming that potential problems on this voltage level may be solved by dispatching actions or in some other way.

The following table (Table 5.4) presents the difference between the computed NTC values using PSS/E network model for 2012, depending on the monitored elements' voltage levels (400 kV and 220 kV only, versus 400 kV, 220 kV and 110 (154) kV). The computed NTC values are generally higher if we exclude 110 (154) kV networks from our observations.

Significantly higher NTC values, calculated by evaluating 400 kV and 220 kV networks and neglecting the 110 (154) kV network, were computed for the following borders and directions (difference in the NTC > 200 MW):

Bulgaria/Macedonia	(BG to MK direction)
Bulgaria/Serbia	(both directions)
Bulgaria/Turkey	(BG to TR direction)
Bulgaria/Greece	(BG to GR direction)
Croatia/Slovenia	(HR to SI direction)
Croatia/Hungary	(HU to HR direction)
Serbia/Croatia	(RS to HR direction)
Kosovo/Macedonia	(RS to MK direction)
Serbia&Kosovo/Montenegro	(RS to ME direction)
Serbia/Romania	(RS to RO direction)
Serbia/Hungary	(RS to HU direction)
Turkey/Greece	(TR to GR direction)
Macedonia/Greece	(GR to MK direction)

Especially large differences between two sets of the NTC values, (difference in the NTC > 500 MW) depending on the voltage levels of monitored elements, are noticed for the following borders:

Bulgaria/Turkey	(BG to TR direction)
Kosovo/Macedonia	(RS to MK direction)
Serbia/Romania	(RS to RO direction)
Serbia/Hungary	(RS to HU direction)

The following figure presents the results of our computations on a map of the SEE region if we define NTC as less than 300MW to identify borders with small cross-border capacity, while monitoring only 400 kV and 220 kV elements as potentially critical ones.

According to the PSS/E model and calculations, NTC values below 300 MW, evaluating all 400 kV and 220 kV network elements as possible limiting elements for cross-border transactions, but neglecting potential problems in the 110 (154) kV network, may be expected at the following borders:

Albania/Kosovo	(both directions)
Albania/Montenegro	(ME to AL direction)
BiH/Serbia	(BA to RS direction)
Bulgaria/Romania	(BG to RO direction)
Macedonia/Bulgaria	(MK to BG direction)
Turkey/Bulgaria	(TR to BG direction)

Figure 5.3 Borders with small cross-border capacity (NTC < 300 MW, based on calculations using PSS/E model in 2012, and evaluating all network elements 400 kV and 220 kV)

A large difference (>500 MW) between the indicative annual NTC values published by the ENTSO-E and the computed values for analyzed operational situation is noticed at the following borders:

Croatia/Serbia	(both directions)
Croatia/Slovenia	(HR to SI direction)
Croatia/Hungary	(HU to HR direction)
Macedonia/Greece	(MK to GR direction)
Romania/Serbia	(both directions)
Romania/Hungary	(HU to RO direction)
Kosovo/Macedonia	(RS to MK direction)
Serbia/Hungary	(HU to RS direction)
Slovenia/Italy	(I to SI direction)

Table 5.3 The NTC values for existing network model with all network elements 400 kV and 220 kV monitored

Import	Export														
	AL	**BA**	**BG**	**HR**	**MK**	**ME**	**RO**	**RS**	**SI**		**IT**	**AT**	**HU**	**UA**	**TR**	**GR**
AL		-	-	-	-	291	-	271	-		-	-	-	-	-	427
BA	-		-	775	-	789	-	473	-		-	-	-	-	-	-
BG	-	-		-	282	-	1014	445	-		-	-	-	-	0	331
HR	-	491	-		-	-	-	830	487		-	-	2204	-	-	-
MK	-	-	523	-		-	-	870	-		-	-	-	-	-	636
ME	383	746	-	-	-		-	534	-		-	-	-	-	-	-
RO	-	-	0	-	-	-		999	-		-	-	1256	1119	-	-
RS	178	0	386	669	441	311	830		-		-	-	872	-	-	-
SI	-	-	-	1402	-	-	-	-			893	1502	-	-	-	-
IT	-	-	-	-	-	-	-	-	674			n.a.	-	-	-	500
AT	-	-	-	-	-	-	-	-	519		n.a.		n.a.	-	-	-
HU	-	-	-	789	-	-	681	1051	-		-	n.a.		n.a.	-	-
UA	-	-	-	-	-	-	442	-	-		-	-	n.a.		-	-
TR	-	-	1457	-	-	-	-	-	-		-	-	-	-		913
GR	360	-	512	-	879	-	-	-	-		500	-	-	-	804	

Table 5.4 Difference between calculated NTC values using PSS/E model for 2012 depending on monitored elements (400 kV and 220 kV versus 400 kV, 220 kV and 110(154) kV)

	Export															
Import	**AL**	**BA**	**BG**	**HR**	**MK**	**ME**	**RO**	**RS**	**SI**		**IT**	**AT**	**HU**	**UA**	**TR**	**GR**
AL		-	-	-	-	0	-	162	-		-	-	-	-	-	87
BA	-		-	0	-	0	-	0	-		-	-	-	-	-	-
BG	-	-		-	0	-	0	313	-		-	-	-	-	0	0
HR	-	111	-		-	-	-	387	143		-	-	393	-	-	-
MK	-	-	256	-		-	-	550	-		-	-	-	-	-	424
ME	0	107	-	-	-		-	231	-		-	-	-	-	-	-
RO	-	-	0	-	-	-		525	-		-	-	0	0	-	-
RS	0	0	225	0	0	0	0		-		-	-	0	-	-	-
SI	-	-	-	393	-	-	-	-			0	0	-	-	-	-
IT	-	-	-	-	-	-	-	-	0			-	-	-	-	0
AT	-	-	-	-	-	-	-	-	37		-		-	-	-	-
HU	-	-	-	0	-	-	0	562	-		-	-		-	-	-
UA	-	-	-	-	-	-	0	-	-		-	-	-		-	-
TR	-	-	1286	-	-	-	-	-	-		-	-	-	-		0
GR	0	-	293	-	124	-	-	-	-		0	-	-	-	394	

5.3 The NTC computation with tie--lines monitored only

The results of the NTC computation in this scenario are presented in the following table (Table 5.5). Outages of all 400 kV, 220 kV, 110 kV (and 154 kV) network elements were evaluated but only the 400 kV and 220 kV interconnection lines were monitored, ignoring all internal networks elements. Complete 400 kV, 220 kV and 110 kV (154 kV) internal networks were excluded from observations, meaning that the eventual overloading in the internal networks was neglected.

The following table (Table 5.6) presents the differences between computed NTC values using the PSS/E network model for 2012, depending on the monitored elements (interconnection lines 400 kV and 220 kV only, versus all 400 kV and 220 kV network elements). One may notice that the computed NTC values are generally higher when internal networks are excluded from our observations.

Figure 5.4 Borders with small cross-border capacity (NTC < 300 MW, based on calculations using PSS/E model in 2012, and observing interconnection lines 400 kV and 220 kV only)

Especially high differences between two sets of the NTC values, (difference in the NTC > 500 MW) depending on the monitored elements, are noticed for the following borders:

BiH/Serbia	(both directions)
Bulgaria/Macedonia	(BG to MK direction)
Bulgaria/Romania	(both directions)
Bulgaria/Serbia	(BG to RS direction)
Bulgaria/Greece	(both directions)
Romania/Hungary	(both directions)
Slovenia/Austria	(SI to AT direction)

The previous figure presents the results of our computations on the map of the SEE region using results of the PSS/E computations if we define NTC as less than 300 MW to identify borders with small cross-border capacity, but monitor only interconnection lines as potentially critical network elements.

According to the PSS/E model and calculations, NTC values below 300 MW, when evaluating all 400 kV and 220 kV interconnection lines and neglecting internal transmission systems, may be expected at the Montenegrin/Albanian border only, for power flow direction from Montenegro to Albania.

High differences (>500 MW) between the indicative annual NTC values published by the ENTSO-E and computed values for analyzed operational situation is noticed at the following borders:

Bulgaria/Serbia	(both directions)
Bulgaria/Greece	(both directions)
BiH/Croatia	(HR to BA direction)
Croatia/Serbia	(both directions)
Croatia/Slovenia	(HR to SI direction)
Croatia/Hungary	(HU to HR direction)
Macedonia/Greece	(MK to GR direction)
Romania/Serbia	(both directions)
Romania/Hungary	(both directions)
Serbia/BiH	(RS to BA direction)
Kosovo/Macedonia	(RS to MK direction)
Serbia/Hungary	(both directions)
Slovenia/Italy	(both directions)
Slovenia/Austria	(AT to SI direction)

These results lead to the conclusion that there are many limitations in the internal national transmission systems that may decrease the NTC values and the possibilities for power trading at the wholesale market located within. This signals to the TSOs to plan additional internal network reinforcements, in order to increase possibilities for power trading across the region. Congestion revenues may be an important source of financial support for such activities, having in mind that internal network investments are usually significantly less costly than new interconnection lines construction. Another important factor is the expected time period needed to realize transmission projects. Internal network reinforcements are generally well prepared in advance and need significantly less time between making decisions and fully operating.

The appropriate internal network reinforcements may increase the NTC values in a short period of time, thus leaving the TSOs enough time to properly prepare and realize eventual new interconnection projects, while market participants should be able to increase volumes of power trading across the region.

Table 5.5 The NTC values for existing network model with interconnection lines 400 kV and 220 kV monitored

	Export															
Import	**AL**	**BA**	**BG**	**HR**	**MK**	**ME**	**RO**	**RS**	**SI**		**IT**	**AT**	**HU**	**UA**	**TR**	**GR**
AL		-	-	-	-	430	-	327	-		-	-	-	-	-	683
BA	-		-	1076	-	1088	-	1278	-		-	-	-	-	-	-
BG	-	-		-	412	-	1814	745	-		-	-	-	-	1684	987
HR	-	569	-		-	-	-	1078	880		-	-	2597	-	-	-
MK	-	-	1185	-		-	-	870	-		-	-	-	-	-	636
ME	383	746	-	-	-		-	534	-		-	-	-	-	-	-
RO	-	-	891	-	-	-		999	-		-	-	1924	2280	-	-
RS	671	731	1635	669	441	311	830		-		-	-	872	-	-	-
SI	-	-	-	1402	-	-	-	-			893	1645	-	-	-	-
IT	-	-	-	-	-	-	-	-	774			n.a.	-	-	-	500
AT	-	-	-	-	-	-	-	-	1162		n.a.		n.a.	-	-	-
HU	-	-	-	789	-	-	2006	1401	-		-	n.a.		n.a.	-	-
UA	-	-	-	-	-	-	442	-	-		-	-	n.a.		-	-
TR	-	-	1457	-	-	-	-	-	-		-	-	-	-		913
GR	440	-	1693	-	879	-	-	-	-		500	-	-	-	2260	

Table 5.6 Difference between calculated NTC values using PSS/E model for 2012 depending on monitored elements (interconnection lines 400 kV and 220 kV versus all network elements 400 kV and 220 kV)

Import	Export															
	AL	**BA**	**BG**	**HR**	**MK**	**ME**	**RO**	**RS**	**SI**		**IT**	**AT**	**HU**	**UA**	**TR**	**GR**
AL		-	-	-	-	139	-	56	-		-	-	-	-	-	256
BA	-		-	301	-	299	-	805	-		-	-	-	-	-	-
BG	-	-		-	130	-	800	300	-		-	-	-	-	1684	656
HR	-	78	-		-	-	-	248	393		-	-	393	-	-	-
MK	-	-	662	-		-	-	0	-		-	-	-	-	-	0
ME	0	0	-	-	-		-	0	-		-	-	-	-	-	-
RO	-	-	891	-	-	-		0	-		-	-	668	1161	-	-
RS	493	731	1249	0	0	0	0		-		-	-	0	-	-	-
SI	-	-	-	0	-	-	-	-			0	143	-	-	-	-
IT	-	-	-	-	-	-	-	-	100			n.a.	-	-	-	0
AT	-	-	-	-	-	-	-	-	643		n.a.		n.a.	-	-	-
HU	-	-	-	0	-	-	1325	350	-		-	n.a.		n.a.	-	-
UA	-	-	-	-	-	-	0	-	-		-	-	n.a.		-	-
TR	-	-	0	-	-	-	-	-	-		-	-	-	-		0
GR	0	-	1181	-	0	-	-	-	-		0	-	-	-	1456	

6. CRITICAL PARTS OF THE SEE TRANSMISSION NETWORK WITH RESPECT TO NTC VALUES

Critical network elements that limit the NTC values for all SEE borders are analyzed and described in this chapter, evaluating networks from both sides of each border. Monitored elements were all 400 kV, 220 kV and 110 (154) kV network elements, 400 kV and 220 kV network elements only (ignoring network 110-154 kV), and 400 kV and 220 kV interconnection lines only. The NTC values were calculated with respect to the first network overloading among monitored elements, neglecting the N-1 situation overloading in the base case. The set of critical elements in each TSO and the location of critical branches (interconnection lines or internal networks) are determined by monitoring different voltage levels of network elements.

Evaluating one border, the NTC values are calculated with respect to critical elements from both sides of a border, noticing the difference between two sets of possible NTC values. Because the lower value is used as the final NTC value, dispatching actions or network reinforcements may be prioritized when evaluating both countries that share a border in order to increase the NTC values as much as possible.

6.1 Albania/Montenegro border

The NTC values for Albania/Montenegro border have been calculated using the model for 2012 as follows:

Table 6.1 The NTC values for Albania/Montenegro border (2012, ALBANIA to MONTENEGRO direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Albania	Montenegro	
400 kV, 220 kV, 110 kV & tie-lines	386	383	383
400 kV, 220 kV & tie-lines	386	383	383
tie-lines (400 kV, 220 kV)	386	383	383

Table 6.2 The NTC values for Albania/Montenegro border (2012, MONTENEGRO to ALBANIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Albania	Montenegro	
400 kV, 220 kV, 110 kV & tie-lines	291	439	291
400 kV, 220 kV & tie-lines	291	439	291
tie-lines (400 kV, 220 kV)	430	439	430

For the direction of power flows from Albania to Montenegro, evaluating all 400 kV, 220 kV and 110 kV network elements on Albanian side, the NTC value is set to 386 MW. It is limited by the 220 kV internal line, V.Dejes – Koman, which gets overloaded as a consequence of an OHL 220 kV Tirana – Kolac outage. For the same direction of power flow and evaluating only tie-lines on the Albanian side, the NTC value stays the same due to maximum generation shift in Albania at the model.

For the direction of power flows from Albania to Montenegro, and evaluating all 400 kV, 220 kV and 110 kV network elements on Montenegrin side, the NTC value is set to 383 MW, limited by the 220 kV interconnection line, Podgorica – V.Dejes, that gets overloaded as a consequence of an OHL 400 kV Podgorica – Tirana outage.

Based on the lower NTC between both sides, the final NTC value for the Albania to Montenegro direction of power exchange is set to 383 MW and is limited by the 220 kV interconnection line, Podgorica – Vau Dejes, thermal rating (defined as 274 MVA on Montenegrin side and 278 MVA on Albanian side at the model).

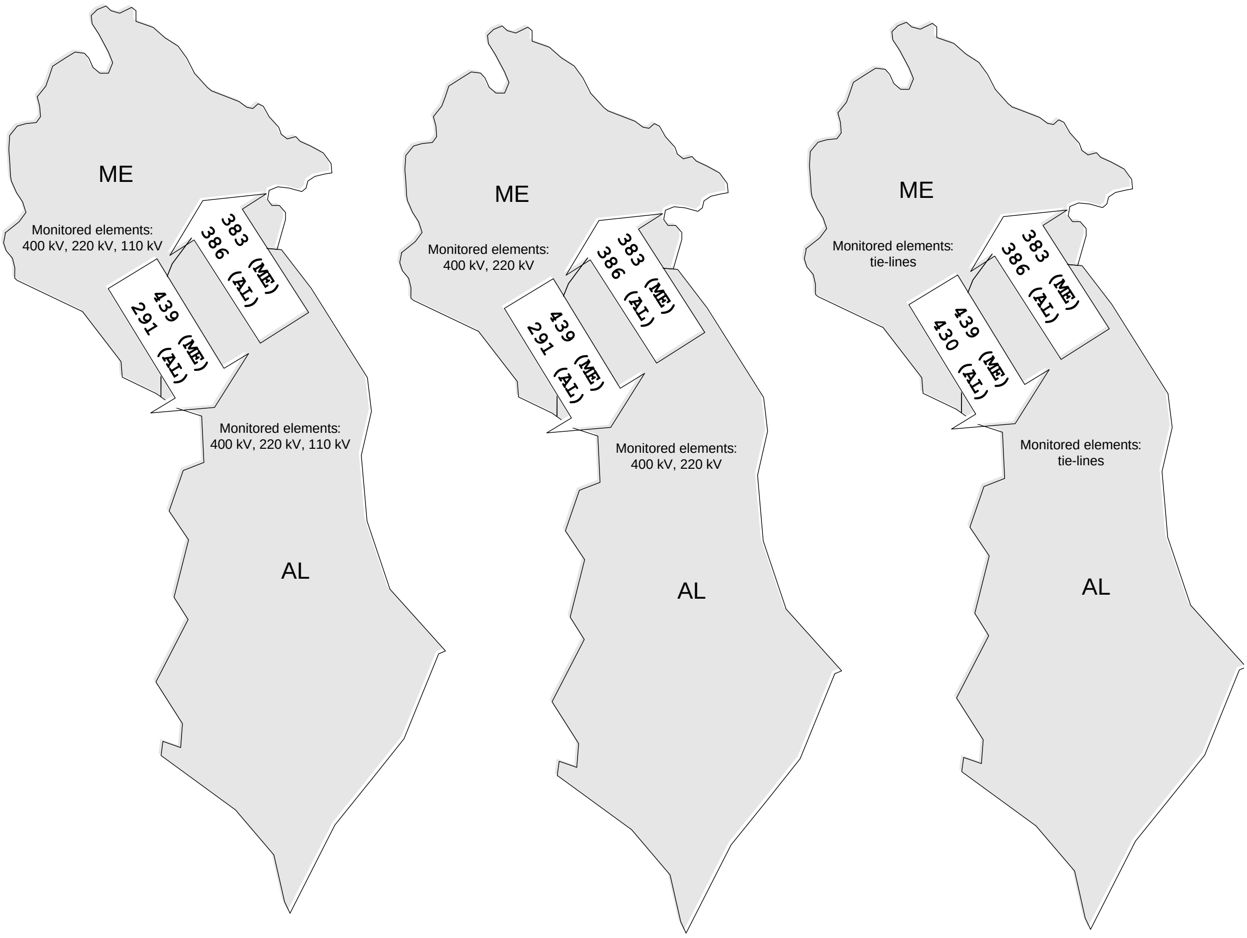


Figure 6.1 Calculated NTC values for Albania/Montenegro border depending on the monitored elements (model 2012)

For the direction of power flows from Montenegro to Albania, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Albanian side, the NTC value is set to 291 MW. It is limited by the 400/220/30 kV transformers in the SS Elbassan, which get overloaded as a consequence of an OHL 220 kV Podgorica – Vau Dejes outage. For the same direction of power flow and evaluating tie-lines on the Albanian side only, the NTC value is increased to 430 MW. It is limited by the 220 kV interconnection line, Podgorica – V.Dejes, which gets overloaded as a consequence of a OHL 400 kV Podgorica – Tirana outage.

For the direction of power flows from Montenegro to Albania, and evaluating all 400 kV, 220 kV and 110 kV network elements on Montenegrin side, the NTC value is set to 439 MW, limited by the 220 kV interconnection line Podgorica – V.Dejes.

Based on the lower NTC value between both sides, the final NTC value for the Montenegro to Albania direction of power exchange is set to 291 MW if we evaluate the internal Albanian network, and is limited by the number and rating of transformers in Elbassan (defined as 2x300 MVA). The final NTC value is 430 MW if we evaluate tie-lines only and is limited by the 220 kV interconnection line, Podgorica – V.Dejes.

Table 6.3 Critical network elements for a power exchange on the Albania/Montenegro border

RESULTS	**TTC (MW)**	**TRM (MW)**	**NTC (MW)**	**Critical contingency**	**Critical line**
Albania to Montenegro direction					
Albanian side (monitored elements: 400 kV, 220 kV and 110 kV)	528	141	386	OHL 220 kV Tirana - Kolac	OHL 220 kV V.Dejes - Koman
Albanian side (monitored elements: 400 kV, 220 kV)	528	141	386	OHL 220 kV Tirana - Kolac	OHL 220 kV V.Dejes - Koman
Albanian side (monitored elements: tie-lines)	528	141	386	-	*maximum generation shift in Albania*
Montenegrin side (monitored elements: 400 kV, 220 kV and 110 kV)	524	141	383	OHL 400 kV Podgorica - Tirana	OHL 220 kV Podgorica - V.Dejes*
Montenegrin side (monitored elements: 400 kV, 220 kV)	524	141	383	OHL 400 kV Podgorica - Tirana	OHL 220 kV Podgorica - V.Dejes
Montenegrin side (monitored elements: tie-lines)	524	141	383	OHL 400 kV Podgorica - Tirana	OHL 220 kV Podgorica - V.Dejes
Montenegro to Albania direction					
Albanian side (monitored elements: 400 kV, 220 kV and 110 kV)	432	141	291	OHL 220 kV V.Dejes-Podgorica	TR 400/220/30 kV Elbassan 1,2
Albanian side (monitored elements: 400 kV, 220 kV)	432	141	291	OHL 220 kV V.Dejes-Podgorica	TR 400/220/30 kV Elbassan 1,2
Albanian side (monitored elements: tie-lines)	571	141	430	OHL 400 kV Podgorica - Tirana	OHL 220 kV Podgorica - V.Dejes
Montenegrin side (monitored elements: 400 kV, 220 kV and 110 kV)	581	141	439	OHL 400 kV Podgorica - Tirana	OHL 220 kV Podgorica - V.Dejes
Montenegrin side (monitored elements: 400 kV, 220 kV)	581	141	439	OHL 400 kV Podgorica - Tirana	OHL 220 kV Podgorica - V.Dejes
Montenegrin side (monitored elements: tie-lines)	581	141	439	OHL 400 kV Podgorica - Tirana	OHL 220 kV Podgorica - V.Dejes

MEPSO comment: Here is the problem of parallel path on 400 kV and 220 kV level. We have noticed it in composite approach of calculation of NTC for North-South direction. Switching of 220 kV OHL Podgorica - V. Dejes after outage of 400 kV OHL Podgorica - Tirana resolves the problem. Therefore, we neglect this contingency.

Remark: The Albanian TSO (OST) doesn't consider transformers 400/110/35 kV in the Elbassan substation to be critical and limiting network elements for the NTC values. Due to that, the NTC value for the analyzed border for Montenegro to Albania direction of power exchange may be higher than calculated here.

OST confirmed that the OHL 220 kV V.Dejes – Koman is critical element due to outage of the OHL 220 kV Tirana – Kolac.

Montenegrin TSO (CGES) didn't response on their critical elements which limit power exchanges over the analyzed border.

6.2 Albania/Kosovo border (area RS at the PSS/E 2012 model)

The NTC values for Albania/Kosovo border have been calculated using the model for 2012 as follows:

Table 6.4 The NTC values for Albania/Kosovo border (2012, ALBANIA to KOSOVO direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Albania**	**Kosovo**	
400 kV, 220 kV, 110 kV & tie-lines	641	178	178
400 kV, 220 kV & tie-lines	671	178	178
tie-lines (400 kV, 220 kV)	671	671	671

Table 6.5 The NTC values for Albania/Kosovo border (2012, KOSOVO to ALBANIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Albania**	**Kosovo**	
400 kV, 220 kV, 110 kV & tie-lines	109	109	109
400 kV, 220 kV & tie-lines	271	309	271
tie-lines (400 kV, 220 kV)	327	570	327

For the direction of power flows from Albania to Kosovo, and evaluating all 400 kV, 220 kV and 110 kV network elements on Albanian side, the NTC value would be set to 641 MW, limited by the 220/110 kV transformers in the SS Tirana, which get overloaded if one of them goes out of operation. For the same direction of power flow and evaluating 400 kV and 220 kV networks or tie-lines on Albanian side only, the NTC value would be increased up to 671 MW without any critical network element due to maximum generation shift in Albanian at the model.

For the direction of power flows from Albania to Kosovo, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Kosovo and Serbia side, the NTC value is set to 178 MW. It is limited by the 220/110 kV transformers in the SS Sremska Mitrovica, which get overloaded if one of them goes out of operation. The PSS/E model includes area "RS," which comprises of Serbia and Kosovo, so generation shift in these countries was performed using generators, not only in Kosovo, but in Serbia as well. Limitations in the 220/110 kV transformation in the SS Sremska Mitrovica are not realistic because critical transformers are situated far away from the evaluated border and they are highly loaded in the base case (99 % S_r). Due to a decrease of generation in Kosovo and Serbia (RS area), there will be an increase of power exchange between the Serbian/Croatian and Bosnian border, with a slight increase of the 220/110 kV transformers in the SS S. Mitrovica loading. Ignoring this loading violation, we approach a more realistic possible NTC value between Albania and Kosovo for the direction of exchange from Kosovo and Serbia to Albania but evaluating the network of Kosovo and Serbia only, in the amount of 671 MW. It is limited by maximum generation shift in Albania and without any limitations in the networks of Kosovo and Serbia.

Based on the lower NTC value between both sides, the final NTC value for the Albania to Kosovo direction of power exchange is set to 178 MW if we evaluate the internal transmission systems of Albania, Kosovo and Serbia. It is limited by the high loading of the 220/110 kV transformers in the SS S. Mitrovica (rating 2x150 MVA at the model). Ignoring this non-realistic limitation, the NTC value increases to 641 MW, limited by the 220/110 kV transformers in the SS Tirana, and up to 671 MW evaluating tie-lines only, due to maximum generation shift in Albania at the model. Excluding Serbia from the NTC calculations, meaning that only generation shift in Kosovo is performed (with constant generation in Serbia), the NTC value for the Albania/Kosovo border and Albania to Kosovo direction of power exchange will be set to 127 MW. It is not limited by any network element but limited due to maximum generation shift in Kosovo.

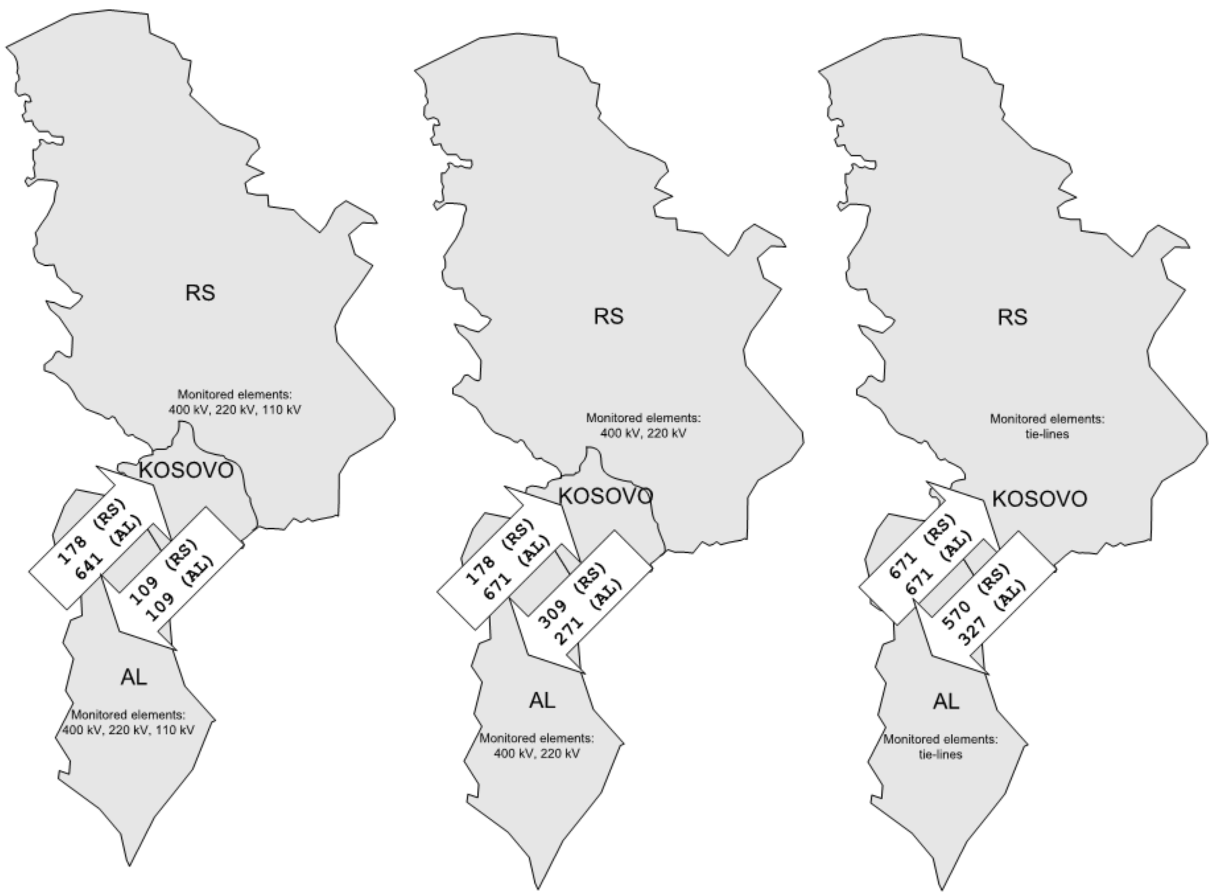


Figure 6.2 Calculated NTC values for Albania/Kosovo border depending on the monitored elements (model 2012)

For the direction of power flows from Kosovo and Serbia to Albania, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Albanian side, the NTC value is set to 109 MW. It is limited by the OHL 110 kV Tirana – Selite, which gets overloaded as a consequence of an OHL 220 kV Tirana – Rrashbull outage. For the same direction of power flow and evaluating the 400 kV and 220 kV networks on Albanian side, the NTC value is increased to 271 MW, limited by 400/220/30 kV transformers in the SS Elbassan and 220/110 kV in the SS Fierze, which get overloaded if one transformer in those substations go out of operation. If we evaluate tie-lines only, the NTC values rises up to 327 MW, limited by the OHL 220 kV Podgorica – Vau Dejes, which gets overloaded when OHL 400 kV Podgorica – Tirana goes out of operation.

Table 6.6 Critical network elements for a power exchange on the Albania/Kosovo&Serbia border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Albania to Kosovo direction					
Albanian side (monitored elements: 400 kV, 220 kV and 110 kV)	741	100	641	TR 220/110 kV Tirana 1,2	TR 220/110 kV Tirana 2,1
Albanian side (monitored elements: 400 kV, 220 kV)	771	100	671	-	*maximum generation shift in Albania*
Albanian side (monitored elements: tie-lines)	771	100	671	-	*maximum generation shift in Albania*
RS side (monitored elements: 400 kV, 220 kV and 110 kV)	278	100	178	TR 220/110/10 kV S.Mitrovica 1,2	TR 220/110/10 kV S.Mitrovica 2,1
RS side (monitored elements: 400 kV, 220 kV)	278	100	178	TR 220/110/10 kV S.Mitrovica 1,2	TR 220/110/10 kV S.Mitrovica 2,1
RS side (monitored elements: tie-lines)	771	100	671	-	*maximum generation shift in Albania*
Kosovo to Albania direction					
Albanian side (monitored elements: 400 kV, 220 kV and 110 kV)	209	100	109	OHL 220 kV Tirana – Rrashbull	OHL 110 kV Tirana – Selite
Albanian side (monitored elements: 400 kV, 220 kV)	371	100	271	TR 400/220/30 kV Elbassan 1,2	TR 400/220/30 kV Elbassan 2,1
				TR 220/110/35 kV Fierza 1,2	TR 220/110/35 kV Fierza 2,1
Albanian side (monitored elements: tie-lines)	427	100	327	OHL 400 kV Podgorica - Tirana	OHL 220 kV Podgorica - V.Dejes
RS side (monitored elements: 400 kV, 220 kV and 110 kV)	209	100	109	OHL 220 kV Prizren – Drenas	OHL 110 kV Prizren – Theranda
					OHL 110 kV Theranda – Ferizaji
RS side (monitored elements: 400 kV, 220 kV)	409	100	309	TR 400/220/20 Niš	TR 400/110/35 Niš
RS side (monitored elements: tie-lines)	670	100	570	-	*maximum generation shift in Albania*

For the direction of power flows from Kosovo to Albania, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Kosovo and Serbia side, the NTC value is set to 109 MW. It is limited by lines 110 kV Prizren – Theranda and Theranda – Ferizaji (ratings 83,8 MVA at the model), which get overloaded as a consequence of an OHL 220 kV Prizren – Drenas outage. Monitoring 400 kV and 220 kV networks on the Kosovo and Serbian side, the NTC value rises to 309 MW. It is limited by the 400/110/35 kV transformer in the SS Niš, which gets overloaded by a 400/220/20 kV transformer Niš outage. If we evaluate tie-lines only, the NTC value is calculated as 570 MW, due to maximum generation shift in Albania.

Based on the lower NTC value between both sides, the final NTC value for the Kosovo and Serbia to Albania direction of power exchange is set to 109 MW if we evaluate internal networks including 110 kV, 271 MW if we evaluate 400 kV and 220 kV networks and 327 MW if we evaluate tie-lines only.

Remark: Albanian TSO (OST) doesn't consider transformers 220/110 kV in the Tirana substation to be critical and limiting network elements for the NTC values. Overloading of transformers in the Tirana substation is not realistic because in reality there are three autotransformers and in the model of January 14, 2012, 12:40, the third transformer was out of operation. Due to that, the NTC value for analyzed border and both directions of power exchanges may be higher than calculated here.

OST confirmed that the OHL 110 kV Tirana – Selite and OHL 220 kV Elbasan – Fieri are critical elements due to outage of the OHL 220 kV Tirana – Rrashbull.

Serbian TSO (EMS) stated that overloading of transformers 400/110 kV and 220/110 kV, together with possible overloading of the 110 kV lines, are not critical and limiting elements for the NTC values over Serbian borders. Due to that, one may expect that the NTC values for the analyzed border should be higher than calculated here.

6.3 Albania/Greece border

The NTC values for Albania/Greece border have been calculated using the model for 2012 as follows:

Table 6.7 The NTC values for Albania/Greece border (2012, ALBANIA to GREECE direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Albania**	**Greece**	
400 kV, 220 kV, 110 kV & tie-lines	360	-	360
400 kV, 220 kV & tie-lines	360	-	360
tie-lines (400 kV, 220 kV)	440	-	440

Table 6.8 The NTC values for Albania/Greece border (2012, GREECE to ALBANIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Albania**	**Greece**	
400 kV, 220 kV, 110 kV & tie-lines	340	-	340
400 kV, 220 kV & tie-lines	427	-	427
tie-lines (400 kV, 220 kV)	683	-	683

The NTC values for the Albania/Greece border were calculated with respect to security criterion in the Albanian network only, so they may be reduced additionally by possible limitations in Greek transmission system.

For the direction of power flows from Albania to Greece, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Albanian side, the NTC value is set to 360 MW. It is limited by the 220/110 kV transformers in Tirana (rating of 2x120 MVA at the model), which are jeopardized if one of them goes out of operation. For the same direction of power flow, but evaluating tie-lines on the Albanian side only, the NTC value rises to 440 MW and is limited by the maximum generation shift in Albania at the model.

For the direction of power flows from Greece to Albania, and evaluating all 400 kV, 220 kV and 110 kV network elements on Albanian side, the NTC value is set to 340 MW. It is limited by the OHL 110 kV Tirana – Selite, which gets overloaded as a consequence of an OHL 220 kV Tirana – Rrashbull outage. For the same direction of power flow and monitoring the Albanian 400 kV and 220 kV network elements only, the NTC value would be set up to 427 MW. It is limited by the 400/220/30 kV transformers in the SS Elbasan (rating of 2x300 MVA at the model), which could be overloaded if one of them trips off. Repeating a calculation but evaluating tie-lines on the Albanian side only, the NTC value is increased to 683 MW. It is limited by the OHL 220 kV Fierza – Prizren (thermal rating 325,4 MVA on Albanian side at the model), which gets overloaded if OHL 400 kV Zemlak – Kardia goes out of operation.

Remark: Albanian TSO (OST) doesn't consider transformers 400/220 kV in the Elbasan substation and 220/110 kV in the Tirana substation to be critical and limiting network elements for the NTC values. Overloading of transformers in the Tirana substation is not realistic because in reality there are three autotransformers and in the model of January 14, 2012, 12:40, the third transformer was out of operation. Due to that, the NTC value for analyzed border and both directions of power exchanges may be higher than calculated here, if not restricted by possible overloading in the transmission system of Greece that has not been analyzed here from the security perspective.

OST confirmed that the OHL 110 kV Tirana – Selite and OHL 220 kV Elbasan – Fieri are critical elements due to outage of the OHL 220 kV Tirana – Rrashbull.

Figure 6.3 Calculated NTC values for Albania/Greece border depending on the monitored elements (model 2012)

Table 6.9 Critical network elements for a power exchange on the Albania/Greece border

RESULTS	**TTC (MW)**	**TRM (MW)**	**NTC (MW)**	**Critical contingency**	**Critical line**
Albania to Greece direction					
Albanian side (monitored elements: 400 kV, 220 kV and 110 kV)	460	100	360	TR 220/110 kV Tirana 1,2	TR 220/110 kV Tirana 2,1
Albanian side (monitored elements: 400 kV, 220 kV)	460	100	360	TR 220/110 kV Tirana 1,2	TR 220/110 kV Tirana 2,1
Albanian side (monitored elements: tie-lines)	540	100	440	-	*maximum generation shift in Albania*
Greek side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Greek side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Greek side (monitored elements: tie-lines)	-	-	-	-	-
Greece to Albania direction					
Albanian side (monitored elements: 400 kV, 220 kV and 110 kV)	440	100	340	OHL 220 kV Tirana – Rrashbull	OHL 110 kV Tirana – Selite
Albanian side (monitored elements: 400 kV, 220 kV)	527	100	427	TR 400/220/30 kV Elbassan 1,2	TR 400/220/30 kV Elbassan 2,1
Albanian side (monitored elements: tie-lines)	783	100	683	OHL 400 kV Zemlak - Kardia	OHL 220 kV Fierza - Prizren
Greek side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Greek side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Greek side (monitored elements: tie-lines)	-	-	-	-	-

6.4 Bosnia and Herzegovina/Croatia border

The NTC values for BiH/Croatia border have been calculated using the model for 2012 as follows:

Table 6.10 The NTC values for BiH/Croatia border (2012, BOSNIA AND HERZEGOVINA to CROATIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	BiH	Croatia	
400 kV, 220 kV, 110 kV & tie-lines	650	380	380
400 kV, 220 kV & tie-lines	650	491	491
tie-lines (400 kV, 220 kV)	650	569	569

Table 6.11 The NTC values for BiH/Croatia border (2012, CROATIA to BOSNIA AND HERZEGOVINA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	BiH	Croatia	
400 kV, 220 kV, 110 kV & tie-lines	775	1076	775
400 kV, 220 kV & tie-lines	775	1076	775
tie-lines (400 kV, 220 kV)	1584	1076	1076

For the direction of power flows from Bosnia and Herzegovina to Croatia, and evaluating all 400 kV, 220 kV and 110 kV network elements on the BiH side, the NTC value is set to 650 MW. It is not limited by any network element on the Bosnian side but due to maximum generation shift in Croatia.

For the same direction of power flows, evaluating all 400 kV, 220 kV and 110 kV network elements on the Croatian side, the NTC value is set to 380 MW. It is limited by OHL 110 kV, Žerjavinec – Jertovec, which gets overloaded as a consequence of an OHL 400 kV Žerjavinec – Tumbri outage. The thermal rating of the 110 kV critical line is set to 110 MVA. Monitoring the 400 kV and 220 kV network elements in Croatia only, the NTC value would rise to 491 MW and be limited by 400/110 kV transformers in the SS Žerjavinec (2x300 MVA). These transformers may be jeopardized when one of them is tripped off. Ignoring the internal Croatian network and evaluating the tie-lines only, the NTC would increase up to 569 MW due to maximum generation shift in Croatia.

Based on the lower NTC value between both sides, the final NTC value for the BiH to Croatia direction of power exchange is set to 380 MW. It is limited by the 110 kV Croatian internal line, Žerjavinec - Jertovec. The final NTC value, ignoring 110 kV networks, would be 491 MW, limited by 400/110 kV transformers in the Žerjavinec substation. If only Bosnian and Croatian tie-lines are evaluated without any network limitation for this value of power exchange across the border, the NTC value could be set to 569 MW.

For the direction of power flows from Croatia to Bosnia and Herzegovina, and evaluating all 400 kV, 220 kV and 110 kV network elements on the BiH side, the NTC value is set to 775 MW. It is limited by transformer 400/110 kV in the SS Ugljevik, which is jeopardized by an OHL 400 kV Tuzla – Ugljevik outage. For the same direction of power flow and evaluating tie-lines only (on Bosnian side), the NTC value is increased to 1584 MW, limited by the interconnection line 220 kV Zakučac – Mostar, which gets overloaded as a consequence of an OHL 400 kV Konjsko – Mostar outage.

Figure 6.4 Calculated NTC values for BiH/Croatia border depending on the monitored elements (model 2012)

For the direction of power flows from Croatia to BiH, evaluating all 400 kV, 220 kV and 110 kV network elements on the Croatian side, the NTC value is set to 1076 MW, limited by the 220 kV interconnection line Zakučac – Mostar.

Based on the lower NTC value between both sides, the final NTC value for the Croatia to BiH direction of power exchange is set to 775 MW if we evaluate internal networks. It is limited by the transformer 400/110 kV (300 MVA) in the SS Ugljevik. If we evaluate only tie-lines, the final NTC value is set to 1076 MW and is limited by interconnection line 220 kV Zakučac – Mostar (thermal rating 280 MVA at the model on Croatian side and 300 MVA on Bosnian side).

Remark: Both TSOs (NOS BiH and HOPS) confirmed critical elements in the networks under their control and listed some dispatching actions which may be applied in order to mitigate overloading and additionally increase the NTC values. These actions are described in the Chapter 7.

Table 6.12 Critical network elements for a power exchange on the BiH/Croatia border

RESULTS	**TTC (MW)**	**TRM (MW)**	**NTC (MW)**	**Critical contingency**	**Critical line**
Bosnia and Herzegovina to Croatia direction					
BiH side (monitored elements: 400 kV, 220 kV and 110 kV)	966	316	650	-	*maximum generation shift in Croatia*
BiH side (monitored elements: 400 kV, 220 kV)	966	316	650	-	*maximum generation shift in Croatia*
BiH side (monitored elements: tie-lines)	966	316	650	-	*maximum generation shift in Croatia*
Croatian side (monitored elements: 400 kV, 220 kV and 110 kV)	696	316	380	OHL 400 kV Žerjavinec - Tumbri	OHL 110 kV Žerjavinec - Jertovec
Croatian side (monitored elements: 400 kV, 220 kV)	807	316	491	TR 400/110 kV Žerjavinec 1,2	TR 400/110 kV Žerjavinec 2,1
Croatian side (monitored elements: tie-lines)	885	316	569	-	*maximum generation shift in Croatia*
Croatia to Bosnia and Herzegovina direction					
BiH side (monitored elements: 400 kV, 220 kV and 110 kV)	1091	316	775	OHL 400 kV Ugljevik - Tuzla	TR 400/110 kV Ugljevik
BiH side (monitored elements: 400 kV, 220 kV)	1091	316	775	OHL 400 kV Ugljevik - Tuzla	TR 400/110 kV Ugljevik
BiH side (monitored elements: tie-lines)	1900	316	1584	OHL 400 kV Mostar - Konjsko	OHL 220 kV Zakučac - Mostar
Croatian side (monitored elements: 400 kV, 220 kV and 110 kV)	1392	316	1076	OHL 400 kV Mostar - Konjsko	OHL 220 kV Zakučac - Mostar
Croatian side (monitored elements: 400 kV, 220 kV)	1392	316	1076	OHL 400 kV Mostar - Konjsko	OHL 220 kV Zakučac - Mostar
Croatian side (monitored elements: tie-lines)	1392	316	1076	OHL 400 kV Mostar - Konjsko	OHL 220 kV Zakučac - Mostar

6.5 Bosnia and Herzegovina/Serbia border

The NTC values for BiH/Serbia border have been calculated using the model for 2012 as follows:

Table 6.13 The NTC values for BiH/Serbia border (2012, BOSNIA AND HERZEGOVINA to SERBIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	BiH	Serbia	
400 kV, 220 kV, 110 kV & tie-lines	494	0	0
400 kV, 220 kV & tie-lines	731	0	0
tie-lines (400 kV, 220 kV)	731	1368	731

Table 6.14 The NTC values for BiH/Serbia border (2012, SERBIA to BOSNIA AND HERZEGOVINA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	BiH	Serbia	
400 kV, 220 kV, 110 kV & tie-lines	473	791	473
400 kV, 220 kV & tie-lines	473	1278	473
tie-lines (400 kV, 220 kV)	1597	1278	1278

For the direction of power flows from Bosnia and Herzegovina to Serbia, and evaluating all 400 kV, 220 kV and 110 kV network elements on the BiH side, the NTC value is set to 494 MW. It is limited by possible overloading of the OHL 110 kV Trebinje – Herceg Novi as a consequence of an OHL 400 kV Trebinje – Podgorica outage. Ignoring the 110 kV network in Bosnia increases NTC up to 731 MW. It is limited by possible overloading of the interconnection line 220 kV Trebinje – Perućica as a consequence of an OHL 400 kV Trebinje – Podgorica outage.

For the same direction of power flows and evaluating all 400 kV, 220 kV and 110 kV network elements on the Serbian side, the NTC value is set to 0 MW. This means that additional power exchanges are not possible due to limitations in the 220/110 kV transformers in the SS Sremska Mitrovica (initially highly loaded at the base case model). By ignoring the internal Serbian network and evaluating tie-lines only, the NTC would increase up to 1368 MW due to maximum generation shift in BiH.

Based on the lowest NTC value between both sides, the final NTC value for the BiH to Serbia direction of power exchange is set to 0 MW and is limited by transformers (2x150 MVA) in Sremska Mitrovica because of their high loading in the base case. The NTC value could be set to 731 MW if only the Bosnian and Serbian tie-lines are evaluated, limited by the OHL 220 kV Trebinje – Perućica with thermal rating defined to 316 MVA on Bosnian side at the model.

For the direction of power flows from Serbia to Bosnia and Herzegovina, and evaluating all 400 kV, 220 kV and 110 kV network elements on BiH side, the NTC value is set to 473 MW. It is limited by the 400/110 kV transformer in the SS Ugljevik that is jeopardized by an OHL 400 kV Tuzla – Ugljevik outage. For the same direction of power flow and evaluating tie-lines on the Bosnian side only, the NTC value is increased to 1597 MW. It is limited by the 220 kV interconnection line, Višegrad – Vardište, that gets overloaded as a consequence of an OHL 400 kV Tuzla – Ugljevik outage.

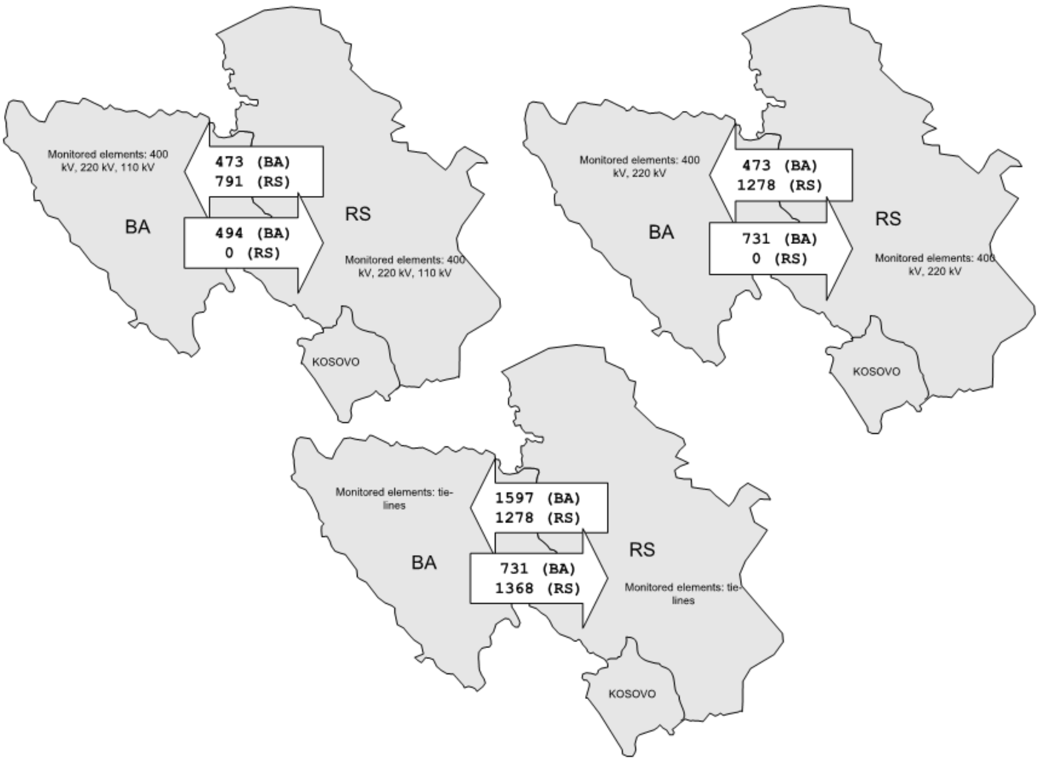


Figure 6.5 Calculated NTC values for BiH/Serbia border depending on the monitored elements (model 2012)

For the direction of power flows from Serbia to BiH, evaluating all 400 kV, 220 kV and 110 kV network elements on the Serbian side, the NTC value is set to 791 MW. It is limited by the OHL 110 kV Đerdap – Negotin, which is jeopardized if the OHL 110 kV Đerdap – Prahovo goes out of operation. This limitation is caused by the increase of the HPP Đerdap production while applying the generation shift key. Ignoring the 110 kV network in Serbia, and also the complete Serbian internal network, the NTC value could be increased up to 1278 MW with limitations in the OHL 220 kV Bajina Bašta – Pljevlja (thermal rating 274,4 MVA on Montenegrin side and 388 MVA on Serbian side at the model) that may be overloaded following an OHL 220 kV Bajina Bašta – Požega outage.

Based on the lower NTC between both sides, the final NTC value for the Serbia to BiH direction of power exchange is set to 473 MW if we evaluate internal networks. It is limited by the transformer 400/110 kV (300 MVA) in the SS Ugljevik. If we evaluate only tie-lines, the final NTC value is 1278 MW and is limited by the interconnection line 220 kV Bajina Bašta – Pljevlja.

Remark: Bosnian TSOs (NOS BiH) confirmed critical elements in the network of Bosnia and Herzegovina. It also listed some dispatching actions which may be applied in order to mitigate overloading and additionally increase the NTC values from Bosnian side of the border. These actions are described in the Chapter 7.

Serbian TSO (EMS) stated that overloading of transformers 220/110 kV and lines 110 kV are not critical and limiting elements for the NTC values over Serbian borders. EMS confirmed that the OHL 220 kV Bajina Bašta – Vardište and OHL 220 kV Bajina Bašta – Pljevlja are critical elements which limit the NTC values. It also described some dispatching actions which may be helpful to mitigate this problem. They are also described in the Chapter 7.

Table 6.15 Critical network elements for a power exchange on the BiH/Serbia border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Bosnia and Herzegovina to Serbia direction					
BiH side (monitored elements: 400 kV, 220 kV and 110 kV)	635	141	494	OHL 400 kV Trebinje - Podgorica	OHL 110 kV Trebinje - H. Novi
BiH side (monitored elements: 400 kV, 220 kV)	872	141	731	OHL 400 kV Trebinje - Podgorica	OHL 220 kV Trebinje - Peručica
BiH side (monitored elements: tie-lines)	872	141	731	OHL 400 kV Trebinje - Podgorica	OHL 220 kV Trebinje - Peručica
Serbian side (monitored elements: 400 kV, 220 kV and 110 kV)	135	141	0	TR 220/110/10 kV S.Mitrovica 1,2	TR 220/110/10 kV S.Mitrovica 2,1
Serbian side (monitored elements: 400 kV, 220 kV)	135	141	0	TR 220/110/10 kV S.Mitrovica 1,2	TR 220/110/10 kV S.Mitrovica 2,1
Serbian side (monitored elements: tie-lines)	1509	141	1368	-	*maximum generation shift in BiH*
Serbia to Bosnia and Herzegovina direction					
BiH side (monitored elements: 400 kV, 220 kV and 110 kV)	615	141	473	OHL 400 kV Ugljevik - Tuzla	TR 400/110 kV Ugljevik
BiH side (monitored elements: 400 kV, 220 kV)	615	141	473	OHL 400 kV Ugljevik - Tuzla	TR 400/110 kV Ugljevik
BiH side (monitored elements: tie-lines)	1739	141	1597	OHL 400 kV Ugljevik - Tuzla	OHL 220 kV Višegrad - Vardište
Serbian side (monitored elements: 400 kV, 220 kV and 110 kV)	933	141	791	OHL 110 kV Đerdap - Negotin	OHL 110 kV Đerdap - Prahovo
Serbian side (monitored elements: 400 kV, 220 kV)	1420	141	1278	OHL 220 kV B.Basta - Pozega	OHL 220 kV B.Basta - Pljevlja
Serbian side (monitored elements: tie-lines)	1420	141	1278	OHL 220 kV B.Basta - Pozega	OHL 220 kV B.Basta - Pljevlja

6.6 Bosnia and Herzegovina/Montenegro border

The NTC values for BiH/Montenegro border have been calculated using the model for 2012 as follows:

Table 6.16 The NTC values for BiH/Montenegro border (2012, BiH to MONTENEGRO direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	BiH	Montenegro	
400 kV, 220 kV, 110 kV & tie-lines	639	640	639
400 kV, 220 kV & tie-lines	751	746	746
tie-lines (400 kV, 220 kV)	751	746	746

Table 6.17 The NTC values for BiH/Montenegro border (2012, MONTENEGRO to BiH direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	BiH	Montenegro	
400 kV, 220 kV, 110 kV & tie-lines	789	1088	789
400 kV, 220 kV & tie-lines	789	1088	789
tie-lines (400 kV, 220 kV)	1088	1088	1088

For the direction of power flows from Bosnia and Herzegovina to Montenegro, and evaluating all 400 kV, 220 kV and 110 kV network elements on the BiH side, the NTC value is set to 639 MW. It is limited by possible overloading of the OHL 110 kV Trebinje – Herceg Novi as a consequence of an OHL 400 kV Trebinje – Podgorica outage. Ignoring the 110 kV network in Bosnia, or complete internal Bosnian network, increases NTC up to 751 MW. It is limited by possible overloading of the interconnection line 220 kV Trebinje – Peručica as a consequence of an OHL 400 kV Trebinje – Podgorica outage.

For the same direction of power flows, but evaluating network elements on the Montenegrin side, the NTC values are almost the same with the same limiting elements.

Based on the lower NTC value between both sides, the final NTC value for the BiH to Montenegro direction of power exchange is set to 639 MW. It is limited by the OHL 110 kV Trebinje – Herceg Novi, with a thermal rating of 90 MVA on the Bosnian side (89,5 MVA on Montenegrin side). The NTC value could be set to 746 MW if only the Bosnian and Montenegrin 400 kV and 220 kV network or if only tie-lines are evaluated. It would be limited by the OHL 220 kV Trebinje – Peručica, with a thermal rating of 316 MVA on the Bosnian side at the model and 274,4 MVA on the Montenegrin side of the model.

For the direction of power flows from Montenegro to Bosnia and Herzegovina, evaluating all 400 kV, 220 kV and 110 kV network elements on the BiH side, the NTC value is set to 789 MW, limited by the 400/110 kV transformer in the SS Ugljevik, which is jeopardized by an OHL 400 kV Tuzla – Ugljevik outage. For the same direction of power flow and evaluating tie-lines on the Bosnian side only, the NTC value increases up to 1088 MW due to maximum generation shift in Montenegro and Bosnia and Herzegovina.

Figure 6.6 Calculated NTC values for BiH/Montenegro border depending on the monitored elements (model 2012)

For the direction of power flows from Montenegro to BiH, no matter which network elements are evaluated on Montenegrin side of the border, the NTC value is set to 1088 MW, due to maximum generation shift at the model.

Based on the lower NTC value between both sides, the final NTC value for the Montenegro to BiH direction of power exchange is set to 789 MW if we evaluate internal networks. It is limited by the transformer 400/110 kV (300 MVA) in the SS Ugljevik, or 1088 MW if we only evaluate tie-lines and not limited by any network element.

Remark: Bosnian TSOs (NOS BiH) confirmed critical elements in the network of Bosnia and Herzegovina. It also listed some dispatching actions which may be applied in order to mitigate overloading and additionally increase the NTC values from Bosnian side of the border. These actions are described in the Chapter 7.

Montenegrin TSO (CGES) didn't response on their critical elements which limit power exchanges over the analyzed border.

Table 6.18 Critical network elements for a power exchange on the BiH/Montenegro border

RESULTS	**TTC (MW)**	**TRM (MW)**	**NTC (MW)**	**Critical contingency**	**Critical line**
Bosnia and Herzegovina to Montenegro direction					
BiH side (monitored elements: 400 kV, 220 kV and 110 kV)	813	173	639	OHL 400 kV Trebinje - Podgorica	OHL 110 kV Trebinje - H. Novi
BiH side (monitored elements: 400 kV, 220 kV)	925	173	751	OHL 400 kV Trebinje - Podgorica	OHL 220 kV Trebinje - Perućica
BiH side (monitored elements: tie-lines)	925	173	751	OHL 400 kV Trebinje - Podgorica	OHL 220 kV Trebinje - Perućica
Montenegrin side (monitored elements: 400 kV, 220 kV and 110 kV)	813	173	640	OHL 400 kV Trebinje - Podgorica	OHL 110 kV Trebinje - H. Novi
Montenegrin side (monitored elements: 400 kV, 220 kV)	919	173	746	OHL 400 kV Trebinje - Podgorica	OHL 220 kV Trebinje - Perućica
Montenegrin side (monitored elements: tie-lines)	919	173	746	OHL 400 kV Trebinje - Podgorica	OHL 220 kV Trebinje - Perućica
Montenegro to Bosnia and Herzegovina direction					
BiH side (monitored elements: 400 kV, 220 kV and 110 kV)	962	173	789	OHL 400 kV Ugljevik - Tuzla	TR 400/110 kV Ugljevik
BiH side (monitored elements: 400 kV, 220 kV)	962	173	789	OHL 400 kV Ugljevik - Tuzla	TR 400/110 kV Ugljevik
BiH side (monitored elements: tie-lines)	1261	173	1088	-	*maximum generation shift in Montenegro*
Montenegrin side (monitored elements: 400 kV, 220 kV and 110 kV)	1261	173	1088	-	*maximum generation shift in Montenegro*
Montenegrin side (monitored elements: 400 kV, 220 kV)	1261	173	1088	-	*maximum generation shift in Montenegro*
Montenegrin side (monitored elements: tie-lines)	1261	173	1088	-	*maximum generation shift in Montenegro*

6.7 Bulgaria/Romania border

The NTC values for the Bulgaria/Romania border have been calculated using the model for 2012 as follows:

Table 6.19 The NTC values for Bulgaria/Romania border (2012, BULGARIA to ROMANIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Bulgaria**	**Romania**	
400 kV, 220 kV, 110 kV & tie-lines	0	885	0
400 kV, 220 kV & tie-lines	0	885	0
tie-lines (400 kV, 220 kV)	885	885	891

Table 6.20 The NTC values for Bulgaria/Romania border (2012, ROMANIA to BULGARIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Bulgaria**	**Romania**	
400 kV, 220 kV, 110 kV & tie-lines	1014	1220	1014
400 kV, 220 kV & tie-lines	1014	1220	1014
tie-lines (400 kV, 220 kV)	1826	1814	1814

For the direction of power flows from Bulgaria to Romania and evaluating internal transmission network of Bulgaria, there are no possibilities for power exchange across the border because of the weaknesses in the 110 kV network in the Dobrudzha area. Several 110 kV lines will be overloaded, in the event multiple 110 kV outages occur, when the power exchange is increased over the transmission reliability margin for this border. If we ignore these limitations, bottleneck appears concerning the OHL 220 kV Plovdiv – Aleko due to an OHL 400 kV Maritza East 1 – Plovdiv outage. The Plovdiv – Aleko line thermal rating is set to 228,6 MVA.

For the same direction of power flows, but evaluating network elements on the Romanian side, the NTC values could be increased up to 885 MW without any network limitations in Romania because of maximum generation shift in Bulgaria.

If only tie-lines between Romania, Bulgaria and other surrounding countries are monitored, the NTC value could be set up to 885 MW, limited by maximum generation shift in Bulgaria.

For the direction of power flows from Romania to Bulgaria, evaluating all 400 kV, 220 kV and 110 kV network elements on the Bulgarian side, the NTC value is set to 1014 MW. It is limited by the 400/110 kV transformer in the SS Plovdiv, which is jeopardized due to the outage of a parallel transformer (ratings of the transformers are 2x250 MVA at the model). For the same direction of power flow, evaluating tie-lines on the Bulgarian side only, the NTC value is increased up to 1826 MW, due to possible overloading of the OHL 400 kV between Tantareni in Romania and Kozloduy in Bulgaria in the case of a parallel line outage. This contingency comprises of an outage of a single-circuit only, with a parallel circuit staying in operation. If we evaluate the outage of a double-circuit line (as an exceptional type of contingency defined under ENTSO-E Operational Handbook – Policy 3), the NTC for the Bulgaria/Romania border and the power exchange between Romania (source) and Bulgaria (sink) would be increased by 100 MW and the OHL 400 kV Sofija – Niš will become a new limiting element.

Analyzing the direction of power flows from Romania to Bulgaria, no matter which internal network elements are evaluated on Romanian side of the border, the NTC value is set to 1220 MW, due to the 400/110 kV transformers in the SS Tariverde (2x250 MVA at the model).

Figure 6.7 Calculated NTC values for Bulgaria/Romania border depending on the monitored elements (model 2012)

Based on the lower NTC value between both sides, the final NTC value for the Romania to Bulgaria direction of power exchange is set to 1014 MW if we evaluate the internal networks. It is limited by the transformer 400/110 kV (250 MVA) in the SS Plovdiv, or 1814 MW if we evaluate only tie-lines, limited by 400 kV lines between Tantareni and Kozloduy.

Remark: Bulgarian TSO (ESO) confirmed network limiting elements found here. It stated that 110 kV network limitations in the Dobrudzha are due to possible high engagement of wind farms, but ESO doesn't take into account this problem while calculating the NTC values because of dispatching actions, described in the Chapter 7, which may mitigate this problem. It also described some other dispatching actions in order to keep the security of supply concerning possible overloading of the OHL 220 kV Plovdiv – Aleko line. ESO observe outage of the OHL 2x400 kV Tantareni – Kozloduy as loss of both circuits, so one circuit is not critical element according to their considerations. They define this contingency according to the UCTE OH, Policy 3. ESO also stated that the TRM value for Bulgaria/Romania border is set to 100 MW, not 200 MW as Authors of this study assumed. Because all of this, one may expect that the NTC values over Bulgarian and Romanian border should be higher than calculated here, but still limited due to internal Bulgarian network weaknesses (OHL 220 kV Plovdiv – Aleko and transformers 400/110 kV in the Plovdiv substation).

Romanian TSO (Transelectrica) also confirmed critical elements on their side of the border, but stated that transformers 400/110 kV in the Tariverde substation are not critical because of power exchanges, but due to wind power generation. These transformers have been used for wind power evacuation only.

Table 6.21 Critical network elements for a power exchange on the Bulgaria/Romania border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Bulgaria to Romania direction					
Bulgarian side (monitored elements: 400 kV, 220 kV and 110 kV)	0	200	0	110 kV network in the area of Dobrudzha	
Bulgarian side (monitored elements: 400 kV, 220 kV)	0	200	0	OHL 400 kV Maritsa East 1 - Plovdiv	OHL 220 kV Plovdiv - Aleko
Bulgarian side (monitored elements: tie-lines)	1085	200	885	-	*maximum generation shift in Bulgaria*
Romanian side (monitored elements: 400 kV, 220 kV and 110 kV)	1085	200	885	-	*maximum generation shift in Bulgaria*
Romanian side (monitored elements: 400 kV, 220 kV)	1085	200	885	-	*maximum generation shift in Bulgaria*
Romanian side (monitored elements: tie-lines)	1085	200	885	-	*maximum generation shift in Bulgaria*
Romania to Bulgaria direction					
Bulgarian side (monitored elements: 400 kV, 220 kV and 110 kV)	1214	200	1014	TR 400/110/31,5 kV Plovdiv 1, 2	TR 400/110/31,5 kV Plovdiv 2, 1
Bulgarian side (monitored elements: 400 kV, 220 kV)	1214	200	1014	TR 400/110/31,5 kV Plovdiv 1, 2	TR 400/110/31,5 kV Plovdiv 2, 1
Bulgarian side (monitored elements: tie-lines)	2026	200	1826	OHL 400 kV Tantareni - Kozloduy 1,2	OHL 400 kV Tantareni - Kozloduy 2,1
Romanian side (monitored elements: 400 kV, 220 kV and 110 kV)	1420	200	1220	TR 400/110 kV Tariverde 1, 2	TR 400/110 kV Tariverde 2, 1
Romanian side (monitored elements: 400 kV, 220 kV)	1420	200	1220	TR 400/110 kV Tariverde 1, 2	TR 400/110 kV Tariverde 2, 1
Romanian side (monitored elements: tie-lines)	2014	200	1814	OHL 400 kV Tantareni - Kozloduy 1,2	OHL 400 kV Tantareni - Kozloduy 2,1

6.8 Bulgaria/Serbia border

The NTC values for the Bulgaria/Serbia border have been calculated using the model for 2012 as follows:

Table 6.22 The NTC values for Bulgaria/Serbia border (2012, BULGARIA to SERBIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Bulgaria	Serbia	
400 kV, 220 kV, 110 kV & tie-lines	161	816	161
400 kV, 220 kV & tie-lines	386	816	386
tie-lines (400 kV, 220 kV)	1635	1635	1635

Table 6.23 The NTC values for Bulgaria/Serbia border (2012, SERBIA to BULGARIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Bulgaria	Serbia	
400 kV, 220 kV, 110 kV & tie-lines	445	132	132
400 kV, 220 kV & tie-lines	445	745	445
tie-lines (400 kV, 220 kV)	1938	745	745

For the direction of power flows from Bulgaria to Serbia and the evaluating internal transmission network of Bulgaria, the NTC value would be limited to 161 MW because of weaknesses in the 110 kV network in the Dobrudzha area. Ignoring limitations in the 110 kV network of Bulgaria, bottleneck appears concerning the OHL 220 kV Plovdiv – Aleko due to an OHL 400 kV Maritza East 1 – Plovdiv outage. It limits the NTC value up to 386 MW. By monitoring interconnection lines only and ignoring the problems in the Bulgarian internal network, the NTC value could be increased significantly, up to 1635 MW, without any limitations but due to maximum generation shift in Bulgaria.

For the same direction of power flows but evaluating network elements on the Serbian side, the NTC values could be increased up to 816 MW, without any network limitations in Serbia but due to maximum generation shift in Serbia. If only the tie-lines of Serbia and other surrounding countries are monitored, the NTC value could be set up to 1635 MW, limited by maximum generation shift in Bulgaria.

Based on the lower NTC between both sides, the final NTC value for the Bulgaria to Serbia direction of power exchange is set to 161 MW if we evaluate internal networks. It is limited by the 110 kV network in the Dobrudzha area, 386 MW if we ignore 110 kV networks limited by the OHL 220 kV Plovdiv – Aleko, and 1635 MW if we only evaluate tie-lines, without any network limitations.

For the direction of power flows from Serbia to Bulgaria, evaluating all 400 kV, 220 kV and 110 kV network elements on the Bulgarian side, the NTC value is set to 445 MW. It is limited by 400/110 kV transformer in the SS Plovdiv, which is jeopardized due to the outage of a parallel transformer. For the same direction of power flow and evaluating tie-lines on Bulgarian side only, the NTC value is increased up to 1938 MW due to maximum generation shift in Serbia.

For the direction of power flows from Serbia to Bulgaria and monitoring the 400 kV, 220 kV and 110 kV network of Serbia, a limitation appears due to OHL 110 kV Valjevo – Kosjerić overloading when the NTC values is 132 MW as a consequence of an OHL 220 kV Bajina Bašta – Požega outage. The thermal rating of this 110 kV line is set to 68,6 MVA. The NTC value would be increased to 745 MW if limitations in the network 110 kV of Serbia are ignored and it would be limited by the OHL 220 kV Bajina Bašta – Pljevlja (thermal rating 388,7 MVA on the Serbian side at the model), which is jeopardized due to a possible OHL 220 kV Bajina Bašta – Požega outage.

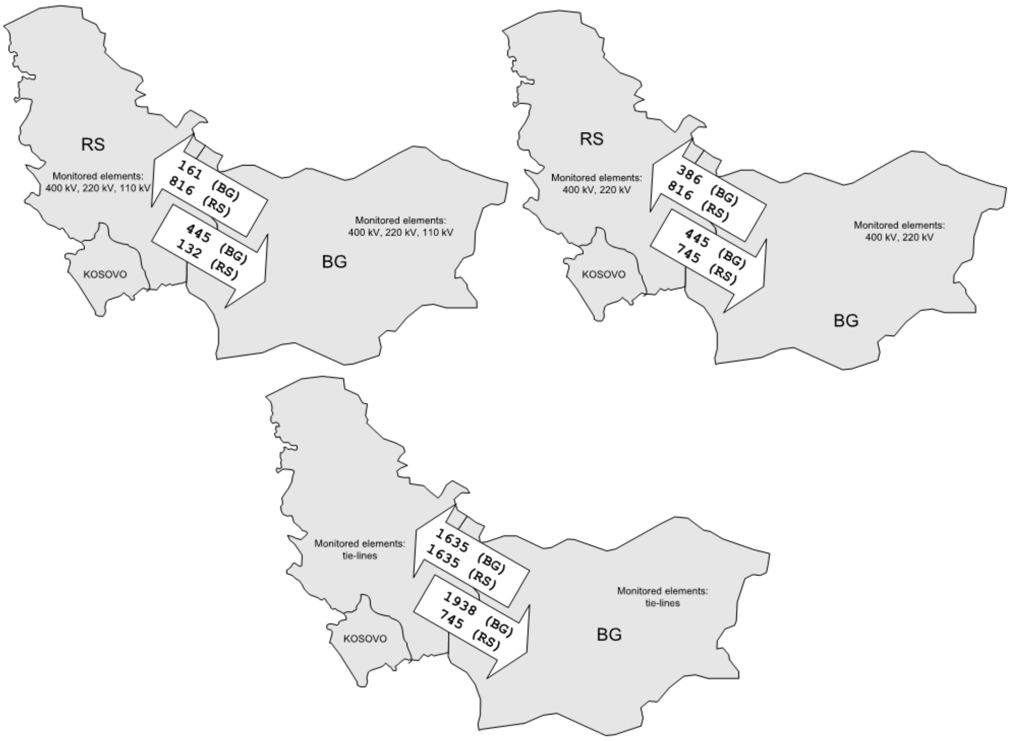


Figure 6.8 Calculated NTC values for Bulgaria/Serbia border depending on the monitored elements (model 2012)

Based on the lowest NTC value between both sides, the final NTC value for the Serbia to Bulgaria direction of power exchange is set to 132 MW if we evaluate internal networks. It is limited by the OHL 110 kV around Valjevo in Serbia. The final NTC value is 445 MW if we ignore 110 kV networks and limited by 400/110 kV transformers in the SS Plovdiv in Bulgaria, and finally 745 MW if we evaluate tie-lines only due to possible overloading of the OHL 220 kV B.Bašta – Pljevlja.

Remark: Bulgarian TSO (ESO) confirmed network limiting elements found here. It stated that 110 kV network limitations in the Dobrudzha are due to possible high engagement of wind farms, but ESO doesn't take into account this problem while calculating the NTC values because of dispatching actions, described in the Chapter 7, which may mitigate this problem. It also described some other dispatching actions in order to keep the security of supply concerning possible overloading of the OHL 220 kV Plovdiv – Aleko line. One may expect that the NTC values over Bulgarian and Serbian border should be higher than calculated here, but still limited mainly due to internal Bulgarian network weaknesses (OHL 220 kV Plovdiv – Aleko and transformers 400/110 kV in the Plovdiv substation).

Serbian TSO (EMS) stated that overloading of lines 110 kV are not critical and limiting elements for the NTC values over Serbian borders. EMS confirmed that the OHL 220 kV Bajina Bašta – Pljevlja is critical element which limit the NTC values. It also described some dispatching actions which may be helpful to mitigate this problem. They are also described in the Chapter 7.

Table 6.24 Critical network elements for a power exchange on the Bulgaria/Serbia border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Bulgaria to Serbia direction					
Bulgarian side (monitored elements: 400 kV, 220 kV and 110 kV)	261	100	161	110 kV network in the area of Dobrudzha	
Bulgarian side (monitored elements: 400 kV, 220 kV)	486	100	386	OHL 400 kV Maritsa East 1 - Plovdiv	OHL 220 kV Plovdiv - Aleko
Bulgarian side (monitored elements: tie-lines)	1735	100	1635	-	*maximum generation shift in Bulgaria*
Serbian side (monitored elements: 400 kV, 220 kV and 110 kV)	916	100	816	-	*maximum generation shift in Serbia*
Serbian side (monitored elements: 400 kV, 220 kV)	916	100	816	-	*maximum generation shift in Serbia*
Serbian side (monitored elements: tie-lines)	1735	100	1635	-	*maximum generation shift in Bulgaria*
Serbia to Bulgaria direction					
Bulgarian side (monitored elements: 400 kV, 220 kV and 110 kV)	545	100	445	TR 400/110/31,5 kV Plovdiv 1, 2	TR 400/110/31,5 kV Plovdiv 2, 1
Bulgarian side (monitored elements: 400 kV, 220 kV)	545	100	445	TR 400/110/31,5 kV Plovdiv 1, 2	TR 400/110/31,5 kV Plovdiv 2, 1
Bulgarian side (monitored elements: tie-lines)	2038	100	1938	-	*maximum generation shift in Serbia*
Serbian side (monitored elements: 400 kV, 220 kV and 110 kV)	232	100	132	OHL 220 kV B.Basta - Pozega	OHL 110 kV Valjevo - Kosjerić
Serbian side (monitored elements: 400 kV, 220 kV)	845	100	745	OHL 220 kV B.Basta - Pozega	OHL 220 kV B.Basta - Pljevlja
Serbian side (monitored elements: tie-lines)	845	100	745	OHL 220 kV B.Basta - Pozega	OHL 220 kV B.Basta - Pljevlja

6.9 Bulgaria/Macedonia border

The NTC values for the Bulgaria/Macedonia border have been calculated using the model for 2012 as follows:

Table 6.25 The NTC values for Bulgaria/Macedonia border (2012, BULGARIA to MACEDONIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Bulgaria	Macedonia	
400 kV, 220 kV, 110 kV & tie-lines	267	855	267
400 kV, 220 kV & tie-lines	523	1074	523
tie-lines (400 kV, 220 kV)	1185	1186	1185

Table 6.26 The NTC values for the Bulgaria/Macedonia border (2012, MACEDONIA to BULGARIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Bulgaria	Macedonia	
400 kV, 220 kV, 110 kV & tie-lines	282	288	282
400 kV, 220 kV & tie-lines	282	412	282
tie-lines (400 kV, 220 kV)	413	412	412

For the direction of power flows from Bulgaria to Macedonia and evaluating the internal transmission network of Bulgaria, the NTC value would be limited to 267 MW due to weaknesses in the 110 kV network in the Dobrudzha area. Ignoring limitations in the 110 kV network of Bulgaria, bottleneck appears concerning the OHL 220 kV Plovdiv – Aleko due to an OHL 400 kV Maritza East 1 – Plovdiv outage. It limits the NTC value up to 523 MW. Monitoring interconnection lines only and ignoring the problems in the Bulgarian internal network, the NTC value could be increased significantly, up to 1185 MW, without any limitations but due to maximum generation shift in Macedonia.

For the same direction of power flows but evaluating network elements on the Macedonian side, the NTC values could be increased up to 855 MW. It would be limited by possible overloading of the OHL 110 kV Skopje 3 – Skopje 4 as a consequence of an OHL 110 kV G.Petrov – Skopje 1 outage. Further increase is possible up to 1074 MW if we ignore the Macedonian 110 kV network, the new critical element becomes 400/110 kV transformer Štip that is jeopardized by the interconnection line 400 kV Dubrovo – Štip outage. Monitoring tie-lines only, the NTC value of 1186 MW could be reached, limited by maximum generation shift in Macedonia.

Based on the lower NTC value between both sides, the final NTC value for the Bulgaria to Macedonia direction of power exchange is set to 267 MW if we evaluate internal networks. It is limited by the 110 kV network in the Dobrudzha area. The NTC value is 523 MW if we ignore 110 kV networks and is limited by the OHL 220 kV Plovdiv – Aleko. The NTC value is 1185 MW if we evaluate tie-lines only, without any network limitations.

For the direction of power flows from Macedonia to Bulgaria, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Bulgarian side, the NTC value is set to 282 MW. It is limited by the 400/110 kV transformer in the SS Plovdiv, which is jeopardized due to an outage of the parallel transformer. For the same direction of power flow and evaluating tie-lines on the Bulgarian side only, the NTC value is increased up to 413 MW due to maximum generation shift in Macedonia.

For the direction of power flows from Macedonia to Bulgaria, monitoring the 400 kV, 220 kV and 110 kV networks of Macedonia, limitations appear due to OHL 110 kV TETO – Skopje 4 overloading when the NTC value is 288 MW as a consequence of an OHL 110 kV Skopje 1 – Kumanovo 1 outage. The thermal rating of this 110 kV line is set to 157 MVA. The NTC value would be increased up to 412 MW if limitations in the 110 kV network of Macedonia are ignored, due to maximum generation shift in Macedonia.

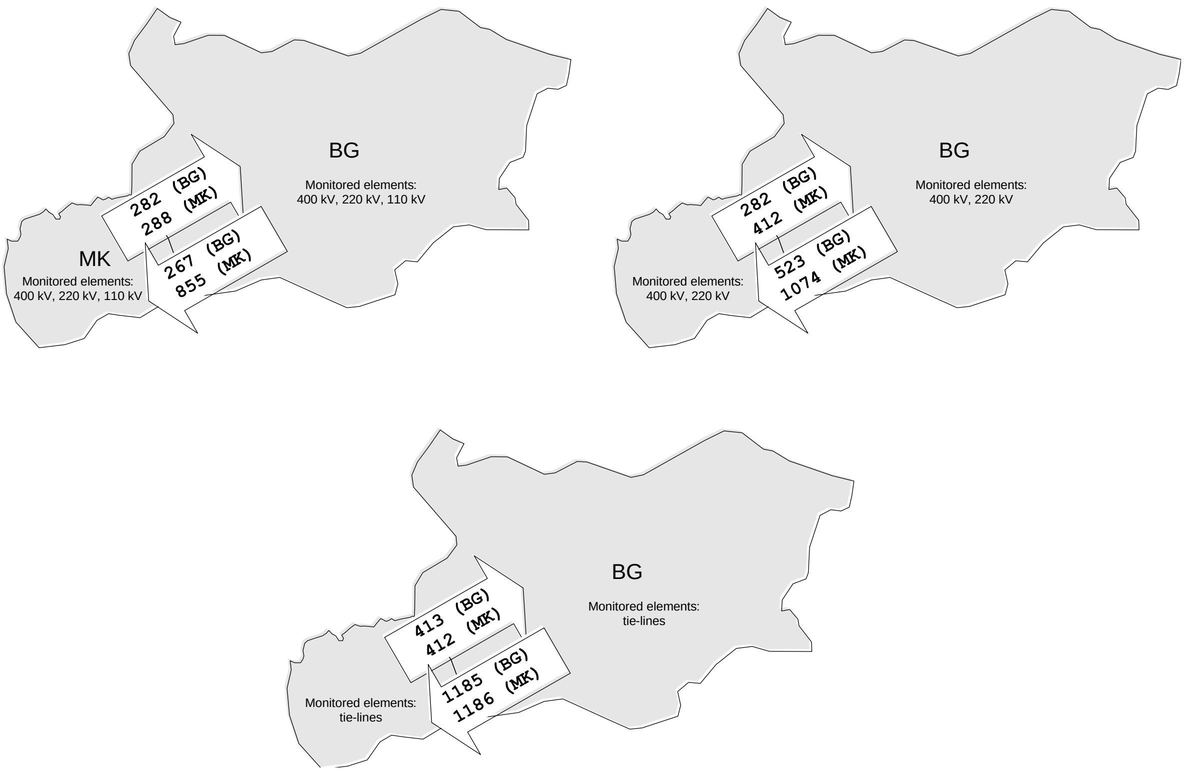


Figure 6.9 Calculated NTC values for the Bulgaria/Macedonia border depending on the monitored elements (model 2012)

Based on the lower NTC value between both sides, the final NTC value for the Macedonia to Bulgaria direction of power exchange is set to 282 MW if we evaluate internal networks and is limited by the transformers in the SS Plovdiv. The NTC value is 412 MW if we only evaluate tie-lines due to maximum generation shift in Macedonia.

Remark: Bulgarian TSO (ESO) confirmed network limiting elements found here. It stated that 110 kV network limitations in the Dobrudzha are due to possible high engagement of wind farms, but ESO doesn't take into account this problem while calculating the NTC values because of dispatching actions, described in the Chapter 7, which may mitigate this problem. It also described some other dispatching actions in order to keep the security of supply concerning possible overloading of the OHL 220 kV Plovdiv – Aleko line.

Macedonian TSO (MEPSO) also confirmed critical network elements found here, but stressed that 110 kV network limitations are not observed while calculating the NTC values. All limitations may be removed by dispatching actions, described in the Chapter 7.

Table 6.27 Critical network elements for a power exchange on the Bulgaria/Macedonia border

RESULTS	**TTC (MW)**	**TRM (MW)**	**NTC (MW)**	**Critical contingency**	**Critical line**
Bulgaria to Macedonia direction					
Bulgarian side (monitored elements: 400 kV, 220 kV and 110 kV)	367	100	267	110 kV network in the area of Dobrudzha	
Bulgarian side (monitored elements: 400 kV, 220 kV)	623	100	523	OHL 400 kV Maritsa East 1 - Plovdiv	OHL 220 kV Plovdiv - Aleko
Bulgarian side (monitored elements: tie-lines)	1285	100	1185	-	*maximum generation shift in Macedonia*
Macedonian side (monitored elements: 400 kV, 220 kV and 110 kV)	955	100	855	OHL 110 kV G.Petrov - Skopje 1	OHL 110 kV Skopje 3 - Skopje 4
Macedonian side (monitored elements: 400 kV, 220 kV)	1174	100	1074	OHL 400 kV Dubrovo - Štip	TR 400/110/10 kV Štip
Macedonian side (monitored elements: tie-lines)	1286	100	1186	-	*maximum generation shift in Macedonia*
Macedonia to Bulgaria direction					
Bulgarian side (monitored elements: 400 kV, 220 kV and 110 kV)	382	100	282	TR 400/110/31,5 kV Plovdiv 1, 2	TR 400/110/31,5 kV Plovdiv 2, 1
Bulgarian side (monitored elements: 400 kV, 220 kV)	382	100	282	TR 400/110/31,5 kV Plovdiv 1, 2	TR 400/110/31,5 kV Plovdiv 2, 1
Bulgarian side (monitored elements: tie-lines)	513	100	413	-	*maximum generation shift in Macedonia*
Macedonian side (monitored elements: 400 kV, 220 kV and 110 kV)	388	100	288	OHL 110 kV Skopje 1 - Kumanovo 1	OHL 110 kV TETO - Skopje 4
Macedonian side (monitored elements: 400 kV, 220 kV)	512	100	412	-	*maximum generation shift in Macedonia*
Macedonian side (monitored elements: tie-lines)	512	100	412	-	*maximum generation shift in Macedonia*

6.10 Bulgaria/Greece border

The NTC values for Bulgaria/Greece border have been calculated using the model for 2012 as follows:

Table 6.28 The NTC values for Bulgaria/Greece border (2012, BULGARIA to GREECE direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Bulgaria	Greece	
400 kV, 220 kV, 110 kV & tie-lines	219	-	219
400 kV, 220 kV & tie-lines	512	-	512
tie-lines (400 kV, 220 kV)	1693	-	1693

Table 6.29 The NTC values for Bulgaria/Greece border (2012, GREECE to BULGARIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Bulgaria	Greece	
400 kV, 220 kV, 110 kV & tie-lines	331	-	331
400 kV, 220 kV & tie-lines	331	-	331
tie-lines (400 kV, 220 kV)	987	-	987

For the direction of power flows from Bulgaria to Greece and evaluating the internal transmission network of Bulgaria, the NTC value would be limited to 219 MW due to the 110 kV network weaknesses in the Dobrudzha area. Ignoring the 110 kV network, NTC would rise to 512 MW, limited by the OHL 220 kV Plovdiv – Aleko, or up to 1693 MW if we ignore internal network of Bulgaria and only evaluate tie-lines due to maximum generation shift in Bulgaria.

For the direction of power flows from Greece to Bulgaria, the NTC value will be limited by the transformers in the Plovdiv substation up to 331 MW. Ignoring problems within the internal Bulgarian transmission system, the NTC value would be increased to 987 MW and be limited due to maximum generation shift in Greece.

Remark: Confirmation of Bulgarian TSO (ESO) is described in the previous sub-chapters.

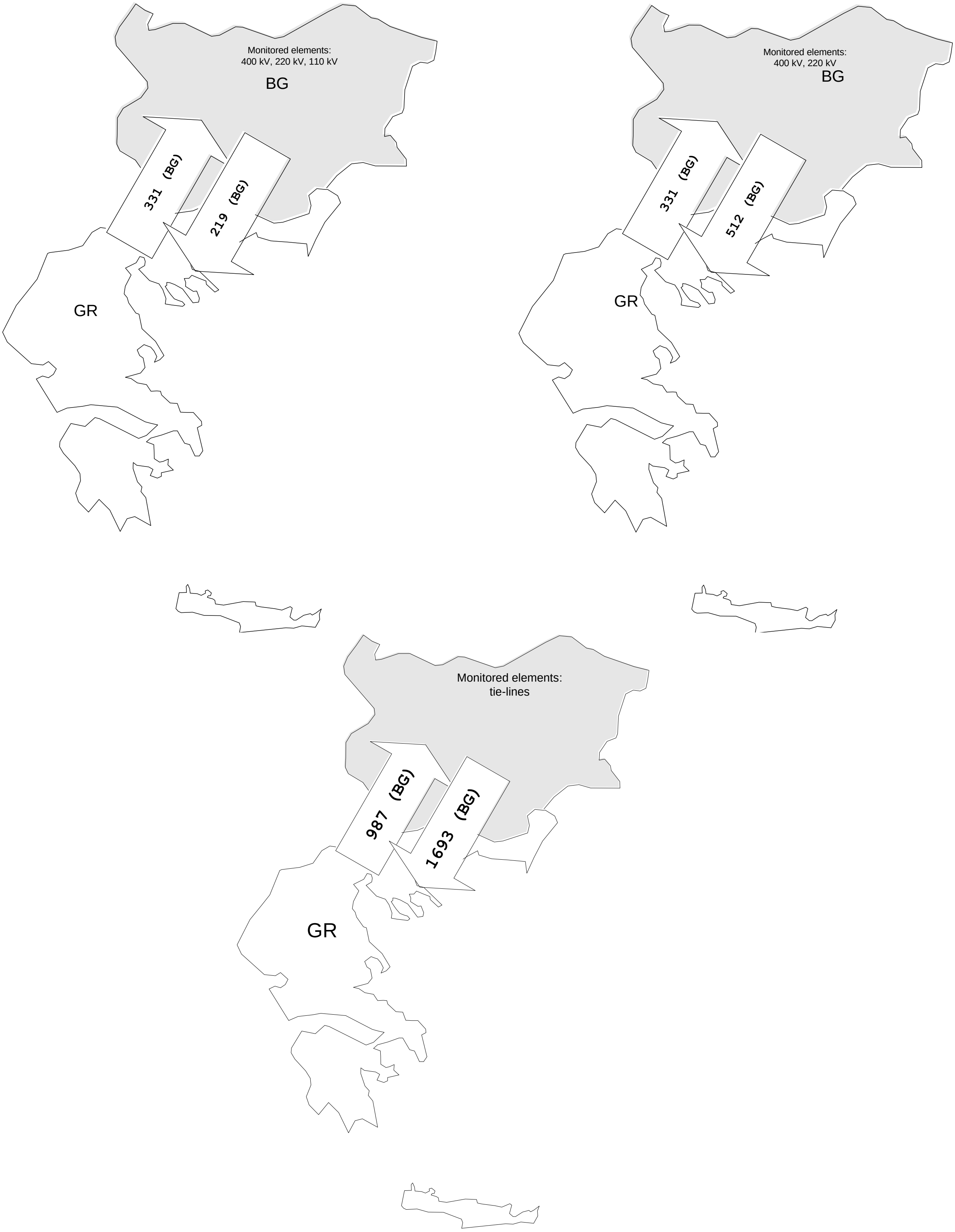


Figure 6.10 Calculated NTC values for the Bulgaria/Greece border depending on the monitored elements (model 2012)

Table 6.30 Critical network elements for a power exchange on the Bulgaria/Greece border

RESULTS	**TTC (MW)**	**TRM (MW)**	**NTC (MW)**	**Critical contingency**	**Critical line**
Bulgaria to Greece direction					
Bulgarian side (monitored elements: 400 kV, 220 kV and 110 kV)	319	100	219	110 kV network in the area of Dobrudzha	
Bulgarian side (monitored elements: 400 kV, 220 kV)	612	100	512	OHL 400 kV Maritsa East 1 - Plovdiv	OHL 220 kV Plovdiv - Aleko
Bulgarian side (monitored elements: tie-lines)	1793	100	1693	-	*maximum generation shift in Bulgaria*
Greek side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Greek side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Greek side (monitored elements: tie-lines)	-	-	-	-	-
Greece to Bulgaria direction					
Bulgarian side (monitored elements: 400 kV, 220 kV and 110 kV)	431	100	331	TR 400/110/31,5 kV Plovdiv 1, 2	TR 400/110/31,5 kV Plovdiv 2, 1
Bulgarian side (monitored elements: 400 kV, 220 kV)	431	100	331	TR 400/110/31,5 kV Plovdiv 1, 2	TR 400/110/31,5 kV Plovdiv 2, 1
Bulgarian side (monitored elements: tie-lines)	1087	100	987	-	*maximum generation shift in Greece*
Greek side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Greek side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Greek side (monitored elements: tie-lines)	-	-	-	-	-

6.11 Bulgaria/Turkey border

The NTC values for the Bulgaria/Turkey border have been calculated using the model for 2012 as follows:

Table 6.31 The NTC values for Bulgaria/Turkey border (2012, BULGARIA to TURKEY direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Bulgaria	Turkey	
400 kV, 220 kV, 110 kV & tie-lines	170	1457	170
400 kV, 220 kV & tie-lines	1457	1457	1457
tie-lines (400 kV, 220 kV)	1457	1457	1457

Table 6.32 The NTC values for the Bulgaria/Turkey border (2012, TURKEY to BULGARIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Bulgaria	Turkey	
400 kV, 220 kV, 110 kV & tie-lines	0	0	0
400 kV, 220 kV & tie-lines	0	78	78
tie-lines (400 kV, 220 kV)	1684	1684	1684

For the direction of power flows from Bulgaria to Turkey and evaluating the internal transmission network of Bulgaria, the NTC value would be limited to 170 MW due to 110 kV network weaknesses in the Dobrudzha area. Ignoring limitations in the 110 kV network of Bulgaria, the NTC could be increased up to 1457 MW, limited by the OHL 400 kV Maritza East – Babaesku, which is jeopardized by the 400 kV line Maritza East – Hamitabad outage. For the same direction of power flows but evaluating network elements on Turkish side, the NTC values could be increased up to 1457 MW due to OHL 400 kV Maritza East – Babaesku limitations.

For the direction of power flows from Turkey to Bulgaria, evaluating all 400 kV, 220 kV and 110 kV network elements on Bulgarian side, there would be no possibility for power exchanges between two countries because of the OHL 220 kV Plovdiv – Aleko in Bulgaria. If only interconnection lines were monitored, the NTC could be set up to 1684 MW. Possible power exchange from Turkey to Bulgaria would also be limited by congestions in the internal Turkish 110 kV network and 400/154 kV transformers in the Adapazari substation.

All values have been calculated using load flow calculations evaluating the (n-1) criterion, without any dynamic analysis that may introduce additional limitations for this border.

Remark: Both TSOs (ESO and TEIAS) confirmed that limiting network element is the OHL 400 kV Maritsa East - Babaesku. TEIAS stated that critical 154 kV lines are located in the far east Turkey and (n-1) problems are related to loads at Kızıltepe (Irrigation pumps), not related to exchange levels. For critical transformers in the Adapazari substation, there will be a new 400/154kV substation near to Adapazari so autotransformer contingency loadings at Adapazari will significantly drop. TEIAS also stressed that for Turkish transmission network, only tie lines between Turkey and Bulgaria & Greece must be taken as limiting element in the NTC/TTC calculations.

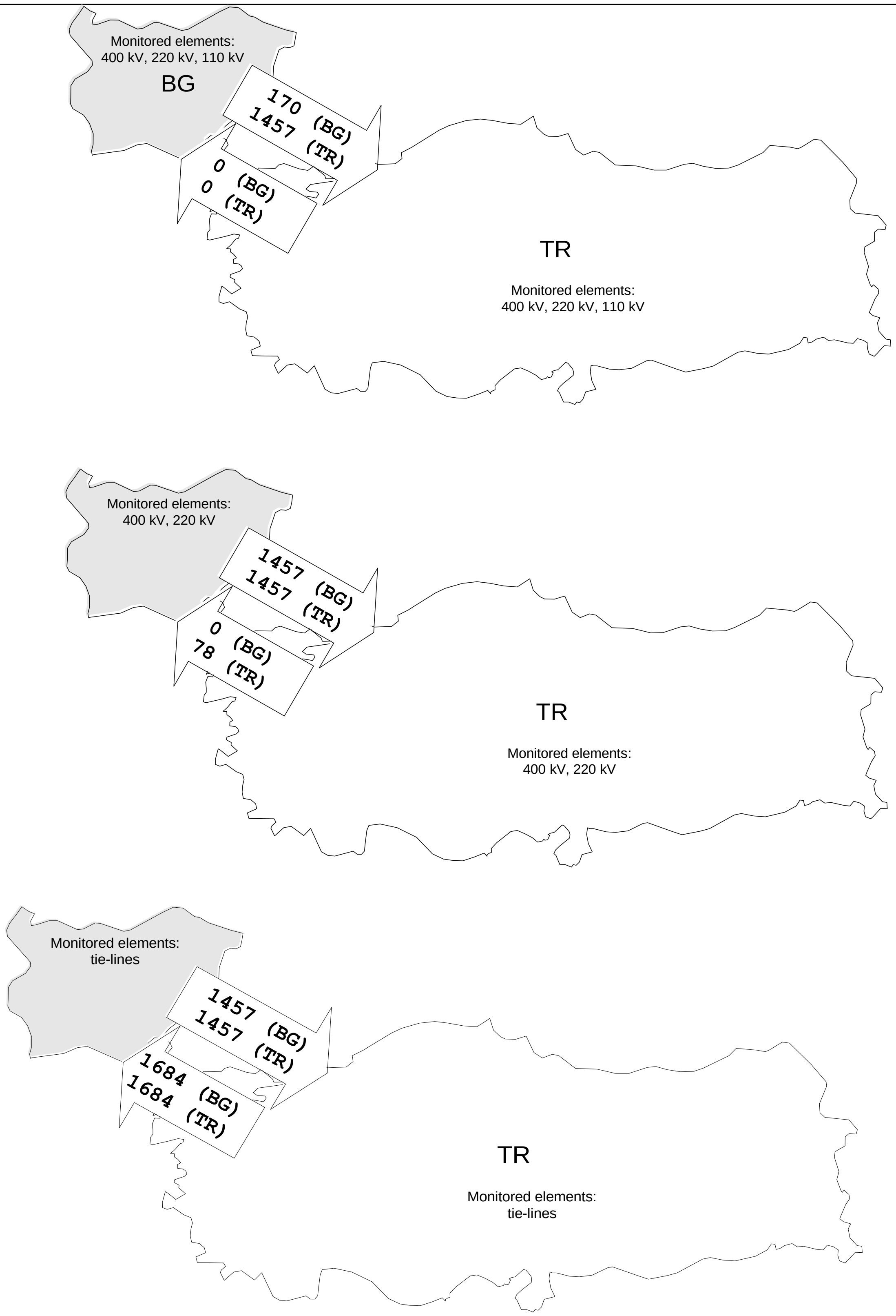


Figure 6.11 Calculated NTC values for the Bulgaria/Turkey border depending on the monitored elements (model 2012)

Table 6.33 Critical network elements for a power exchange on the Bulgaria/Turkey border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Bulgaria to Turkey direction					
Bulgarian side (monitored elements: 400 kV, 220 kV and 110 kV)	312	141	170	110 kV network in the area of Dobrudzha	
Bulgarian side (monitored elements: 400 kV, 220 kV)	1599	141	1457	OHL 400 kV Maritsa East-Hamitabad	OHL 400 kV Maritsa East - Babaesku
Bulgarian side (monitored elements: tie-lines)	1599	141	1457	OHL 400 kV Maritsa East-Hamitabad	OHL 400 kV Maritsa East - Babaesku
Turkish side (monitored elements: 400 kV, 220 kV and 110 kV)	1598	141	1457	OHL 400 kV Maritsa East-Hamitabad	OHL 400 kV Maritsa East - Babaesku
Turkish side (monitored elements: 400 kV, 220 kV)	1598	141	1457	OHL 400 kV Maritsa East-Hamitabad	OHL 400 kV Maritsa East - Babaesku
Turkish side (monitored elements: tie-lines)	1598	141	1457	OHL 400 kV Maritsa East-Hamitabad	OHL 400 kV Maritsa East - Babaesku
Turkey to Bulgaria direction					
Bulgarian side (monitored elements: 400 kV, 220 kV and 110 kV)	0	141	0	OHL 400 kV Maritsa East 1 - Plovdiv	OHL 220 kV Plovdiv - Aleko
Bulgarian side (monitored elements: 400 kV, 220 kV)	0	141	0	OHL 400 kV Maritsa East 1 - Plovdiv	OHL 220 kV Plovdiv - Aleko
Bulgarian side (monitored elements: tie-lines)	1825	141	1684	OHL 400 kV Maritsa East-Hamitabad	OHL 400 kV Maritsa East - Babaesku
Turkish side (monitored elements: 400 kV, 220 kV and 110 kV)	0	141	0	4ELGUN 400.0 kV - 4KIZILTEPE 400.0 kV	PS4-A 154.00 - VIRANSEHIR 154.00 PS4-A 154.00 - KARAKECILI 154.00 KIRLIK 154.00 - ODASDGKC 154.00 ETIFOSFAT 154.00 - MARDIN2 154.00
Turkish side (monitored elements: 400 kV, 220 kV)	220	141	78	TR 400/154 4ADAPAZARI 1,2	TR 400/154 4ADAPAZARI 2,1
Turkish side (monitored elements: tie-lines)	1826	141	1684	OHL 400 kV Maritsa East-Hamitabad	OHL 400 kV Maritsa East - Babaesku

6.12 Croatia/Slovenia border

The NTC values for the Croatia/Slovenia border have been calculated using the model for 2012 as follows:

Table 6.34 The NTC values for Croatia/Slovenia border (2012, CROATIA to SLOVENIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Croatia	Slovenia	
400 kV, 220 kV, 110 kV & tie-lines	1009	1259	1009
400 kV, 220 kV & tie-lines	1471	1402	1402
tie-lines (400 kV, 220 kV)	1471	1402	1402

Table 6.35 The NTC values for Croatia/Slovenia border (2012, SLOVENIA to CROATIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Croatia	Slovenia	
400 kV, 220 kV, 110 kV & tie-lines	344	594	344
400 kV, 220 kV & tie-lines	487	631	487
tie-lines (400 kV, 220 kV)	880	880	880

For the direction of power flows from Croatia to Slovenia, evaluating all 400 kV, 220 kV and 110 kV network elements, the NTC value would be 1009 MW from the Croatian side and 1259 MW from the Slovenian side. The NTC value is limited because of the OHL 110 kV Crikvenica – Krk, which is jeopardized by an OHL 110 kV Melina – Vinodol – Crikvenica outage. This contingency provides a lower NTC value, evaluationg both sides of the border. The critical line has a thermal rating of 70 MVA at the model and consists of submarine cable and overhead line sections. The submarine cable has low cross-section that reduces thermal capacity of the line. The NTC value would be limited by the Slovenian side by possible overloading of the OHL 110 kV I. BIstrica – Matulji as a consequence of the line 220 kV Pehlin – Divača outage. The critical line is a cross-border line between Slovenia (I. Bistrica) and Croatia (Matulji) with low thermal capacity (83,8 MVA on Slovenian side and 89 MVA on Croatian side at the model, constructed long ago).

Monitoring 400 kV and 220 kV network elements of the Croatian and Slovenian transmission system and ignoring the 110 kV networks, the NTC value would be limited by the 220 kV tie-line Pehlin – Divača, with a thermal capacity of 360 MVA on the Croatian side and 365,8 MVA on the Slovenian side at the model. Critical contingences in Croatia and Slovenia are different. The OHL 220 kV Pehlin – Divača is jeopardized by outages of the tie-line 400 kV Melina (HR) – Divača (SI) when evaluating the Croatian side, and outages of the tie-line Divača (SI) – Redipuglia (I) when evaluating the Slovenian side. The NTC values would be defined up to 1471 MW on the Croatian side and 1402 MW on the Slovenian side, so the final NTC value of 1402 has been defined as the lower one.

For the opposite direction of power exchanges (Slovenia to Croatia), the NTC value is limited by the OHL 110 kV HPP Formin – Nedeljanec, which gets overloaded as a consequence of an OHL 110 kV Žerjavinec – Jertovec outage on the Croatian side (NTC is 344 MW) or the OHL 400 kV NPP Krško – Maribor on the Slovenian side (NTC is 594 MW). Ignoring the 110 kV network and monitoring 400 kV and 220 kV network elements, the NTC values would be increased to 487 MW on the Croatian side and 631 MW on the Slovenian side, limited by the 400/110 kV transformers in the SS Tumbri (3x300 MVA, one transformer is permanently out of operation but may be putted in operation) in Croatia and 220/110 kV SS Divača in Slovenia (2x143,5 MVA at the model). Evaluating the tie-lines of both countries only, the NTC values would be increased up to 880 MW due to maximum generation shift in Croatia and without any network limitations.

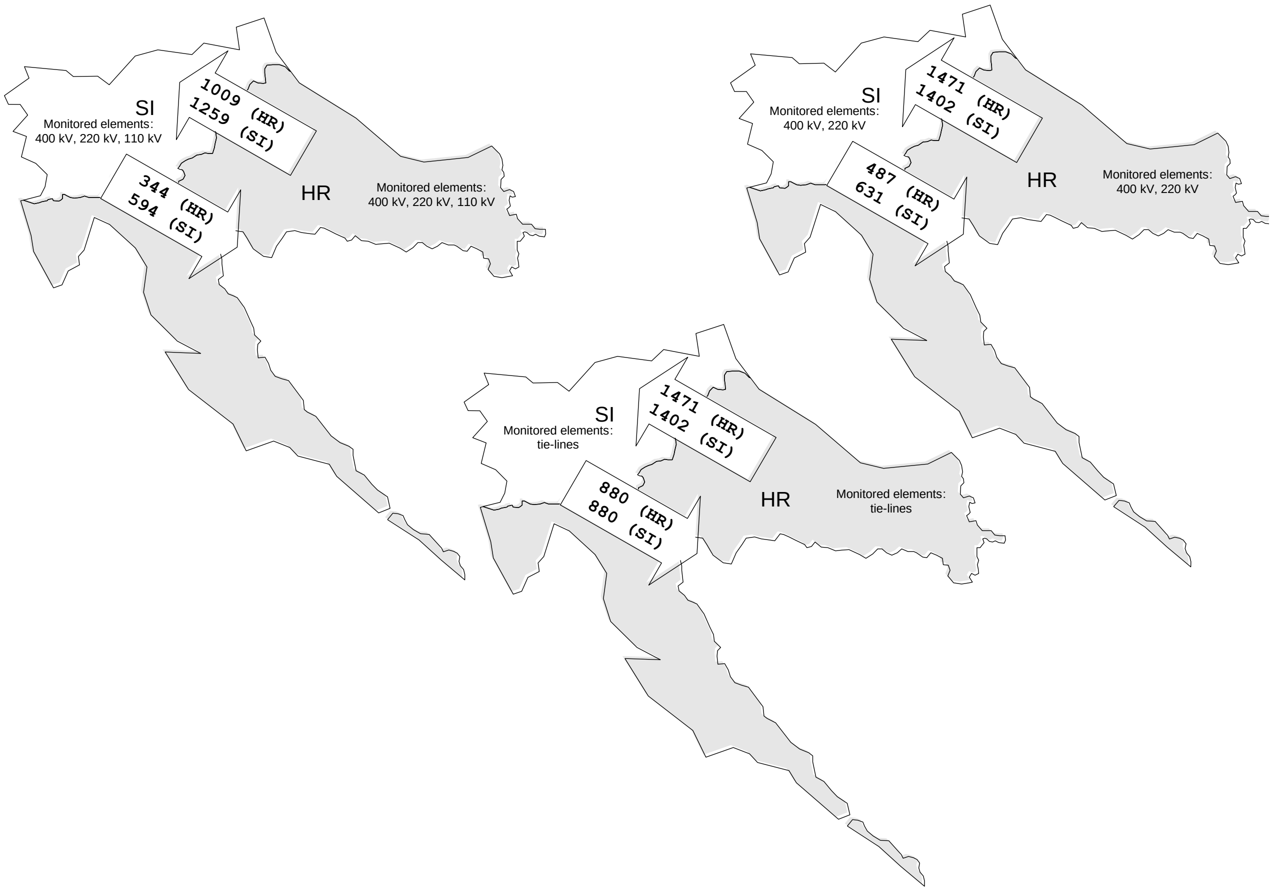


Figure 6.12 Calculated NTC values for the Croatia/Slovenia border depending on the monitored elements (model 2012)

Remark: Croatian TSO (HOPS) confirmed critical network elements but stated that there are three transformers 400/110 kV in the SS Tumbri, among which only two are in operation with occasional switching on the third transformer in necessary. This would increase the NTC value on Croatian side for the power exchange between Slovenia and Croatia. Possible overloading of the OHL 110 kV Crikvenica – Krk may also be solved by network sectioning. Loading of the OHL 220 kV Pehlin – Divača may be efficiently controlled by phase-shift transformers in the Divača and Padriciano substations. Overloading of the 110 kV interconnection lines Matulji – I. Bistrica and Nedeljanec – HPP Formin are not critical because both lines may be in radial operation or out of operation during normal operational conditions.

Table 6.36 Critical network elements for a power exchange on the Croatia/Slovenia border

RESULTS	**TTC (MW)**	**TRM (MW)**	**NTC (MW)**	**Critical contingency**	**Critical line**
Croatia to Slovenia direction					
Croatian side (monitored elements: 400 kV, 220 kV and 110 kV)	1232	224	1009	OHL 110 kV Melina - Vinodol – Crikvenica	OHL 110 kV Crikvenica - Krk
Croatian side (monitored elements: 400 kV, 220 kV)	1694	224	1471	OHL 400 kV Melina - Divača	OHL 220 kV Pehlin - Divača
Croatian side (monitored elements: tie-lines)	1694	224	1471	OHL 400 kV Melina - Divača	OHL 220 kV Pehlin - Divača
Slovenian side (monitored elements: 400 kV, 220 kV and 110 kV)	1482	224	1259	OHL 220 kV Pehlin - Divača	OHL 110 kV Matulji - I. Bistrica
Slovenian side (monitored elements: 400 kV, 220 kV)	1625	224	1402	OHL 400 kV Divača - Redipuglia	OHL 220 kV Divača - Pehlin
Slovenian side (monitored elements: tie-lines)	1625	224	1402	OHL 400 kV Divača - Redipuglia	OHL 220 kV Divača - Pehlin
Slovenia to Croatia direction					
Croatian side (monitored elements: 400 kV, 220 kV and 110 kV)	568	224	344	OHL 110 kV Žerjavinec - Jertovec	OHL 110 kV HE Formin - Nedeljanec
Croatian side (monitored elements: 400 kV, 220 kV)	711	224	487	TR 400/110 kV Tumbri 1,2	TR 400/110 kV Tumbri 2,1
Croatian side (monitored elements: tie-lines)	1104	224	880	-	*maximum generation shift in Croatia*
Slovenian side (monitored elements: 400 kV, 220 kV and 110 kV)	818	224	594	OHL 400 kV Krško - Maribor	OHL 110 kV Nedeljanec - Formin
Slovenian side (monitored elements: 400 kV, 220 kV)	855	224	631	OHL 400 kV Divača - Redipuglia	TR 220/110 kV Divača
Slovenian side (monitored elements: tie-lines)	1104	224	880	-	*maximum generation shift in Croatia*

6.13 Croatia/Hungary border

The NTC values for the Croatia/Hungary border have been calculated using the model for 2012 as follows:

Table 6.37 The NTC values for Croatia/Hungary border (2012, CROATIA to HUNGARY direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Croatia	Hungary	
400 kV, 220 kV, 110 kV & tie-lines	789	-	789
400 kV, 220 kV & tie-lines	789	-	789
tie-lines (400 kV, 220 kV)	789	-	789

Table 6.38 The NTC values for the Croatia/Hungary border (2012, HUNGARY to CROATIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Croatia	Hungary	
400 kV, 220 kV, 110 kV & tie-lines	1811	-	1811
400 kV, 220 kV & tie-lines	2204	-	2204
tie-lines (400 kV, 220 kV)	2797	-	2797

For the direction of power flows from Croatia to Hungary, the NTC value is set to 789 MW without any network limitations, 400 kV, 220 kV and 110 kV evaluating voltage levels, but due to maximum generation shift in Croatia.

For the direction of power flows from Hungary to Croatia, evaluating all 400 kV, 220 kV and 110 kV network elements on the Croatian side, limitations appear when NTC values are set to 1811 MW, concerning the 110 kV line Žerjavinec – Jertovac (thermal capacity 110 MVA at the model), jeopardized by an OHL 400 kV Tumbri – Žerjavinec outage. Ignoring the 110 kV network in Croatia, the NTC value could be increased above 2000 MW, limited by 400/110 kV transformers in the SS Ernestinovo (2x300 MVA).

Obviously, there are possibilities for significant power exchanges between these two countries in present conditions.

Remark: Croatian TSO (HOPS) confirmed critical network elements. Line 110 kV Žejavinec – Jertovec is jeopardized as a consequence of the OHL 400 kV Tumbri – Žerjavinec outage and Croatian TSO plan to reinforce this path. Transformers 400/110 kV in the Ernestinovo substation may be jeopardized when local demand is high and local generation (at the network 110 kV) is low.

Figure 6.13 Calculated NTC values for the Croatia/Hungary border depending on the monitored elements (model 2012)

Table 6.39 Critical network elements for a power exchange on the Croatia/Hungary border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Croatia to Hungary direction					
Croatian side (monitored elements: 400 kV, 220 kV and 110 kV)	989	200	789	-	*maximum generation shift in Croatia*
Croatian side (monitored elements: 400 kV, 220 kV)	989	200	789	-	*maximum generation shift in Croatia*
Croatian side (monitored elements: tie-lines)	989	200	789	-	*maximum generation shift in Croatia*
Hungarian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Hungarian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Hungarian side (monitored elements: tie-lines)	-	-	-	-	-
Hungary to Croatia direction					
Croatian side (monitored elements: 400 kV, 220 kV and 110 kV)	2011	200	1811	OHL 400 kV Žerjavinec - Tumbri	OHL 110 kV Žerjavinec - Jertovec
Croatian side (monitored elements: 400 kV, 220 kV)	2404	200	2204	TR 400/110 kV Ernestinovo 1,2	TR 400/110 kV Ernestinovo 2,1
Croatian side (monitored elements: tie-lines)	2797	200	2597	-	*maximum generation shift in Croatia*
Hungarian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Hungarian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Hungarian side (monitored elements: tie-lines)	-	-	-	-	-

6.14 Croatia/Serbia border

The NTC values for the Croatia/Serbia border have been calculated using the model for 2012 as follows:

Table 6.40 The NTC values for the Croatia/Serbia border (2012, CROATIA to SERBIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Croatia	Serbia	
400 kV, 220 kV, 110 kV & tie-lines	1207	669	669
400 kV, 220 kV & tie-lines	1738	669	669
tie-lines (400 kV, 220 kV)	1738	669	669

Table 6.41 The NTC values for the Croatia/Serbia border (2012, SERBIA to CROATIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Croatia	Serbia	
400 kV, 220 kV, 110 kV & tie-lines	443	642	443
400 kV, 220 kV & tie-lines	830	1004	830
tie-lines (400 kV, 220 kV)	1518	1078	1078

For the direction of power flows from Croatia to Serbia when evaluating the internal transmission network of Croatia, the NTC value would be limited to 1207 MW due to 110 kV line Crikvenica - Krk. Because this line is situated far away from the evaluated border, one may assume that this critical contingency may be neglected. Ignoring the 110 kV network on the Croatian side, the NTC value could be increased up to 1738 MW, the critical line then becomes a tie-line between Croatia and Bosnia and Herzegovina, OHL 220 kV Zakučac – Mostar.

For the same direction of power flows, but evaluating network elements on Serbian side, the NTC values are set to 669 MW due to maximum generation shift in Serbia in a downward direction.

For the direction of power flows from Serbia to Croatia, evaluating all 400 kV, 220 kV and 110 kV network elements on the Croatian side, the limiting network elements are OHL 110 kV Žerjavinec – Jertovec, 400/110 kV transformers in the Žerjavinec substation (if we ignore the network 110 kV), and OHL 220 kV Zakučac – Mostar if we ignore internal network of Croatia and only evaluate tie-lines.

For the direction of power flows from Serbia to Croatia, evaluating all 400 kV, 220 kV and 110 kV network elements on the Serbian side, the limiting network element is the OHL 110 kV Đerdap – Prahovo, which is jeopardized by an outage of the 110 kV line Đerdap – Negotin. Monitoring 400 kV and 220 kV networks in Serbia, limiting network elements becomes the OHL 220 kV Bajina Bašta – Vardište. If we only evaluate tie-lines, the NTC value could be set to 1078 MW from the Serbian side, due to maximum generation shift in Croatia.

Remark: Croatian TSO (HOPS) confirmed critical network elements but stated that there are dispatching actions, described in the Chapter 7, which may mitigate overloading problems.

Serbian TSO (EMS) confirmed the OHL 220 kV Bajina Bašta – Vardište to be critical network element, but stressed that overloading in the network 110 kV should be ignored while calculating the NTC values.

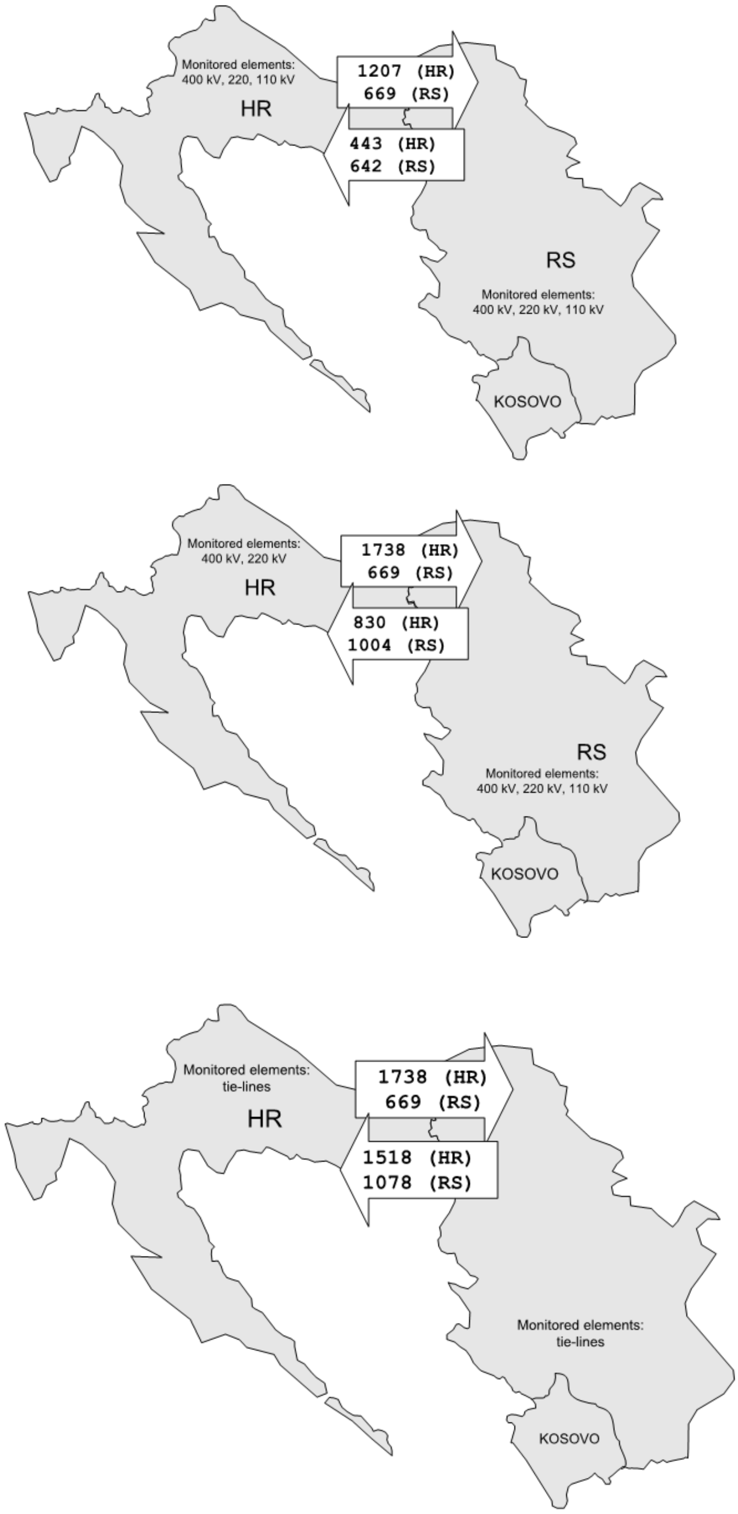


Figure 6.14 Calculated NTC values for the Croatia/Serbia border depending on the monitored elements (model 2012)

Table 6.42 Critical network elements for a power exchange on the Croatia/Serbia border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Croatia to Serbia direction					
Croatian side (monitored elements: 400 kV, 220 kV and 110 kV)	1307	100	1207	OHL 110 kV Melina - Vinodol	OHL 110 kV Crikvenica - Krk
Croatian side (monitored elements: 400 kV, 220 kV)	1838	100	1738	OHL 400 kV Konjsko - Mostar	OHL 220 kV Zakučac - Mostar
Croatian side (monitored elements: tie-lines)	1838	100	1738	OHL 400 kV Konjsko - Mostar	OHL 220 kV Zakučac - Mostar
Serbian side (monitored elements: 400 kV, 220 kV and 110 kV)	769	100	669	-	*maximum generation shift in Serbia*
Serbian side (monitored elements: 400 kV, 220 kV)	769	100	669	-	*maximum generation shift in Serbia*
Serbian side (monitored elements: tie-lines)	769	100	669	-	*maximum generation shift in Serbia*
Serbia to Croatia direction					
Croatian side (monitored elements: 400 kV, 220 kV and 110 kV)	543	100	443	OHL 400 kV Žerjavinec - Tumbri	OHL 110 kV Žerjavinec - Jertovec
Croatian side (monitored elements: 400 kV, 220 kV)	930	100	830	TR 400/110 kV Žerjavinec 1,2	TR 400/110 kV Žerjavinec 2,1
Croatian side (monitored elements: tie-lines)	1618	100	1518	OHL 400 kV Konjsko - Mostar	OHL 220 kV Zakučac - Mostar
Serbian side (monitored elements: 400 kV, 220 kV and 110 kV)	742	100	642	OHL 110 kV Đerdap - Negotin	OHL 110 kV Đerdap - Prahovo
Serbian side (monitored elements: 400 kV, 220 kV)	1104	100	1004	OHL 220 kV B.Basta - Požega	OHL 220 kV B.Basta - Vardište
Serbian side (monitored elements: tie-lines)	1178	100	1078	-	*maximum generation shift in Croatia*

6.15 Montenegro/Serbia&Kosovo border

The NTC values for the Montenegro/Serbia & Kosovo border have been calculated using the model for 2012 as follows:

Table 6.43 The NTC values for the Montenegro/Serbia & Kosovo border (2012, MONTENEGRO to RS direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Montenegro	RS	
400 kV, 220 kV, 110 kV & tie-lines	788	311	311
400 kV, 220 kV & tie-lines	788	311	311
tie-lines (400 kV, 220 kV)	788	311	311

Table 6.44 The NTC values for the Montenegro/Serbia & Kosovo border (2012, RS to MONTENEGRO direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Montenegro	RS	
400 kV, 220 kV, 110 kV & tie-lines	583	303	303
400 kV, 220 kV & tie-lines	583	534	534
tie-lines (400 kV, 220 kV)	583	534	534

For the direction of power flows from Montenegro to Serbia and Kosovo, the NTC values are limited by maximum generation shifts in the Montenegro, Serbia and Kosovo area to 788 MW, evaluating the Montenegrin side, and 311 MW evaluating the Serbian and Kosovan side. Network limitations in Montenegro, Serbia and Kosovo for these ranges of power exchanges are not visible at the model.

For the direction of power flows from Kosovo and Serbia to Montenegro, evaluating all 400 kV, 220 kV and 110 kV network elements on the Montenegrin side, the NTC value is set to 583 MW. It is limited by the OHL 220 kV Pljevlja – Bajina Bašta, which gets overloaded as a consequence of an OHL 400 kV Ribarevine – Peć outage. Evaluating the Serbian side and 400 kV, 220 kV and 110 kV networks, a limitation appears concerning the 110 kV line Valjevo – Kosjerić. The NTC values for this direction of power exchanges may be increased up to 534 MW if we ignore 110 kV network elements in Serbia and Kosovo. A new limitation will appear on the OHL 220 kV Pljevlja – Bajina Bašta as a consequence of an OHL 220 kV Bajina Bašta – Požega outage. The thermal rating of this line is set to 274,4 MVA on the Montenegrin side and 388,7 MVA on the Serbian side at the model.

Remark: Serbian TSO (EMS) stated that overloading of lines 110 kV are not critical and limiting elements for the NTC values over Serbian borders. EMS confirmed that the OHL 220 kV Bajina Bašta – Pljevlja is critical element which limit the NTC values. It also described some dispatching actions which may be helpful to mitigate this problem. They are also described in the Chapter 7.

Montenegrin TSO (CGES) didn't response on their critical elements which limit power exchanges over the analyzed border.

Figure 6.15 Calculated NTC values for the Montenegro/Serbia & Kosovo border depending on the monitored elements (model 2012)

Table 6.45 Critical network elements for a power exchange on the Montenegro/Serbia & Kosovo border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Montenegro to Serbia and Kosovo direction					
Montenegrin side (monitored elements: 400 kV, 220 kV and 110 kV)	961	173	788	-	*maximum generation shift in Montenegro*
Montenegrin side (monitored elements: 400 kV, 220 kV)	961	173	788	-	*maximum generation shift in Montenegro*
Montenegrin side (monitored elements: tie-lines)	961	173	788	-	*maximum generation shift in Montenegro*
RS side (monitored elements: 400 kV, 220 kV and 110 kV)	485	173	311	-	*maximum generation shift in Serbia*
RS side (monitored elements: 400 kV, 220 kV)	485	173	311	-	*maximum generation shift in Serbia*
RS side (monitored elements: tie-lines)	485	173	311	-	*maximum generation shift in Serbia*
Serbia and Kosovo to Montenegro direction					
Montenegrin side (monitored elements: 400 kV, 220 kV and 110 kV)	757	173	583	OHL 400 kV Ribarevine - Peć	OHL 220 kV Pljevlja - B.Bašta
Montenegrin side (monitored elements: 400 kV, 220 kV)	757	173	583	OHL 400 kV Ribarevine - Peć	OHL 220 kV Pljevlja - B.Bašta
Montenegrin side (monitored elements: tie-lines)	757	173	583	OHL 400 kV Ribarevine - Peć	OHL 220 kV Pljevlja - B.Bašta
RS side (monitored elements: 400 kV, 220 kV and 110 kV)	476	173	303	OHL 220 kV B.Basta - Pozega	OHL 110 kV Valjevo - Kosjerić
RS side (monitored elements: 400 kV, 220 kV)	707	173	534	OHL 220 kV B.Basta - Požega	OHL 220 kV Pljevlja - B.Bašta
RS side (monitored elements: tie-lines)	707	173	534	OHL 220 kV B.Basta - Požega	OHL 220 kV Pljevlja - B.Bašta

6.16 Macedonia/Kosovo border

The NTC values for the Macedonia/Kosovo border (calculations have been performed including Serbia and Kosovo, "RS" area" at the model) have been calculated using the model for 2012 as follows:

Table 6.46 The NTC values for the Macedonia/Kosovo border (2012, MACEDONIA to RS direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Macedonia	RS	
400 kV, 220 kV, 110 kV & tie-lines	681	441	441
400 kV, 220 kV & tie-lines	681	441	441
tie-lines (400 kV, 220 kV)	681	441	441

Table 6.47 The NTC values for the Macedonia/Kosovo border (2012, RS to MACEDONIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Macedonia	RS	
400 kV, 220 kV, 110 kV & tie-lines	600	320	320
400 kV, 220 kV & tie-lines	943	870	870
tie-lines (400 kV, 220 kV)	943	870	870

For the direction of power flows from Macedonia to Serbia and Kosovo, the NTC values are limited by maximum generation shifts in the Macedonia, Serbia and Kosovo area to 681 MW, evaluating the Macedonian side, and 441 MW, evaluating the Serbian and Kosovan side. Network limitations in Macedonia, Serbia and Kosovo for these ranges of power exchanges are not visible at the model, except for one network limitation in the 110 kV network of Macedonia, related to the OHL 110 kV TETO – Skopje 4, which gets overloaded as a consequence of an OHL 400 kV Skopje 5 – Kosovo B outage.

For the direction of power flows from Kosovo and Serbia to Macedonia, evaluating all 400 kV, 220 kV and 110 kV network elements on the Macedonian side, the NTC value is set to 600 MW. It is limited by the OHL 110 kV Skopje 3 – Skopje 4, which gets overloaded as a consequence of an OHL 110 kV G. Petrov – Skopje 1 outage. Evaluating the Kosovan and Serbian side and network 400 kV, 220 kV and 110 kV, a limitation appears concerning the 110 kV line Valjevo – Kosjerić. The NTC values for this direction of power exchanges may be increased up to 870 MW if we ignore 110 kV network elements in Macedonia, Serbia and Kosovo. A new limitation will appear on the OHL 220 kV Pljevlja – Bajina Bašta as a consequence of an OHL 220 kV Bajina Bašta – Požega outage.

Remark: Macedonian TSO (MEPSO) confirmed critical network elements found here, but stressed that 110 kV network limitations are not observed while calculating the NTC values. This refers to possible overloading of the overhead lines 110 kV Skopje 3 – Skopje 4 and TETO – Skopje 4. All limitations may be removed by dispatching actions, described in the Chapter 7.

Serbian TSO (EMS) stated that overloading of lines 110 kV are not critical and limiting elements for the NTC values over Serbian borders. EMS confirmed that the OHL 220 kV Bajina Bašta – Pljevlja is critical element which limit the NTC values. It also described some dispatching actions which may be helpful to mitigate this problem. They are also described in the Chapter 7.

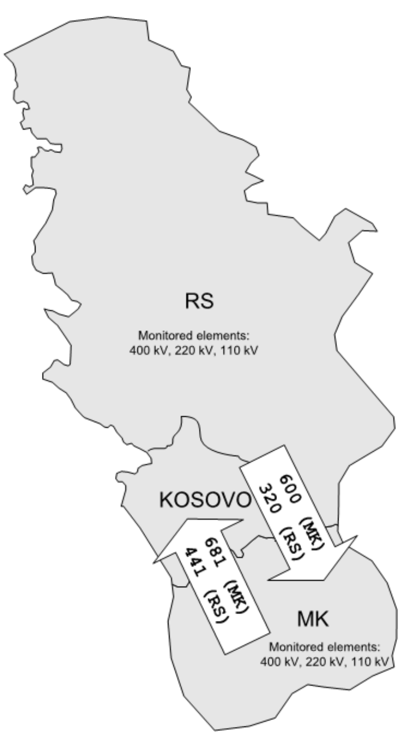


Figure 6.16 Calculated NTC values for the Macedonia/ Kosovo border depending on the monitored elements (model 2012)

Table 6.48 Critical network elements for a power exchange on the the Macedonia/Kosovo border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Macedonia to Kosovo direction					
Macedonian side (monitored elements: 400 kV, 220 kV and 110 kV)	781	100	681	OHL 400 kV Skopje 5 - Kosovo B	OHL 110 kV TETO - Skopje 4
Macedonian side (monitored elements: 400 kV, 220 kV)	781	100	681	-	*maximum generation shift in Macedonia*
Macedonian side (monitored elements: tie-lines)	781	100	681	-	*maximum generation shift in Macedonia*
RS side (monitored elements: 400 kV, 220 kV and 110 kV)	541	100	441	-	*maximum generation shift in Serbia*
RS side (monitored elements: 400 kV, 220 kV)	541	100	441	-	*maximum generation shift in Serbia*
RS side (monitored elements: tie-lines)	541	100	441	-	*maximum generation shift in Serbia*
Kosovo to Macedonia direction					
Macedonian side (monitored elements: 400 kV, 220 kV and 110 kV)	700	100	600	OHL 110 kV G.Petrov - Skopje 1	OHL 110 kV Skopje 3 - Skopje 4
Macedonian side (monitored elements: 400 kV, 220 kV)	1043	100	943	-	*maximum generation shift in Macedonia*
Macedonian side (monitored elements: tie-lines)	1043	100	943	-	*maximum generation shift in Macedonia*
RS side (monitored elements: 400 kV, 220 kV and 110 kV)	420	100	320	OHL 220 kV B.Bašta - Požega	OHL 110 kV Valjevo - Kosjerić
RS side (monitored elements: 400 kV, 220 kV)	970	100	870	OHL 220 kV B.Bašta - Požega	OHL 220 kV B.Bašta - Pljevlja
RS side (monitored elements: tie-lines)	970	100	870	OHL 220 kV B.Bašta - Požega	OHL 220 kV B.Bašta - Pljevlja

6.17 Macedonia/Greece border

The NTC values for Macedonia/Greece border have been calculated using the model for 2012 as follows:

Table 6.49 The NTC values for the Macedonia/Greece border (2012, MACEDONIA to GREECE direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Macedonia	Greece	
400 kV, 220 kV, 110 kV & tie-lines	755	-	755
400 kV, 220 kV & tie-lines	879	-	879
tie-lines (400 kV, 220 kV)	879	-	879

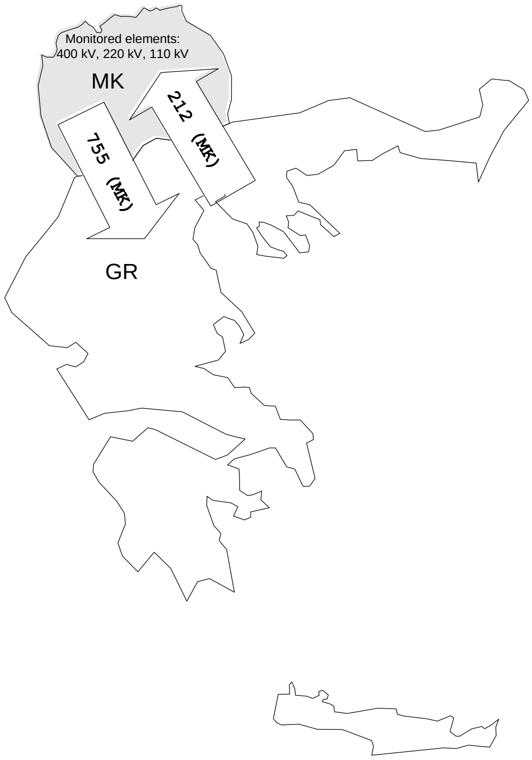
Table 6.50 The NTC values for the Macedonia/Greece border (2012, GREECE to MACEDONIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Macedonia	Greece	
400 kV, 220 kV, 110 kV & tie-lines	212	-	212
400 kV, 220 kV & tie-lines	636	-	636
tie-lines (400 kV, 220 kV)	636	-	636

For the direction of power flows from Macedonia to Greece and monitoring 400 kV, 220 kV and 110 kV networks on the Macedonian side, the NTC value is set to 755 MW. It is limited by the OHL 110 kV TETO – Skopje 4, which is jeopardized by an outage of the OHL 110 kV Skopje 1 – Kumanovo 1. Ignoring the 110 kV network in Macedonia, the NTC values are limited by maximum generation shift in Macedonia to 879 MW.

For the direction of power flows from Greece to Macedonia, evaluating all 400 kV, 220 kV and 110 kV network elements on the Macedonian side, the NTC value is set to 212 MW. It is limited by the OHL 110 kV Skopje 3 – Skopje 4, which gets overloaded as a consequence of an OHL 110 kV G. Petrov – Skopje 1 outage. The NTC value for this direction of power exchanges may be increased up to 636 MW if we ignore 110 kV network elements in Macedonia. No new critical network elements have been noticed for the maximum level of power exchange due to maximum generation shift in Macedonia.

Remark: Macedonian TSO (MEPSO) confirmed critical network elements found here, but stressed that 110 kV network limitations are not observed while calculating the NTC values. All limitations may be removed by dispatching actions, described in the Chapter 7. Generally, MEPSO considers limitations in the network 400 kV only while calculating the NTC values. Real transits over Macedonian network go in direction of Greece from North (Bulgaria, Serbia). That's the reason why they use composite NTC calculation approach. They define one area as SINK or SOURCE area, comprising of Macedonia, Greece and Albania in one area and Serbia, Bulgaria and Romania in another area.



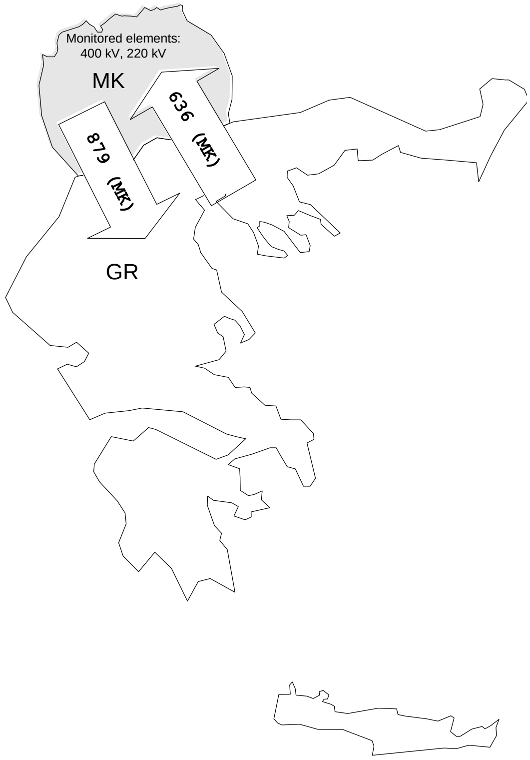


Figure 6.17 Calculated NTC values for the Macedonia/ Greece border depending on the monitored elements (model 2012)

Table 6.51 Critical network elements for a power exchange on the Macedonia/Greece border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Macedonia to Greece direction					
Macedonian side (monitored elements: 400 kV, 220 kV and 110 kV)	896	141	755	OHL 110 kV Skopje 1 - Kumanovo 1	OHL 110 kV TETO - Skopje 4
Macedonian side (monitored elements: 400 kV, 220 kV)	1020	141	879	-	*maximum generation shift in Macedonia*
Macedonian side (monitored elements: tie-lines)	1020	141	879	-	*maximum generation shift in Macedonia*
Greek side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Greek side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Greek side (monitored elements: tie-lines)	-	-	-	-	-
Greece to Macedonia direction					
Macedonian side (monitored elements: 400 kV, 220 kV and 110 kV)	354	141	212	OHL 110 kV G.Petrov - Skopje 1	OHL 110 kV Skopje 3 - Skopje 4
Macedonian side (monitored elements: 400 kV, 220 kV)	778	141	636	-	*maximum generation shift in Macedonia*
Macedonian side (monitored elements: tie-lines)	778	141	636	-	*maximum generation shift in Macedonia*
Greek side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Greek side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Greek side (monitored elements: tie-lines)	-	-	-	-	-

6.18 Romania/Serbia border

The NTC values for the Romania/Serbia border have been calculated using the model for 2012 as follows:

Table 6.52 The NTC values for the Romania/Serbia border (2012, ROMANIA to SERBIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Romania**	**Serbia**	
400 kV, 220 kV, 110 kV & tie-lines	830	830	830
400 kV, 220 kV & tie-lines	830	830	830
tie-lines (400 kV, 220 kV)	830	830	830

Table 6.53 The NTC values for the Romania/ Serbia border (2012, SERBIA to ROMANIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Romania**	**Serbia**	
400 kV, 220 kV, 110 kV & tie-lines	1266	474	474
400 kV, 220 kV & tie-lines	1542	999	999
tie-lines (400 kV, 220 kV)	1542	999	999

For the direction of power flows from Romania to Serbia, the NTC values from both sides of the border are limited by maximum generation shift in Serbia at the model. The NTC value of 830 MW has been calculated based on this limiting factor, regardless of the monitored network elements. For this value of power exchange from Romania to Serbia, no network limitations in Romania and Serbia, including the 110 kV networks, have been detected at the model. Increasing possible generation shift in a downward direction in Serbia, network limitations have been detected in the Romanian network concerning the 220/110 kV transformers in the Targoviste substation and the OHL 400 kV P.D.Fier – Đerdap, which is jeopardized by an OHL 400 kV Tantareni – Urechesti outage (for power exchange level of 1612 MW from Romania to Serbia).

For the direction of power flows from Serbia to Romania, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Romanian side, the NTC value is set to 1266 MW due to maximum generation shift in Romania. evaluating the Serbian side and 400 kV, 220 kV and 110 kV networks, limitations appear concerning the 110 kV line Đerdap – Prahovo. The NTC value for this direction of power exchanges will increase up to 999 MW if we ignore 110 kV network elements in Romania and Serbia. A new limitation will appear on the OHL 220 kV Pljevlja – Bajina Bašta as a consequence of an OHL 220 kV Bajina Bašta – Požega outage. For this level of power exchanges, no network limitations have been found in Romanian 400 kV, 220 kV and 110 kV networks.

Remark: Serbian TSO (EMS) stated that overloading of lines 110 kV is not a critical and limiting element for the NTC values over Serbian borders. EMS confirmed that the OHL 220 kV Bajina Bašta – Pljevlja is critical element which limit the NTC values. It also described some dispatching actions which may be helpful to mitigate this problem. They are also described in the Chapter 7.

Romanian TSO (Transelectrica) confirmed critical elements on their side of the border which appear when generation shift in both countries is increased. Critical element on Romanian side for larger volumes of power exchange is OHL 400 kV P.D. Fier – Djerdap, jeopardized by outage of the OHL 400 kV Tantareni – Urechesti.

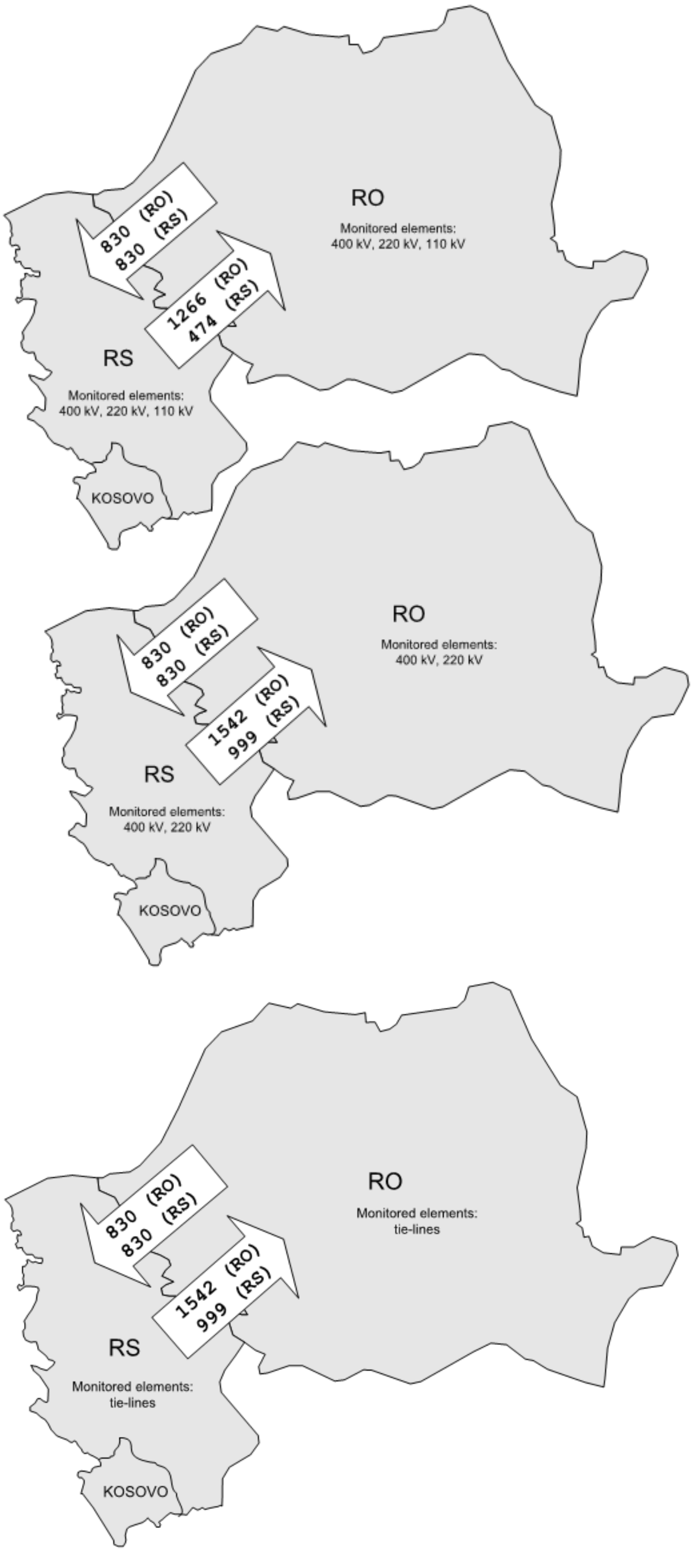


Figure 6.18 Calculated NTC values for the Romania/ Serbia border depending on the monitored elements (model 2012)

Table 6.54 Critical network elements for a power exchange on the Romania/Serbia border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Romania to Serbia direction					
Romanian side (monitored elements: 400 kV, 220 kV and 110 kV)	930	100	830	-	*maximum generation shift in Serbia*
Romanian side (monitored elements: 400 kV, 220 kV)	930	100	830	-	*maximum generation shift in Serbia*
Romanian side (monitored elements: tie-lines)	930	100	830	-	*maximum generation shift in Serbia*
Serbian side (monitored elements: 400 kV, 220 kV and 110 kV)	930	100	830	-	*maximum generation shift in Serbia*
Serbian side (monitored elements: 400 kV, 220 kV)	930	100	830	-	*maximum generation shift in Serbia*
Serbian side (monitored elements: tie-lines)	930	100	830	-	*maximum generation shift in Serbia*
Serbia to Romania direction					
Romanian side (monitored elements: 400 kV, 220 kV and 110 kV)	1366	100	1266	-	*maximum generation shift in Romania*
Romanian side (monitored elements: 400 kV, 220 kV)	1642	100	1542	-	*maximum generation shift in Romania*
Romanian side (monitored elements: tie-lines)	1642	100	1542	-	*maximum generation shift in Romania*
Serbian side (monitored elements: 400 kV, 220 kV and 110 kV)	574	100	474	OHL 110 kV Đerdap - Negotin	OHL 110 kV Đerdap - Prahovo
Serbian side (monitored elements: 400 kV, 220 kV)	1099	100	999	OHL 220 kV B.Basta - Pozega	OHL 220 kV B.Basta - Pljevlja
Serbian side (monitored elements: tie-lines)	1099	100	999	OHL 220 kV B.Basta - Pozega	OHL 220 kV B.Basta - Pljevlja

6.19 Romania/Hungary border

The NTC values for the Romania/Hungary border have been calculated using the model for 2012 as follows:

Table 6.55 The NTC values for the Romania/Hungary border (2012, ROMANIA to HUNGARY direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Romania	Hungary	
400 kV, 220 kV, 110 kV & tie-lines	681	-	681
400 kV, 220 kV & tie-lines	681	-	681
tie-lines (400 kV, 220 kV)	2006	-	2006

Table 6.56 The NTC values for the Romania/ Hungary border (2012, HUNGARY to ROMANIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Romania	Hungary	
400 kV, 220 kV, 110 kV & tie-lines	1256	-	1256
400 kV, 220 kV & tie-lines	1256	-	1256
tie-lines (400 kV, 220 kV)	1924	-	1924

For the direction of power flow from Romania to Hungary, evaluating 400 kV, 220 kV and 110 kV network elements in Romania, the NTC value is set to 681 MW. It is limited by a possible overloading of the 400/110 kV transformers Tariverde if a transformer goes out of operation. The rating of these transformers is defined as 2x250 MVA at the model. If we ignore the Romanian internal transmission system and only evaluate tie-lines, the NTC value could be increased up to 2006 MW, limited by the OHL 400 kV P.D.Fier – Đerdap, which is jeopardized in case of an OHL 400 kV Tantareni – Urechesti outage.

For the direction of power flows from Hungary to Romania, evaluating all 400 kV, 220 kV and 110 kV network elements on the Romanian side, the NTC value is set to 1256 MW and limited by the 400/220 kV transformer in the Rosiori substation, jeopardized by an outage of the OHL 400 kV Gadalin – Rosiori. The rating of the critical transformer is 400 MVA at the model. Ignoring the internal Romanian transmission network and monitoring the tie-lines only, the NTC value could be set to 1924 MW, limited by maximum generation shift in Hungary. This means that no limitations concerning tie-lines may be found for this level of power exchange between Hungary and Romania.

Remark: Romanian TSO (Transelectrica) confirmed critical elements on their side of the border, but stated that transformers 400/110 kV in the Tariverde substation are not critical because of power exchanges, but due to wind power generation. These transformers have been used for wind power evacuation only.

Figure 6.19 Calculated NTC values for the Romania/ Hungary border depending on the monitored elements (model 2012)

Table 6.57 Critical network elements for a power exchange on the Romania/Hungary border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Romania to Hungary direction					
Romanian side (monitored elements: 400 kV, 220 kV and 110 kV)	781	100	681	TR 400/110 kV Tariverde 1, 2	TR 400/110 kV Tariverde 2, 1
Romanian side (monitored elements: 400 kV, 220 kV)	781	100	681	TR 400/110 kV Tariverde 1, 2	TR 400/110 kV Tariverde 2, 1
Romanian side (monitored elements: tie-lines)	2106	100	2006	OHL 400 kV Tantareni - Urechesti	OHL 400 kV P.D. Fier - Djerdap
Hungarian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Hungarian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Hungarian side (monitored elements: tie-lines)	-	-	-	-	-
Hungary to Romania direction					
Romanian side (monitored elements: 400 kV, 220 kV and 110 kV)	1356	100	1256	OHL 400 kV Gadalin - Rosiori	TR 400/220 kV Rosiori
Romanian side (monitored elements: 400 kV, 220 kV)	1356	100	1256	OHL 400 kV Gadalin - Rosiori	TR 400/220 kV Rosiori
Romanian side (monitored elements: tie-lines)	2024	100	1924	-	*maximum generation shift in Hungary*
Hungarian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Hungarian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Hungarian side (monitored elements: tie-lines)	-	-	-	-	-

6.20 Romania/Ukraine border

The NTC values for the Romania/Ukraine border have been calculated using the model for 2012 as follows:

Table 6.58 The NTC values for the Romania/Ukraine border (2012, ROMANIA to UKRAINE direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Romania**	**Ukraine**	
400 kV, 220 kV, 110 kV & tie-lines	442	-	442
400 kV, 220 kV & tie-lines	442	-	442
tie-lines (400 kV, 220 kV)	442	-	442

Table 6.59 The NTC values for the Romania/ Ukraine border (2012, UKRAINE to ROMANIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Romania**	**Ukraine**	
400 kV, 220 kV, 110 kV & tie-lines	1119	-	1119
400 kV, 220 kV & tie-lines	1119	-	1119
tie-lines (400 kV, 220 kV)	2280	-	2280

For the direction of power flow from Romania to Ukraine, evaluating 400 kV, 220 kV and 110 kV network elements in Romania, the NTC value is set to 442 MW due to maximum generation shift in Ukraine. Network limitations in the Romanian network cannot be found for this level of power exchange across the analyzed border.

For the direction of power flows from Ukraine to Romania, evaluating all 400 kV, 220 kV and 110 kV network elements on Romanian side, the NTC value is set to 1119 MW and limited by the 400/220 kV transformer in the Rosiori substation, jeopardized by an outage of the OHL 400 kV Gadalin – Rosiori. Ignoring the internal Romanian transmission network and monitoring the tie-lines only, the NTC value could be set to 2280 MW, limited by maximum generation shift in Romania at the model. This means that no limitations concerning tie-lines may be found for this level of power exchange between Ukraine and Romania.

Remark: Romanian TSO (Transelectrica) confirmed critical element (transformer 400/220 kV in the Rosiori substation) as limiting element for the NTC value over analyzed border.

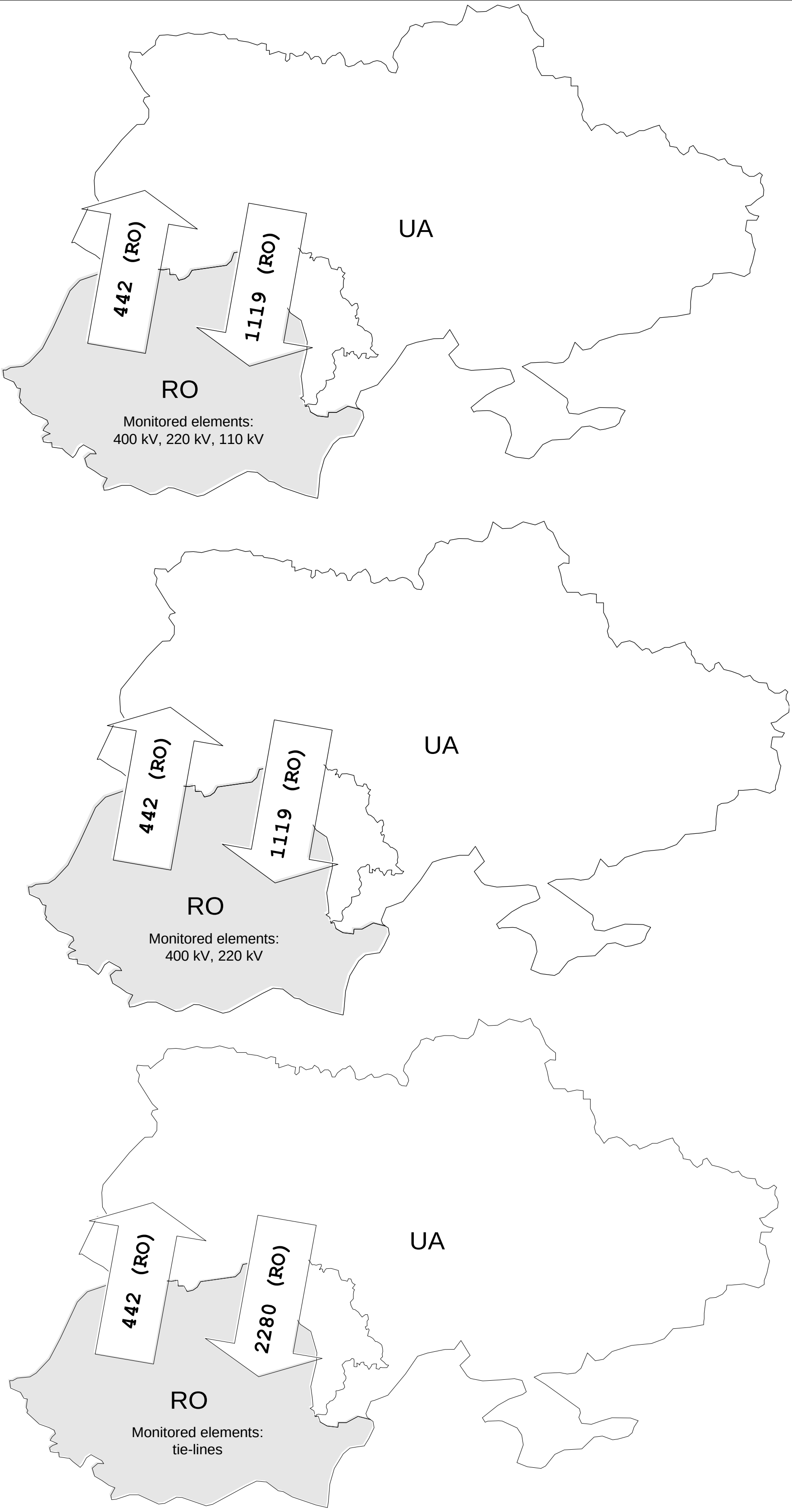


Figure 6.20 Calculated NTC values for the Romania/ Ukraine border depending on the monitored elements (model 2012)

Table 6.60 Critical network elements for a power exchange on the Romania/Ukraine border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Romania to Ukraine direction					
Romanian side (monitored elements: 400 kV, 220 kV and 110 kV)	542	100	442	-	*maximum generation shift in Ukraine*
Romanian side (monitored elements: 400 kV, 220 kV)	542	100	442	-	*maximum generation shift in Ukraine*
Romanian side (monitored elements: tie-lines)	542	100	442	-	*maximum generation shift in Ukraine*
Ukrainian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Ukrainian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Ukrainian side (monitored elements: tie-lines)	-	-	-	-	-
Ukraine to Romania direction					
Romanian side (monitored elements: 400 kV, 220 kV and 110 kV)	1219	100	1119	OHL 400 kV Gadalin - Rosiori	TR 400/220 kV Rosiori
Romanian side (monitored elements: 400 kV, 220 kV)	1219	100	1119	OHL 400 kV Gadalin - Rosiori	TR 400/220 kV Rosiori
Romanian side (monitored elements: tie-lines)	2380	100	2280	-	*maximum generation shift in Romania*
Ukrainian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Ukrainian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Ukrainian side (monitored elements: tie-lines)	-	-	-	-	-

6.21 Serbia/Hungary border

The NTC values for the Serbia/Hungary border have been calculated using the model for 2012 as follows:

Table 6.61 The NTC values for the Serbia/Hungary border (2012, SERBIA to HUNGARY direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Serbia	Hungary	
400 kV, 220 kV, 110 kV & tie-lines	489	-	489
400 kV, 220 kV & tie-lines	1051	-	1051
tie-lines (400 kV, 220 kV)	1401	-	1401

Table 6.62 The NTC values for the Serbia/ Hungary border (2012, HUNGARY to SERBIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	Serbia	Hungary	
400 kV, 220 kV, 110 kV & tie-lines	872	-	872
400 kV, 220 kV & tie-lines	872	-	872
tie-lines (400 kV, 220 kV)	872	-	872

For the direction of power flow from Serbia to Hungary, evaluating 400 kV, 220 kV and 110 kV network elements in Serbia, the NTC value is set to 489 MW. It is limited by possible overloading of the OHL 110 kV Đerdap – Prahovo after the OHL 110 kV Đerdap – Negotin went out of operation. Ignoring 110 kV network limitations and monitoring 400 kV and 220 kV network elements in Serbia, the calculated NTC value is increased to 1051 MW and becomes limited due to OHL 220 kV Bajina Bašta – Vardište overloading as a consequence of an OHL 220 kV Bajina Bašta – Požega outage. Monitoring tie-lines only, the NTC value may be further increased up to 1401 MW, when the limiting element becomes the OHL 220 kV Bajina Bašta – Pljevlja. Both lines are located in the south-western part of Serbia. The OHL 220 kV Bajina Bašta – Pljevlja is the interconnection line between Serbia and Montenegro, located far away from the Serbia/Hungary border. Generation shift key in Serbia is the real cause of this limitation, not power exchange from Serbia to Hungary. One may assume that the NTC value for the analyzed border may be additionally increased if generation shift key in Serbia is changed, for example, by increasing production of generators located at the north of the country, closer to the Hungarian border.

For the direction of power flows from Hungary to Serbia, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Serbian side, the NTC value is set to 872 MW. It is limited by maximum generation shift in Serbia. This means that no limitations concerning transmission system of Serbia may be found for this level of power exchange between Hungary and Serbia.

Remark: Serbian TSO (EMS) confirmed that the OHL 220 kV Bajina Bašta – Vardište and OHL 220 kV Bajina Bašta – Pljevlja are critical elements which limit the NTC values. It also described some dispatching actions which may be helpful to mitigate this problem. They are also described in the Chapter 7.

Figure 6.21 Calculated NTC values for the Serbia/ Hungary border depending on the monitored elements (model 2012)

Table 6.63 Critical network elements for a power exchange on the Serbia/Hungary border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Serbia to Hungary direction					
Serbian side (monitored elements: 400 kV, 220 kV and 110 kV)	589	100	489	OHL 110 kV Đerdap - Negotin	OHL 110 kV Đerdap - Prahovo
Serbian side (monitored elements: 400 kV, 220 kV)	1151	100	1051	OHL 220 kV B.Basta - Pozega	OHL 220 kV B.Basta - Vardiste
Serbian side (monitored elements: tie-lines)	1501	100	1401	OHL 220 kV B.Basta - Pozega	OHL 220 kV B.Basta - Pljevlja
Hungarian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Hungarian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Hungarian side (monitored elements: tie-lines)	-	-	-	-	-
Hungary to Serbia direction					
Serbian side (monitored elements: 400 kV, 220 kV and 110 kV)	972	100	872	-	*maximum generation shift in Serbia*
Serbian side (monitored elements: 400 kV, 220 kV)	972	100	872	-	*maximum generation shift in Serbia*
Serbian side (monitored elements: tie-lines)	972	100	872	-	*maximum generation shift in Serbia*
Hungarian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Hungarian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Hungarian side (monitored elements: tie-lines)	-	-	-	-	-

6.22 Slovenia/Italy border

The NTC values for the Slovenia/Italy border have been calculated using the model for 2012 as follows:

Table 6.64 The NTC values for the Slovenia/Italy border (2012, SLOVENIA to ITALY direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Slovenia**	**Italy**	
400 kV, 220 kV, 110 kV & tie-lines	674	-	674
400 kV, 220 kV & tie-lines	674	-	674
tie-lines (400 kV, 220 kV)	774	-	774

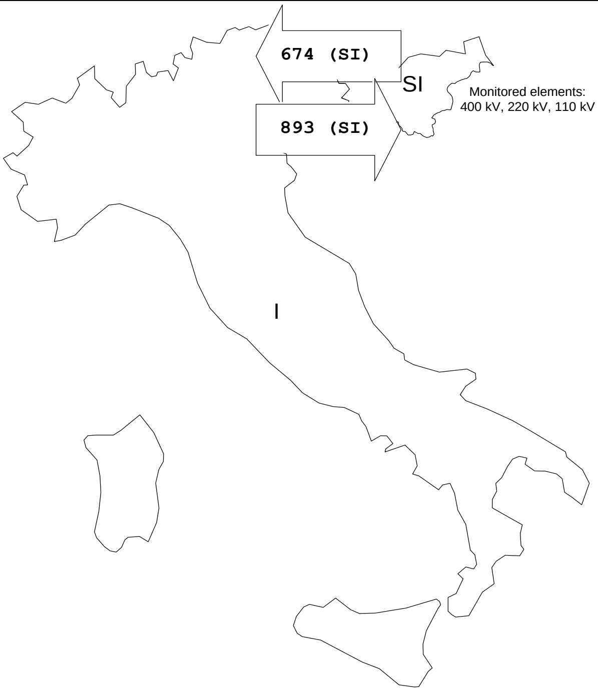
Table 6.65 The NTC values for the Slovenia/ Italy border (2012, ITALY to SLOVENIA direction)

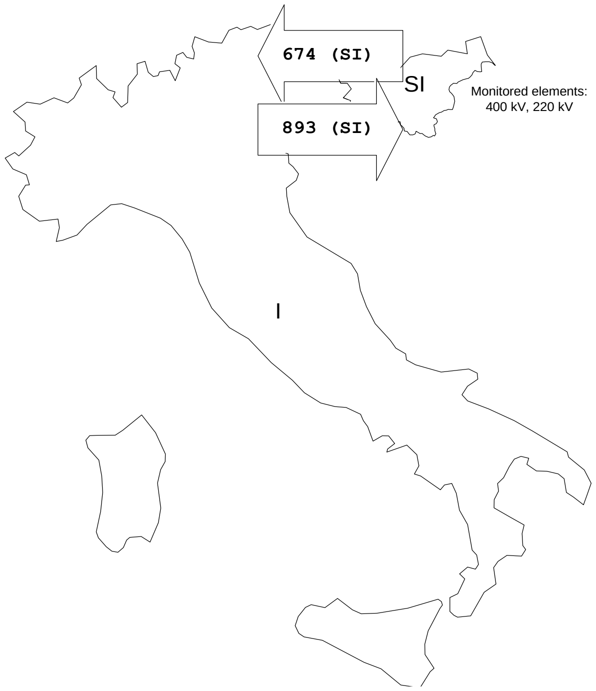
THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Slovenia**	**Italy**	
400 kV, 220 kV, 110 kV & tie-lines	893	-	893
400 kV, 220 kV & tie-lines	893	-	893
tie-lines (400 kV, 220 kV)	893	-	893

For the direction of power flow from Slovenia to Italy, evaluating 400 kV, 220 kV and 110 kV network elements in Slovenia, the NTC value is set to 674 MW. It is limited by a possible overloading of the 220/110 kV transformers in the Divača substation. There are two transformers there, each with a rating of 143,5 MVA at the model. Ignoring the internal network of Slovenia and these limiting transformers, the NTC value could be increased up to 774 MW, now limited by the OHL 220 kV Divača – Pehlin, jeopardized due to an outage of a 400 kV line between Divača and Redipuglia.

For the direction of power flows from Italy to Slovenia, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Slovenian side, the NTC value is set to 893 MW, limited by maximum generation shift in Slovenia. This means that no limitations concerning transmission system of Slovenia may be found for this level of power exchange between Italy and Slovenia.

Power exchanges between Slovenia and Italy may be controlled efficiently due to the existence of phase shift transformers in the Divača substation (400 kV line to Redipuglia) and the Padriciano substation (220 kV line to Divača).





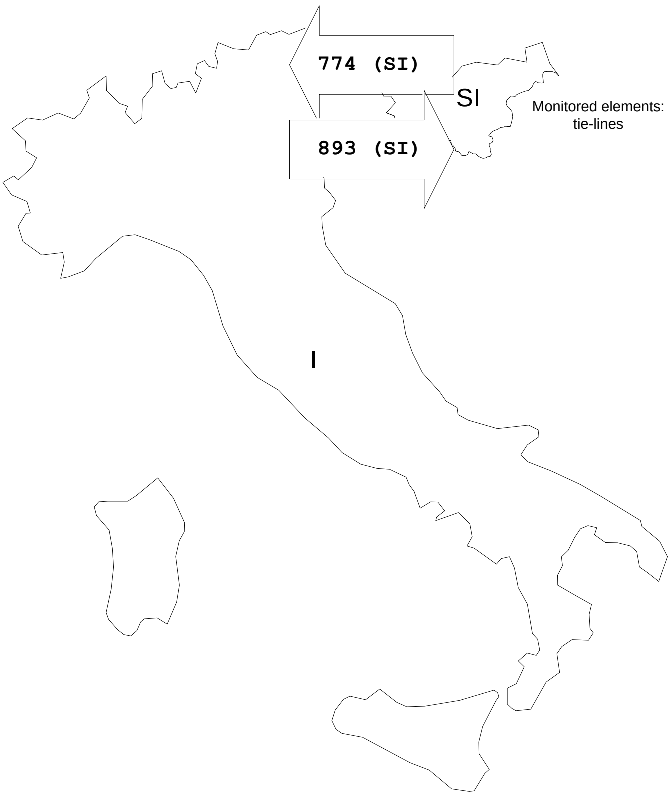


Figure 6.22 Calculated NTC values for the Slovenia/ Italy border depending on the monitored elements (model 2012)

Table 6.66 Critical network elements for a power exchange on the Slovenia/Italy border

RESULTS	**TTC (MW)**	**TRM (MW)**	**NTC (MW)**	**Critical contingency**	**Critical line**
Slovenia to Italy direction					
Slovenian side (monitored elements: 400 kV, 220 kV and 110 kV)	816	141	674	OHL 400 kV Divača - Redipuglia	TR 220/110 kV Divača
Slovenian side (monitored elements: 400 kV, 220 kV)	816	141	674	OHL 400 kV Divača - Redipuglia	TR 220/110 kV Divača
Slovenian side (monitored elements: tie-lines)	916	141	774	OHL 400 kV Divača - Redipuglia	OHL 220 kV Divača - Pehlin
Italian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Italian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Italian side (monitored elements: tie-lines)	-	-	-	-	-
Italy to Slovenia direction					
Slovenian side (monitored elements: 400 kV, 220 kV and 110 kV)	1034	141	893	-	*maximum generation shift in Slovenia*
Slovenian side (monitored elements: 400 kV, 220 kV)	1034	141	893	-	*maximum generation shift in Slovenia*
Slovenian side (monitored elements: tie-lines)	1034	141	893	-	*maximum generation shift in Slovenia*
Italian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Italian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Italian side (monitored elements: tie-lines)	-	-	-	-	-

6.23 Slovenia/Austria border

The NTC values for the Slovenia/Austria border have been calculated using the model for 2012 as follows:

Table 6.67 The NTC values for the Slovenia/Austria border (2012, SLOVENIA to AUSTRIA direction)

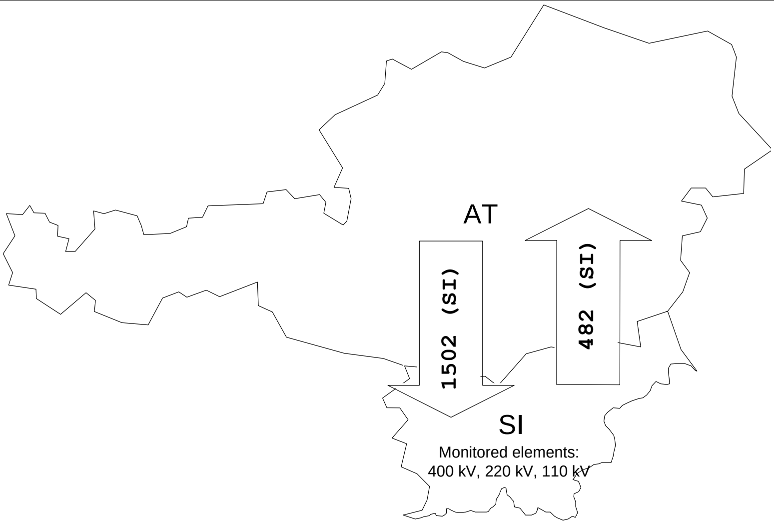
THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Slovenia**	**Austria**	
400 kV, 220 kV, 110 kV & tie-lines	482	-	482
400 kV, 220 kV & tie-lines	519	-	519
tie-lines (400 kV, 220 kV)	1162	-	1162

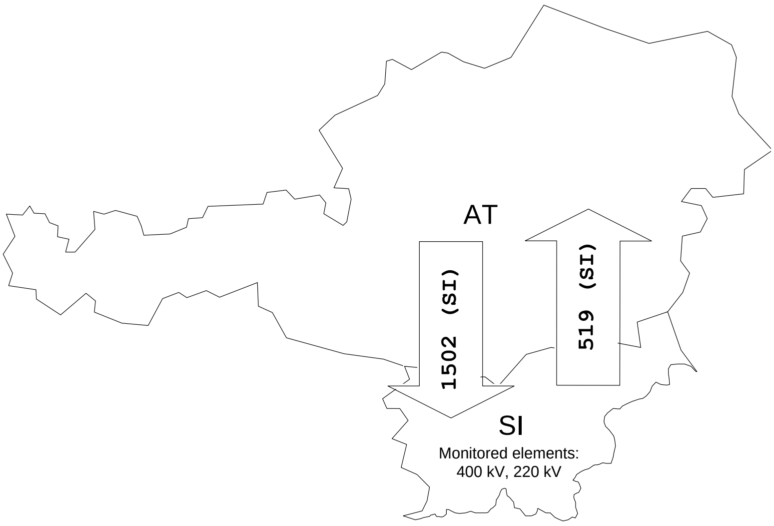
Table 6.68 The NTC values for the Slovenia/Austria border (2012, AUSTRIA to SLOVENIA direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Slovenia**	**Austria**	
400 kV, 220 kV, 110 kV & tie-lines	1502	-	1502
400 kV, 220 kV & tie-lines	1502	-	1502
tie-lines (400 kV, 220 kV)	1645	-	1645

For the direction of power flow from Slovenia to Austria, evaluating 400 kV, 220 kV and 110 kV network elements in Slovenia, the NTC value is set to 482 MW. It is limited by a possible overloading of the OHL 110 kV Plave – Gorica in the case of an OHL 110 kV Maribor – RTP Pekre 2 outage. Ignoring 110 kV network limitations, the NTC value could be increased up to 519 MW, limited by the 220/110 kV transformers in the Divača substation. Monitoring tie-lines only, maximum power exchange of 1162 MW could be reached without any network limitations but due to maximum generation shift in Austria at the model.

For the direction of power flows from Austria to Slovenia, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Slovenian side, the NTC value is set to 1502 MW. It is limited by the 220/110 kV transformer in the substation Podlog, jeopardized when the 400/220 kV transformer in the same substation goes out of operation. Maximum NTC of 1645 MW for this power flow direction could be achieved due to maximum generation shift in Austria, without any tie-lines limitation.





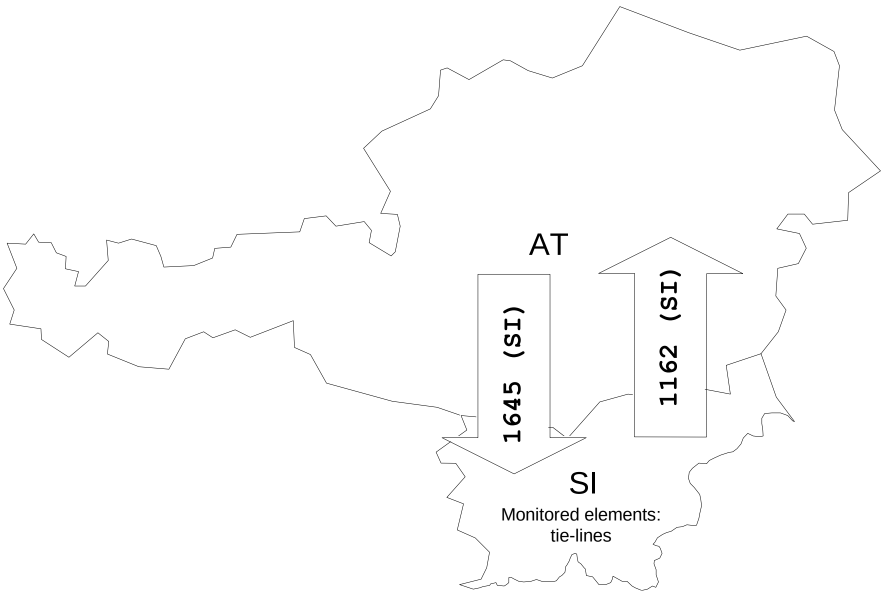


Figure 6.23 Calculated NTC values for the Slovenia/ Austria border depending on the monitored elements (model 2012)

Table 6.69 Critical network elements for a power exchange on the Slovenia/Austria border

RESULTS	TTC (MW)	TRM (MW)	NTC (MW)	Critical contingency	Critical line
Slovenia to Austria direction					
Slovenian side (monitored elements: 400 kV, 220 kV and 110 kV)	656	173	482	OHL 110 kV Maribor - Pekre 2	OHL 110 kV Plave - Gorica
Slovenian side (monitored elements: 400 kV, 220 kV)	693	173	519	OHL 400 kV Divača - Redipuglia	TR 220/110 kV Divača
Slovenian side (monitored elements: tie-lines)	1336	173	1162	-	*maximum generation shift in Austria*
Austrian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Austrian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Austrian side (monitored elements: tie-lines)	-	-	-	-	-
Austria to Slovenia direction					
Slovenian side (monitored elements: 400 kV, 220 kV and 110 kV)	1676	173	1502	TR 400/220 kV Podlog	TR 220/110 kV Podlog
Slovenian side (monitored elements: 400 kV, 220 kV)	1676	173	1502	TR 400/220 kV Podlog	TR 220/110 kV Podlog
Slovenian side (monitored elements: tie-lines)	1819	173	1645	-	*maximum generation shift in Austria*
Austrian side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Austrian side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Austrian side (monitored elements: tie-lines)	-	-	-	-	-

6.24 Turkey/Greece border

The NTC values for the Turkey/Greece border have been calculated using the model for 2012 as follows:

Table 6.70 The NTC values for the Turkey/Greece border (2012, TURKEY to GREECE direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Turkey**	**Greece**	
400 kV, 220 kV, 110 kV & tie-lines	410	-	410
400 kV, 220 kV & tie-lines	804	-	804
tie-lines (400 kV, 220 kV)	2260	-	2260

Table 6.71 The NTC values for the Turkey/ Greece border (2012, GREECE to TURKEY direction)

THE NTC VALUE (MW)	Observed country		The final NTC value (MW)
Monitored elements	**Turkey**	**Greece**	
400 kV, 220 kV, 110 kV & tie-lines	913	-	913
400 kV, 220 kV & tie-lines	913	-	913
tie-lines (400 kV, 220 kV)	913	-	913

For the direction of power flow from Turkey to Greece, evaluating 400 kV, 220 kV and 110 kV network elements in Turkey, the NTC value is set to 410 MW. It is limited by possible overloading of several 154 kV lines following the contingency (outage) of one 400 kV line. If we ignore the 154 kV network, the NTC value could be increased to 804 MW, limited by the 400/154 kV transformers in the Adapazari substation. Maximum NTC value may be reached by ignoring the internal network of Turkey, due to maximum generation shift in Greece, up to 2260 MW.

For the direction of power flows from Greece to Turkey, and evaluating all 400 kV, 220 kV and 110 kV network elements on the Turkish side, there are no limiting elements in the network, allowing the NTC value to be defined to 913 MW due to maximum generation shift in Greece.

Remark: Turkish TSO (TEIAS) confirmed that limiting network elements are the OHL 400 kV Maritsa East – Babaesku and the OHL 400 kV Babaesku – N.Santa. TEIAS stated that critical 154 kV lines are located in the far east Turkey and (n-1) problems are related to loads at Kızıltepe (Irrigation pumps), not related to exchange levels. For critical transformers in the Adapazari substation, there will be a new 400/154kV substation near to Adapazari so autotransformer contingency loadings at Adapazari will significantly drop. TEIAS also stressed that for Turkish transmission network, only tie lines between Turkey and Bulgaria & Greece must be taken as limiting element in the NTC/TTC calculations.

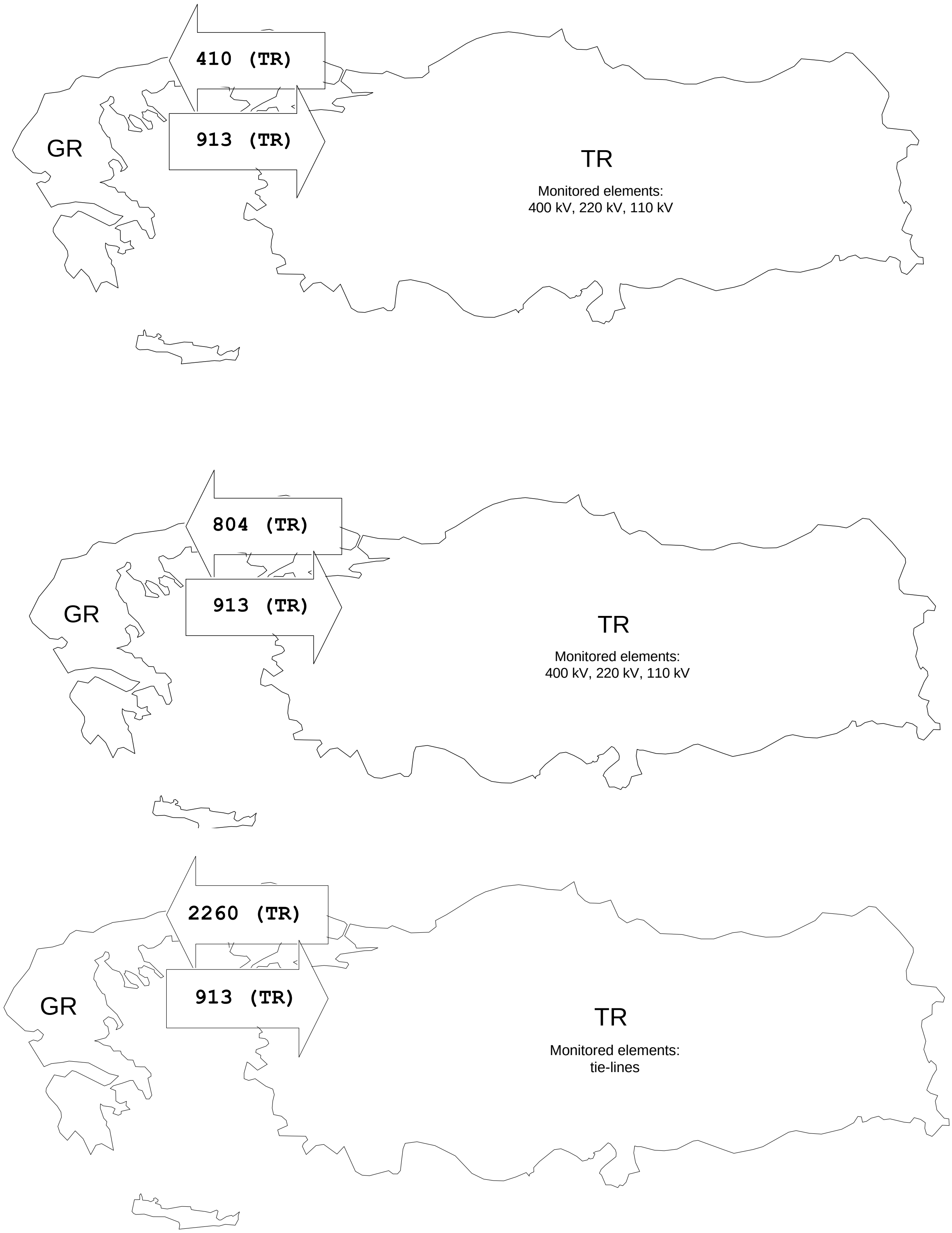


Figure 6.24 Calculated NTC values for the Turkey/ Greece border depending on the monitored elements (model 2012)

Table 6.72 Critical network elements for a power exchange on the Turkey/Italy border

RESULTS	**TTC (MW)**	**TRM (MW)**	**NTC (MW)**	**Critical contingency**	**Critical line**
Turkey to Greece direction					
Turkish side (monitored elements: 400 kV, 220 kV and 110 kV)	510	100	410	4ELGUN 400.0 kV - 4KIZILTEPE 400.0 kV	PS4-A 154.00 - VIRANSEHIR 154.00 PS4-A 154.00 - KARAKECILI 154.00 KIRLIK 154.00 - ODASDGKC 154.00 ETIFOSFAT 154.00 - MARDIN2 154.00
Turkish side (monitored elements: 400 kV, 220 kV)	904	100	804	TR 400/154 4ADAPAZARI 1,2	TR 400/154 4ADAPAZARI 2,1
Turkish side (monitored elements: tie-lines)	2360	100	2260	-	*maximum generation shift in Greece*
Greek side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Greek side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Greek side (monitored elements: tie-lines)	-	-	-	-	-
Greece to Turkey direction					
Turkish side (monitored elements: 400 kV, 220 kV and 110 kV)	1013	100	913	-	*maximum generation shift in Greece*
Turkish side (monitored elements: 400 kV, 220 kV)	1013	100	913	-	*maximum generation shift in Greece*
Turkish side (monitored elements: tie-lines)	1013	100	913	-	*maximum generation shift in Greece*
Greek side (monitored elements: 400 kV, 220 kV and 110 kV)	-	-	-	-	-
Greek side (monitored elements: 400 kV, 220 kV)	-	-	-	-	-
Greek side (monitored elements: tie-lines)	-	-	-	-	-

7. IDENTIFICATION OF NETWORK UPGRADES AND DISPATCHING OR PLANNING ACTIONS NEEDED TO INCREASE NTC VALUES

7.1 General recommendations

7.1.1. NTC computation methodology

As described in Chapter 2, TSOs use the NTC computation methodology defined by the ENTSO-E, keeping in mind the UCTE Operational Handbook, Policies 3 and 4.

The ENTSO-E methodology is related to the base case network modeling in the studied time frame. It involves increasing the generation in one area while simultaneously decreasing the generation in another area, and performing load flow calculations with respect to predefined contingency lists and network security checks. These calculations provide the Total Transfer Capacity (TTC) of individual borders, which is decreased by the Transmission Reliability Margin (TRM) in order to define the Net Transfer Capacity (NTC) value.

The results of the NTC calculation are dependent on the methodology used. The ENTSO-E methodology is suitable for larger power systems that are not very well meshed and not very well meshed with third party neighboring transmission systems. The SEE regional transmission system is very well meshed, with many smaller transmission networks under control of many TSOs, resulting in a large number of borders for which NTC values are calculated. In reality, power exchanges between two countries involve several other countries, which should be better taken into consideration by the basic ENSTO-E methodology. Recommendations concerning this matter are:

1. Composite NTC calculations are better than simple calculations (including two transmission systems only).
2. Flow-based methods are more suitable for the SEE region than the Programmed exchange method.
3. Coordinated flow-based approach seems the most suitable methodology for capacity assessment in the SEE region.

Transelectrica comment:
With regard to recommendations 2 and 3, ENTSO-E should consider the possibility of using different approaches for different time-frames: the FB approach is very good for daily and intra-day allocation, where the nominations of exchanges based on previous auctions are known and the current allocations can be trusted to be used, but at monthly and yearly levels the uncertainty regarding the exercising of acquired transmission rights is higher so NTC calculation based on several possible exchange scenarios can be safer.

In the SEE region, there are several very small transmission systems, such as the Albanian, Macedonian, Kosovo and Montenegrin systems (followed by others including Bosnian, Croatian, Slovenian etc.). The ENTSO-E methodology may give inaccurate results concerning cross-border transmission capacities when evaluating these transmission systems individually. For example, maximum possible generation shift in one country may be small and not enough to detect any network security problems. ENTSO-E methodology states that TTC value is equal to maximum generation shift because no realistic limitation to the cross-border transmission capacity for the base case studied is found. Such TTC values will not provide real possibilities for power exchanges over considered borders because, in reality, larger usage of that border is possible. Based on the evaluation of several national transmission systems, as one area increases maximum possible generation shift ("upwards" and downwards"), it provides a more realistic NTC values due to network limitations and not due to maximum possible generation shift. Many of the small system interconnections are more loaded due to transits, rather than because of imported power. In order to simulate such a case, it is best to consider calculating large exporting systems as Source area and large importing systems as Sink area. Calculated physical flows on interconnections of interest should determine TTC value, by simulating maximal power transfer.

Evaluating the NTC calculations using the network model for 2012 and monitoring 400 kV and 220 kV internal network and tie-lines, the NTC values are defined by maximum generation shift for the following borders and power directions. This means that there are no network limitations for power exchanges over these borders and power directions. However, the NTC values may still be limited due to maximum possible generation shift in one country:

AL → GR (AL side)
AL → RS (AL side)
BA → HR (BA side)
HR → BA (HR side)
HR → HU (HR side)
ME → BA (ME side)
ME → RS (ME side)
MK → RS (MK side)
MK ← RS (MK side)
MK → BG (MK side)
MK → GR (MK side)
MK ← GR (MK side)
RO → RS (RO side)
RO ← RS (RO side)
RO → UA (RO side)
RO ← BG (RO side)
RS ← HR (RS side)
RS ← ME (RS side)
RS ← MK (RS side)
RS ← HU (RS side)
RS ← RO (RS side)
RS ← BG (RS side)
SI ← IT (SI side)
TR ← GR (TR side)

Because SEE national transmission systems are generally well-meshed, programmed exchanges may be quite different than physical exchanges between two countries. The ENTSO-E methodology explains that the TTC value is the sum of the Base Case Exchange (BCE, based on programmed exchange) and the maximum generation shift (ΔE_{max}). Because BCE is quite different than the physical exchange for the studied base case, there may be large inaccuracy in the TTC value, providing smaller NTC values. For example, if the BCE value between two areas (countries) is defined as 500 MW, only a portion of this base case exchange will load interconnection lines between these two areas, while significant load flow will go over a third transmission system. The TTC value will be determined as the sum of the largest generation shift for which security criterion is still fulfilled and the base case exchange that may be significantly larger than physical load flow between two areas by increasing generation in one area and decreasing generation in another area, until security criterion is not fulfilled somewhere. If the BCE is defined in the opposite direction than the studied power exchange over a border, the resulting TTC value will be smaller than it should be. There will be additional inaccuracies in this methodology if there are many different market transactions, which will flow over different borders. This will cause large difference between the programmed exchange and the physical exchange over a studied border. In reality, load flows over the SEE borders may be quite different than programmed values, not only in volumes but in direction as well. Because of this, a coordinated flow-based approach is the most appropriate method for calculating NTC values in the well-meshed SEE transmission system, consisting of many smaller national transmission networks with large number of borders for which the NTC values have to be defined. The coordination office should use a common network model for the studied time-period, model all expected market transactions in the SEE transmission system, check the network security by applying the pre-defined contingency list, and determine the congested transmission systems and the congested borders together with the NTC values for each border.

Some TSOs use a similar methodology based on composite load-flow approach, but further expansion and methodological improvements would be encouraged.

The ENTSO-E methodology and resulting TTC values are very dependent on the studied base case. The methodology recognizes this and suggests that the base case should be defined according to real operational situations or the TSO's forecasts. Evaluating the SEE region and its transmission systems, recommendations concerning this matter are:

1. More realistic base cases should be used*.
2. Time-frame for computation should be short (day-ahead, week-ahead, month-ahead)**.
3. Annual TTC (NTC) values should be defined according to computed day-ahead values (for example: minimum day-ahead NTC value from previous time period).

*MEPSO comment:
If a country's balance the in base case is extreme (high import/export), this base case is adequate for NTC calculation in one "dominant" direction only. The opposite direction could be problematic for the calculation because in order to revert electricity flows in the interconnection, a big generation shift must be made. The recommendation is to use base cases with more balanced systems.

**NOS BiH comment:
NTC calculations have to be done before the daily auction, which is performed day ahead. This means that the NTC calculation cannot be performed in the same day. Because of the fact that NTC/ATC value is used as a part of offered capacity on auction, NTC calculation has to be performed on Day-minus-two. Thus, the term *day ahead* should be changed to D-2 or define *day ahead* as the day before day of daily auction process.

TSOs usually use snapshots of real operational conditions in their networks, which are appropriate for the NTC calculation. Unrealistic situations, like important transmission line maintenance during high load winter or summer situations should be avoided, since it is not probable that TSOs will plan and perform regular maintenance during a high load period.

TSO may decrease the influences of different uncertainties by using shorter time frames for the NTC calculations. More realistic operational conditions will be analyzed if the time period for calculations is closer, because it will yield a higher level of accuracy. TSOs are primarily concerned with network security. This may be a reason why low NTC values are declared as indicative values for the year-ahead time frame. Month-ahead and day-ahead NTC values are always larger than annual NTC values.

Transelectrica comment:
The indicative yearly NTC values and the firm NTC values offered for yearly allocation are defined so as to remain firm for any regional network topology; this is the reason why these values are much smaller than most values in the firm monthly NTC profiles, and it covers both security and financial aspects.

The published indicative annual NTC values demonstrate that TSOs are mainly concerned with network operational security. Generally, low NTC values do not appear as a consequence of real network limitations, rather, they appear as a consequence of a TSO's concerns about network security. A TSO may model unrealistic load growth or an unrealistic combination of load level and expected network topology, thus decreasing the annual NTC value. Our recommendation is that TSOs should calculate the NTC values on a daily basis and organize yearly cross-border capacity auctions based on the minimum day-ahead or intraday NTC values from the previous time period (for example, annual NTC value in 2015 for some border based on minimum day-ahead NTC values related to that border calculated during 2014, while taking into analysis possible influential future circumstances).

Another important issue related to the ENTSO-E methodology is that results of the NTC calculations are dependent on the generation-shift method. Therefore, the following recommendations may be given:

1. Merit order list is preferable (more realistic, unrealistic overloading is avoided)*.
2. Generation pattern should be defined realistically**.
3. Technical data of generators should be accurate (especially P_{max} and P_{min}).

NOS BiH comment:
This is true but not realistic. Introducing this way of NTC calculation, process itself will be long-lasting for TSOs. Beside models that have to be exchanged, TSOs have to exchange merit order list and do calculation step by step. Just because of this reason, a new methodology was developed on the ENTSO-E level to simplify calculation.

Transelectrica comment:
With regard to NTC values imposed by maximum generation shift, the generation shift may be under declared; engaging of generators disconnected in the initial model should be possible. For NTC calculation it can be more feasible to use a model with bulk generation at HV instead of individual representation of each generator at LV, since this makes it possible for the generation shift to cover also increase/decrease of generators number in large PPs.

Network limiting elements and calculated NTC values may be significantly influenced by the generation shift method that is used during calculation. TSOs generally use the generation shift proportional to the power reserve, thus introducing important parameters for a calculation: maximum power generation P_{max} and minimum power generation P_{min}. The maximum possible generation shift, “upwards” or “downwards” strongly depends on the modeled generators engaged during the base case and the parameters of the generators. A negative influence of this approach may be visible by introducing a small maximum generation shift, resulting in small NTC values that do not result from a critical network element. In the 2012 model, there are many hydro power plants in the region with the high minimum possible power (P_{min}) parameters. Due to these parameters, maximum generation shift in “downward” direction is significantly decreased in many SEE transmission systems, resulting in lower NTC values for some borders. Hydro power plants usually have low minimum permitted capacity (power), but their efficiency drops significantly outside certain power ranges. TSOs should not be concerned about hydro power plants’ efficiency during the NTC calculations. The minimum capacity for such production facilities should be modeled using lower values, because the TSOs’ interest is on power exchanges throughout the network, not on the efficient usage of production facilities. Small differences between the power engagement of generators in the model with other generators out of operation and disconnected from the network, may provide a low maximum possible generation shift in the “upwards” direction, again decreasing the NTC values without any real network limitations.

The usage of a generators’ merit order list may give a more realistic value for calculating NTC and bring additional realistic approaches to this process. If there are some generators within a national system that are rarely engaged due to extremely high production costs, their inclusion in the generator shift key may cause unrealistic and unexpected situations in the network. The engagement of generators by merit order, while taking into account possible hydrological conditions and expected hydro power plants engagement, provides a more probable market perspective, resulting in more realistic network limitations and related NTC values.

7.1.2. Transmission reliability margin

According to the ENTSO-E methodology for the NTC calculation, TTC value should be decreased by the TRM value to get the NTC value. NTC values would be higher if TRM values were lower. ENTSO-E methodology prescribes the general terms in defining the TRM but delegates to the TSOs the appropriate values for their respective transmission systems.

Concerning the TRM values, the following recommendations are given here:

1. TRM should be determined according to past experience and realistic operational situations.
2. Unintentional deviations should be minimized (balancing energy, ancillary services).
3. TSOs should consider probabilities of simultaneous events which influence cross-border flows deviations.
4. One value of TRM should be defined and then allocated to different borders.

Transelectrica comment: Transelectrica considers 100 MW TRM per bilateral border, agreed bilaterally with partners, and a 300-400MW TRM in the interconnection interface (simultaneous bilateral TRM on 3-4 borders)

Compared with real operational conditions in a transmission system, determining the TRM values according to mathematical expressions like 100 x N (number of interconnection over analyzed border) or 100 x square root of N seems inaccurate. Each power system and related transmission system has specific operational conditions, such as the largest generators for which tertiary control is defined; power balance; ancillary services availability and engagement; load predictions; renewable sources integration; etc. These may differ greatly from one to another transmission system. TSOs possess knowledge on unintentional deviations that may occur on their borders. They may define the TRM values according to their past experience, so as to minimize it while maintaining operational security. The probability of different events occurring on a line simultaneous to a large internal deviations and the loss of the largest generator should be evaluated. In the case of very low probability (very close to zero), the TRM margin should be defined in order to maximize the NTC values.

In order to minimize internal deviations, it would be helpful to introduce well-defined, efficient, market-based and cost effective approaches for the provision of ancillary services. TSOs often experience large internal and cross-border deviations due to the lack of appropriate ancillary service procurement mechanisms and provisions for balancing energy. The establishment of regional ancillary services and balancing energy market may be helpful in order to decrease unintentional deviation within internal power systems.

In order to minimize the TRM values, while still taking into account uncertainties in real operation, TSOs should define one TRM value and then allocate it to different borders according to their experience and historic data. If historic data for one transmission system shows that maximum deviations of 300 MW may be expected for a whole transmission system, it is not necessary to decrease cross-border capacity for each border under TSO control by 300 MW. An approach based on the PTDF factors may be used in this purpose.

7.1.3. Security criteria

According to national grid codes, TSOs generally employ the (N-1) criterion while calculating NTC. Some of them behave according to the UCTE OH, Policy 3, that defines different types of contingences that should be analyzed. However, without oversight, those contingences may become an unrealistic cause of the NTC values decreasing. Policy 3 states:

- A contingency is defined as the trip of one single or several network elements that cannot be predicted in advance. A scheduled outage is not a contingency. An “old” lasting contingency is considered as a scheduled outage.

- The normal type of contingency is defined as the loss of a single element. Single elements are as follows:
    - a single line,
    - a single generating unit,
    - a single transformer or two transformers connected to the same bay
    - respectively, a Phase Shifter Transformer,
    - a large voltage compensation installation,
    - a DC link considered as a generating unit or a large consumer.

- The exceptional type of contingency is defined as the uncommon loss of the following particular elements based on the design of the network structure and the probability of the event. The probability of the event can be linked to special operational conditions like storm or maintenance:
    - a double line, which refers to two lines on the same tower over a long distance,
    - a single busbar, during periods the TSO assesses a significant higher risk of outage,
    - the common mode failure with the loss of more than one generating unit, including large wind production, common mode failure of DC links.

UCTE Operational Handbook – Policy 3, prescribes that exceptional types of contingencies must be defined according to the likelihood of occurrence and respective risk assessment.

Furthermore, the UCTE OH defines that the N-1 situation is applied on the N situation, which may comprise of some network elements that are out of operation in advance, due to maintenance activities or long lasting outages. It is the TSOs' responsibility to determine realistic scenarios concerning the network topology for the studied time frame. Occasionally, TSOs may consider unrealistic situations occur. For example, a TSO may consider a simultaneous N-1-1 outage of two or more branches, one due to a forced and unpredictable cause and the second due to planned activities such as maintenance during high-level loads in a studied system (usually during winter months).

When a TSO considers and includes exceptional contingencies as their contingency lists, such as double-system line or bus-bar outages, it is unclear whether they take into account the probability of such events. A recent study on the SEE transmission system reliability shows that SEE countries have very reliable 400 kV networks, where forced outages are very rare and of a short duration. A deterministic N-1 approach in system security analysis ignores the characteristics of the SEE network.

NTC values are strongly dependent on the security criteria which are used (N-1). Recommendations related to this topic are:

1. TSOs should consider taking into account probabilities of line outages during the NTC computations.
2. TSOs should consider taking into account probabilities of different simultaneous events (for example simultaneous forced line outage and planned line outage due to maintenance activities (N-1-1).
3. TSOs should consider taking into account effects of individual contingences (for example, minor overloading may be neglected).
4. TSOs should take into account possible dispatching actions (remedial actions).

Transelectrica comment:
Maintenance on a circuit and tripping of the second circuit is not an unrealistic scenario. If probabilities of forced outages are taken into consideration, the magnitude of the outage effects should also be considered; if for instance the outage could affect a NPP or a large system area or generate cascade tripping it should be considered even if probability is low.

7.1.4. List of contingences and monitored network elements

The TSOs' concerns about security of supply are taken into account during the NTC calculations through the contingency list and monitored elements they define. Calculations conducted within this study show that the NTC values are lower if the 110 kV networks in the region are evaluated and if outages of all network elements are considered. Concerning this issue and having in mind that the NTC values are strongly dependent on the contingences that are evaluated and the monitored elements, the following recommendations are given:

1. Clear understanding of mutual influence between cross-border exchanges, individual contingences and consequences is important.
2. TSOs should not observe contingences and their consequences which are not directly and significantly influenced by cross-border transactions.
3. TSOs should primarily evaluate the 400 kV and 220 kV network.
4. The 110 (154) kV network should be observed exceptionally (if some element is directly and significantly influenced by cross-border transactions and consequences of overloading are serious).
5. Transmission lines thermal ratings (transmission capacity) should be defined more accurately (at least seasonal values).
6. TSOs should consider the possibility of allowing temporary higher loading of a line than its thermal limit if dispatching actions are possible to relieve a line.
7. For operational NTC calculation, overcurrent protection setting of transmission elements should be used. On the contrary, for planning purposes, thermal ratings of high voltage equipment should be considered.

Transelectrica comment: If a TSO declares only one limit it does not mean that temporary overloads and temperature dependence are not taken into consideration. Transelectrica takes into consideration possibilities of temporary overload on transformers and current transformers (up to line thermal limit) and dependence of line thermal limit on temperature, by accepting loading over 100% of the limit declared in the model. Exchange of information regarding overload acceptance and post-event measures is important for TSOs who check also contingencies/violations in the interconnected network.

During the NTC calculation process, TSOs should be aware of the consequence of each contingency that is evaluated and each influence of power exchanges over a border on critical network elements. In other words, some network limiting elements found in this study are highly loaded, even at the base case model, but their loading is not very dependent on cross-border power exchanges. TSOs should define such contingences and limiting network elements that are directly influenced by cross-border transactions, not highly loaded due to other operational circumstances (like network topology, local load, unrealistic lack of local generation, high reactive power flows through limiting element etc.).

Cross-border load flows and market transactions mostly go through the highest voltage level network elements, which are 400 kV and 220 kV in the SEE region. For this reason, network elements should be considered a priority for monitoring during the NTC calculations. Differences in the NTC values calculated within this study in two scenarios, by monitoring 400 kV-110 kV network elements in one scenario, and by monitoring network 400-220 kV elements in the other scenario, show that much larger NTC values may be expected if the 110 kV network is ignored. Monitoring the 110 kV network should be exceptional and conducted only if some 110 kV network elements are significantly influenced by cross-border transactions.

The 2012 PSS/E network model shows that the majority of TSOs do not consider different ratings of transmission lines and transformers. Generally, there is only one rating defined, meaning that TSOs do not take into account possible temporary overloading, which should not jeopardize transmission equipment (for example 10 % over 30 minutes of time) or different seasonal values of permitted network equipment loading in normal operation. The only exemption at the 2012 network model that was used in this study was for Macedonia, with two possible ratings of transmission lines (RATE A and RATE B in the PSS/E model). However, according to information received from MEPSO, they do not consider possibilities for temporary overloading or different seasonal values of transmission lines ratings. The Bosnian and Turkish transmission system models also have different ratings defined, but with the second value lower than the first one (RATE A > RATE B).

An example of possible seasonal transmission lines rating influence or higher temporary rating on the calculated NTC value is given here. The NTC value on the 2012 network model for the Bosnia/Montenegro border and the Bosnia to Montenegro direction of power exchange when monitoring 400 kV and 220 kV network elements on Bosnian side (ignoring the network 110 kV), is 751 MW (TTC = 925 MW, TRM = 173

MW). A critical contingency in the network is an outage of the OHL 400 kV Trebinje – Podgorica. A critical network element is the OHL 220 kV Trebinje – Peručica, with a rating of 316 MVA on Bosnian side and 274,4 MVA defined on the Montenegrin side. If we increase line ratings from both sides by 10 % (assuming that temporary overloads are possible or assuming that winter value for line rating should be higher than summer rating because outside temperatures are significantly lower), the NTC value will be increased by 143 MW (NTC = 894 MW, TTC = 1068 MW). Hence, without jeopardizing network security, the potential for cross-border power exchanges over the Bosnia/Montenegro border are increased.

7.2 Network critical elements and possible remedial actions

7.2.1 General overview of network critical elements and possible dispatching actions

Network elements that are found to be critical related to the NTC values, and confirmed by TSOs, are given here, together with TSOs' remarks about possible mitigation of elements overloading.

ALBANIA

Critical network elements in Albanian transmission system with respect to cross-border exchanges are:

OHL 110 kV Tirana – Selite
OHL 220 kV Elbasan – Fieri
OHL 220 kV V.Dejes – Koman

OST expect to resolve problems with the OHL 220 kV Elbasan – Fieri after the realization of the new project: "New double circuit line Elbasan – Fieri". For the moment the problem is resolved with dispatching actions.

OST expect to resolve problems with the OHL 110 kV Tirana – Selite by construction of the second line Tirana – Selite. For the moment the problem is resolved with dispatching actions.

BOSNIA AND HERZEGOVINA

Critical network elements in Bosnian transmission system with respect to cross-border exchanges are:

OHL 110 kV Trebinje - Herceg Novi
OHL 220 kV Trebinje - Peručica
TR 400/110 kV Ugljevik
OHL 220 kV Višegrad – Vardište
OHL 220 kV Mostar – Zakučac

Overloading of the OHL 110 kV Trebinje – Herceg Novi may be solved if this line does not operate in parallel with other transmission lines. Large portion of time this line is used to feed the area of Herceg Novi in Montenegro in radial connection with Bosnian power system, avoiding any probability that this line may be overloaded.

Loading of the OHL 220 kV Trebinje – Peručica may be decreased by re-dispatching from both sides of a border, by decreasing production of the HPP Trebinje in Bosnia and Herzegovina and/or increasing production of HPP Peručica in Montenegro, if possible due to actual hydrological situation and generators engagement in both power systems.

Transformer 400/110 kV in the Ugljevik is loaded very often close to limit, but it depends on network condition in region where transformer is placed. In order to avoid overloading of transformer 400/110 kV, it is necesary to take into account criterion N-1during preparation maintenace plan for BiH network, esspecialy for network in region where transformes are placed.

OHL 220 kV Višegrad – Vardište may be relieved with decrease of the HPP Višegrad production (re-dispatching) and/or if the OHL 110 kV Višegrad – HE Potpeć is put in operation.

OHL 220 kV Mostar – Zakučac may be relieved if HPP Zakučac in Croatia increase its production and western Bosnia hydropower plants (Rama, Salakovac etc.) decrease their production. Transmission capacity of this line may be increased from Croatian side (defined to 280 MVA) by replacement of appropriate current-metering transformers (at least up to 300 MVA, as it is defined for Bosnian side of the same line).

BULGARIA

Critical network elements in Bulgarian transmission system with respect to cross-border exchanges are:

110 kV network in Dobrudzha area
OHL 220 kV Plovdiv – Aleko
TR 400/110 kV transformers in the SS Plovdiv
OHL 400 kV Maritsa East – Babaeski

In the area of Dobrudzha 110 kV network not complies with the criterion N-1 if WPPs in this region have large generation. ESO as the system operator has the right to order to reduce the generation if he considers that there is a threat to security. I.e. this problem is not taken into account when ESO calculates real NTC values.

During the Bulgarian power system's daily work, when calculations show the possibility of the OHL 220 kV Plovdiv - Aleko overload, ESO recommends dispatchers if it becomes a critical contingency to reduce the generation in Maritsa East region and to increase generation in South-West part of country.

CROATIA

Critical network elements in Croatian transmission system with respect to cross-border exchanges are:

OHL 110 kV Crikvenica – Krk
OHL 110 kV Nedeljanec – Formin
OHL 110 kV Žerjavinec – Jertovec
OHL 220 kV Pehlin – Divača
OHL 220 kV Zakučac – Mostar
TR 400/110 kV Žerjavinec
TR 400/110 kV Ernestinovo

The 110 kV Critical line Crikvenica – Krk may be relieved by the HPP Senj lower engagement or network sectioning in the HPP Senj (disconnection of circuit breaker in the 110 kV switchyard junction bay and connection of 110 kV generators to different bus-bars). In the short-time frame HOPS will increase transmission capacity of this line (from 70 MVA to 123 MVA) by submarine cable section replacement.

OHL 110 kV Nedeljanec – Formin may be relieved by decreasing production of the HPP Formin in Slovenia, whit simultaneous increase of production of HPP Varaždin, Čakovec and Dubrava, or TPP Jertovec, in Croatia or vice versa depending on direction of load flow through this line.

Transmission capacity of the OHL 110 kV Žerjavinec – Jertovec may be increased at the model, from 110 MVA that is defined there to 123 MVA at least. In the mid-time frame, HOPS plan to construct new double-circuit line there and new SS 400/110 kV Drava additionally that will relieve this critical line.

Loadings of the OHL 220 kV Pehlin – Divača may be controlled by phase-shift transformers in Padriciano (Italy) and Divača (Slovenia) but out of control of HOPS.

Possible dispatching measures in order to decrease loading of the Mostar – Zakučac line are previously described under Bosnia and Herzegovina section.

The 400/110 kV transformers in the Žerjavinec may be relieved by increase of production of local generators in Zagreb connected to the network 110 kV, or by controlling power flows using the 400/220 kV transformer in the same substation (certain range of active load flow control is possible).

The 400/110 kV transformers in the Ernestinovo may be partially relieved by increase of production of local generators in Osijek, connected to the 110 kV network.

MACEDONIA

Critical network elements in Macedonian transmission system with respect to cross-border exchanges are:

OHL 110 kV Skopje 3 – Skopje 4
OHL 110 kV TETO – Skopje 4
TR 400/110 kV Štip

MEPSO doesn't consider the 110 kV network as a limiting elements for the NTC values, but evaluates limitations in the 400 kV network only.

OHL 110 kV Skopje 3 – Skopje 4 may be overloaded during TPP Oslomej low production or out of operation situation. This line may be relieved by disconnection of the OHL 110 kV Skopje 3 – Saraj.

OHL 110 kV TETO – Skopje 4 may be relieved by bus-bars 110 kV connection in the SS Skopje 1 or by connection of the OHL 110 kV Centralna – Jug Nova.

Overloading of the TR 400/110 kV Štip may be solved by local network 110 kV uncoupling. This problem occurs when high transits flow to Macedonia from Bulgaria and 110 kV generators in Macedonia are engaged poorly. In reality, transits go to Greece over Macedonian network and transformer 400/110 kV in the Štip substation will not be overloaded.

MONTENEGRO

Critical network elements in Montenegrin transmission system with respect to cross-border exchanges are:

220 kV Podgorica – Vau Dejes
110 kV Herceg Novi – Trebinje
220 kV Perućica – Trebinje
220 kV Pljevlja – Bajina Bašta

Possible dispatching actions in order to relieve the OHL 110 kV Herceg Novi – Trebinje and Perućica – Trebinje are previously described (under the Bosnia and Herzegovina section).

Dispatching actions related to the OHL 220 kV Pljevlja – Bajina Bašta will be described under the Serbian section.

ROMANIA

Critical network elements in Romanian transmission system with respect to cross-border exchanges are:

OHL 400 kV P.D. Fier – Đerdap
TR 400/220 kV Rosiori
OHL 2x400 kV Tantareni – Kozloduy (outage of one circuit)

Loading of the OHL 400 kV P.D.Fier – Đerdap depends on the HPP Đerdap engagement on Serbian side (Maximum engagement is 1045 MW in six generation units) so load flows over this line may be influenced by this. Loading on 400kV OHL Portile de Fier-Djerdap depends also on the loading in HPP Portile de Fier. Internal Romanian studies revealed other critical elements such as 220 kV OHL Portile de Fier - Resita (double circuit).

Overloading of transformer 400/220 kV in the Rosiori substation occurs when power exchange is directed to Romania (from Ukraine or Hungary), probably due to lower production in Romania around this substation related to lower voltage networks.

SERBIA

Critical network elements in Serbian transmission system with respect to cross-border exchanges are:

OHL 220 kV Bajina Bašta – Pljevlja
OHL 220 kV Bajina Bašta – Vardište

Dispatching actions which may relieve these two transmission lines are related to a decrease in production of the HPP Bajina Bašta and PSHPP Bajina Bašta. Due to lower production of these power plants, engagement of some other power plants in Serbia has to be increased, which may cause additional re-dispatching costs.

EMS foresees constructing a 400 kV the network in western Serbia, together with new interconnections to Montenegro (Bajina Bašta – Pljevlja) and Bosnia and Herzegovina (Bajina Bašta – Višegrad) that will increase the NTC values over these borders.

SLOVENIA

Critical network elements in Slovenian transmission system with respect to cross-border exchanges are:

TR 220/110 kV Divača
TR 220/110 kV Podlog
OHL 220 kV Divača – Pehlin

TURKEY

Critical network elements in Turkish transmission system with respect to cross-border exchanges are:

OHL 400 kV Babaeski – Maritsa East
OHL 400 kV Hamitabad – Maritsa East
OHL 400 kV Babaeski – N.Santa

TEIAS stated that for the Turkish transmission network, only tie lines between Turkey and Bulgaria & Greece must be taken as a limiting element in NTC/TTC calculations. Power exchanges between Turkey and Bulgaria and Greece are still restricted by the ENTSO-E decision. The main area of concern is related to stability problems between Turkish and the rest of the ENTSO-E system.

Evaluating the 2012 PSS/E model, one may notice quite different ratings for the same lines between Turkey and Bulgaria. For the line Maritsa East – Hamitabad, ratings are defined as 1715 MVA for the Bulgarian side and 2178 MVA for the Turkish side. For the line Maritsa East – Babaesku, ratings are defined as 1310 MVA for the Bulgarian side and 1431 MVA for the Turkish side. A similar situation may be noticed for the line between Greece and Turkey. For the OHL 400 kV Babesku – N. Santa, the rating on Greek side is 2000 MVA, while for the Turkish side, the amount is 2178 MVA. The influence of different ratings of the same transmission line on the NTC values is described in the following chapter.

Recommendations related to this topic are:

1. In order to increase the NTC values in the region, SEE TSOs should more strictly apply UCTE OH suggestions concerning remedial actions and possible mitigation of critical network elements overloading.
2. If TSO practices remedial dispatching actions in order to efficiently relieve critical network element overloading, especially on regular basis and without any serious consequences on a system security, this critical element should be neglected during the NTC calculations.

Transelectrica remark: We disagree with recommendation 2: even if a TSO practices remedial actions, there is a limit to the actions (such as volume of re-dispatch available) and therefore a limit for the overload that can be relieved effectively. The critical element should be considered during NTC calculation, checking the overload limit. This is valid also for Chapter 9.

7.2.2 Tie-lines transmission capacity coordination

Evaluating the transmission system models for 2012 and 2015, one may notice that transmission capacities of many tie-lines in the region have different values related to a side of the border. This may be possible if line materials, cross-section and other parameters such as sag or current-metering transformers in line bays of adjacent substations differ in each country, but usually such differences are the result of inaccuracies that may restrict the NTC values.

An example of possible different tie-line ratings (depending on an observed side of a border) influencing the calculated NTC value is given here. The NTC value for the network 2012 model for the Bosnia/Montenegro border and Bosnia to Montenegro direction of power exchange, monitoring 400 kV and 220 kV network elements on the Bosnian side (ignoring the network 110 kV), is 751 MW (TTC = 925 MW, TRM = 173 MW). A critical contingency in the network is an outage of the OHL 400 kV Trebinje – Podgorica. A critical network element is the OHL 220 kV Trebinje – Peručica, with rating of 316 MVA defined on the Bosnian side and 274,4 MVA defined on the Montenegrin side. If we equalize tie-line ratings from both side of the border to the higher value (316 MVA in this case), the NTC value will be increased by 218 MW (NTC = 970 MW, TTC = 1143 MW). Hence, without jeopardizing network security the potential for cross-border power exchanges over Bosnia/Montenegro border are increased.

Recommendation related to this topic is:

1. Tie-lines ratings should be defined in coordination by both TSOs concerned and equalized to a unique value if the tie-line has the same technical characteristics for both sides of a border and if there are no other limitations which may influence a tie-line rating on one side of a border.

Transelectrica remark: Equipment at the 2 sides of the tie-line can be different (including settings for specific protections) but in the end it is the lowest current limit that limits the exchange. Both TSOs should supervise both halves of the tie-line and choose the minimum limit, so any NTC differences will not be due to differences of declared current limit on tie-line.

Tie-lines at the 2012 PSS/E model with inequalities in transmission capacity are presented in the following table. TSOs should check this table and, if it is technically correct, define unique values of tie-line transmission capacity, valid for both sides of a border.

Table 7.1 Inequalities in the tie-lines ratings depending on a side of a border at the PSS/E model for 2012

Border (area 1/area 2)	Line	Rating (area 1) in MVA	Rating (area 2) in MVA	Difference (MW)
Albania/Greece	400 kV Zemlak – Kardia	1350	1400	50
Albania/Montenegro	400 kV Tirana – Podgorica	1350	1385,6	36
Albania/Montenegro	220 kV V.Dejes – Podgorica	278,2	274,4	4
Albania/Kosovo	220 kV Fierza – Prizren	325,4	274,4	51
Bosnia/Croatia	400 kV Mostar – Konjsko	1329	1030	299
	400 kV Ugljevik – Ernestinovo	1300	1030	270
	220 kV Gradačac – Đakovo	316	280	36
	220 kV Prijedor – Međurić	316	280	36
	220 kV Prijedor – Mraclin	316	280	36
	220 kV Mostar – Zakučac	300	280	20
	220 kV Trebinje – Plat 1	484	297	187
	220 kV Trebinje – Plat 2	484	297	187
	220 kV Tuzla – Đakovo	316	280	36
Bosnia/Montenegro	220 kV Sarajevo 20 - Piva	1200	381,1	819
	400 kV Trebinje – Podgorica	1329	1385,6	57
	220 kV Trebinje – Peručica	316	274,4	42
Bosnia/Serbia	220 kV Višegrad – Vardište	316	297,2	19
Bulgaria/Greece	400 kV Blagoevgrad – Thessaloniki	1310	1400	90
Bulgaria/Macedonia	400 kV C.Mogila – Štip	1310	1218	92
Bulgaria/Romania	400 kV Vustre – Rrahma	1715	850	865
	400 kV Varna – Rstupi	2390	900	1490
Bulgaria/Serbia	400 kV Sofija – Niš	1310	1330,2	20
Bulgaria/Turkey	400 kV Maritsa East – Hamitabad	1715	2178	463
	400 kV Maritsa East - Babaesku	1310	1431	121
Croatia/Hungary	400 kV Ernestinovo – Pecs 1	1030	1385	355
	400 kV Ernestinovo – Pecs 2	1030	1385	355
	400 kV Žerjavinec – Heviz 1	1030	1385,6	356
	400 kV Žerjavinec – Heviz 2	1030	1385,6	356
Croatia/Serbia	400 kV Ernestinovo – S. Mitrovica	1030	1330,2	300
Croatia/Slovenia	400 kV Melina – Divača	1050	1330,2	280
	400 kV Tumbri – Krško 1	1050	1108,5	59
	400 kV Tumbri – Krško 2	1050	1108,5	59
	220 kV Pehlin – Divača	360	365,8	6
	220 kV Žerjavinec – Cirkovce	280	297,2	17
Greece/Macedonia	400 kV Florina – Bitola	2000	860	1140
	400 Thessaloniki – Dubrovo	1400	860	540
Greece/Turkey	400 kV N.Santa – Babaeski	2000	2178	178
Hungary/Romania	400 kV Bekescaba – Nadab	1385	1382	3
	400 kV Sandorfalva – Arad	1108,5	1204	96
Hungary/Serbia	400 kV Sandorfalva – Subotica	1108,5	1330,2	222
Macedonia/Kosovo	400 kV Skopje 5 – Kosovo B	1218	1316,5	99
Montenegro/RS	400 kV Ribarevine – Peć	1385,6	1316,4	69
	220 kV Pljevlja – B.Bašta	274,4	388,7	114
	220 kV Pljevlja – Požega	381,1	411,5	30
Romania/Serbia	400 kV P.D.Fier – Đerdap	1204	1247,1	43
Romania/Ukraine	400 kV Rosiori – Mukachevo	1204	1178	26

7.3 Investments

7.3.1 Low-cost investments

TSOs should operate transmission systems and plan their development to support market transactions in the region and restrict market power of individual electricity producers. Low NTC values prevent this. TSOs must balance their efforts between the market transactions through their transmission networks and the security of supply of the transmission consumers.

Currently, TSOs are primarily concerned with security of supply, which can result in unnecessary restrictions of market activities on the wholesale market. Market participants are interested in increasing volumes of electricity trading. However, they are restricted with limited cross-border transmission capacities. This results in a large amount of congestion revenue collected by the TSOs on an annual basis. Generally, the way these congestion revenues are spent is unsatisfactory. According to the questionnaire provided within this study, the majority of TSOs spend congestion revenue in order to guarantee cross-border transmission capacity or to decrease transmission tariffs, but rarely to increase the NTC values through network investments or other ways. With such a practice, the NTC values are not going to be significantly increased in the near future.

The authors of this study believe that the larger portion of congestion revenues should be directed to increase existing cross-border transmission capacities, in order to support market transactions. According to the Energy Community Treaty, the SEE region should operate as a regional electricity market, part of the larger European electricity market. This will not be accomplished unless cross-border trading possibilities change.

In addition to the methodological and organizational recommendations to increase NTC described in previous chapters, it is recommended that TSOs plan network investments in order to support greater cross-border trade in the region. Network investments should be prioritized based on the minimum costs principle, meaning that low-cost investments should be initiated before high-costs investments in the new interconnection lines.

Among low-cost methods to increase transmission cross-border capacities, the following should be considered by the SEE TSOs where applicable:

- replacement of the current measuring transformers that limit the transmission capacity of important transmission lines,
- investments in the 110 kV lines, where such lines limit cross-border transmission capacities, if necessary, by increasing their thermal ratings or by construction of the new 110 kV line(s) that will relieve the existing and limiting ones,
- investments related to the increase of critical 220 kV transmission lines transmission capacities, where such a measure is applicable,
- removal of internal transmission network limitations.

Important recommendations concerning this topic and described in the following chapters, are the following:

NTC values may be increased by network reinforcements:

1. Low-cost investments should be made the highest priority (replacements of current-measuring transformers, 110 kV network reinforcements etc.).
2. Adjacent TSOs should closely cooperate in investments towards increasing NTC values (Calculating NTC values concerns determining contingences on both sides of a border. Significantly different values could be achieved).
3. TSOs should plan internal network reinforcements in order to increase NTC values – regulatory approval should be more probable.

IMPORTANT RECOMMANDATION:

Internal network investments have to be conducted before new interconnection line construction!

7.3.2 Internal network investments

NTC calculations using 2012 and 2015 PSS/E network models indicate that there is a large number of limiting network elements concerning cross-border transmission capacities located within national internal transmission systems. NTC calculations also indicate that possible limitations for the NTC values are almost never caused by the 400 kV transmission lines overloading and especially not caused by 400 kV interconnection line overloading.

The NTC calculations also indicate the following:

1. In many cases by ignoring the 110 (154) kV network and evaluating the 400 kV and 220 kV network only, the NTC values for large number of borders are significantly higher.
2. In many cases, by ignoring internal transmission network limitations and observing the existing tie-lines only, the NTC values for a large number of borders are significantly higher and practically limited by maximum generation shifts in observed countries.
3. Limitations detected on the existing tie-lines are always related to the 220 kV lines and almost never to the 400 kV lines.

These three basic findings of the calculations conducted within this study lead to logical conclusions and recommendations:

1. If a TSO considers 110 kV network as limiting the NTC values of a transmission system, it should plan actions or investments to remove the limitations.
2. TSOs should primarily plan internal transmission networks investments in order to increase the NTC values. Such investments are lower cost than interconnection lines investments, need shorter time period for realization, and regulatory approval is more probable.
3. Some TSOs should reevaluate the significance of 220 kV interconnection lines and reconsider the operational practicesrelated to them.

110 kV network elements (lines and transformers) are the least expensive part of transmission systems. Unit investments in the 110 kV lines cost approximately four times less than unit investments in the 400 kV lines. Furthermore, 110 kV lines are shorter than 400 kV lines, resulting in much smaller total investments related to their construction and compared to the total costs of new 400 kV lines. Rights-of-way for 110 kV lines can be assured more easily than the same for 400 kV lines. Investments in the 110 kV lines are more probable, feasible and economically justified.

Similar arguments are applicable to internal network investments compared with new interconnection lines investments. Today, the SEE transmission system is well meshed. There are 36 existing tie-lines operated at

400 kV and 18 tie-lines operated at 220 kV between the observed countries and between the surrounding countries (Table 7.2, Figure 7.1, additionally see Chapter 4). Regulatory approval for internal network investments could be provided more easily, assuming that the TSOs will be able to prove the necessity for network reinforcements to a Regulatory Authority.

220 kV tie-lines were constructed in the former Yugoslavia during the 1960's, when construction of 400 kV was still expensive and unnecessary for the level of generation and load at that time. Because seven of the eleven countries evaluated in this report were once part of Yugoslavia, it is important to note that these interconnection lines were once considered to be internal network lines. This has resulted in the existence of a large number of 220 kV interconnection lines (the total number is 18), operated parallel to 400 kV interconnection lines, although the typical transmission capacity of a 400 kV line is four times larger than typical transmission capacity of a line 220 kV (1300 MVA versus 300 MVA). A consequence of this is possible 220 kV interconnection lines overloading following the outages of the parallel 400 kV interconnection lines where larger power exchange goes from one country to another one. Slovenian, Bosnian, Croatian, Montenegrin and Serbian TSOs should reconsidered operating 220 kV tie-lines parallel to 400 kV tie-lines, and if necessary, assess the possibility of using 220 kV transmission line corridors in order to reinforce the 400 kV lines. An alternative is to abandon some of the old 220 kV lines when significant investment will be needed for their revitalization, and consider reinforcement of their internal networks.

Table 7.2 Total number of existing tie-lines in the SEE countries

Country	**Number of tie-lines**	
	400 kV	**220 kV**
Albania	2	2
Bosnia and Herzegovina	4	10
Bulgaria	9	0
Croatia	10	9
Macedonia	4	0
Montenegro	3	5
Romania	8	0
Serbia and Kosovo	7	4
Slovenia	6	4
Turkey	3	0

* Double-circuit lines are listed as two separate lines

Figure 7.1 Existing tie-lines 400 kV and 220 kV in the SEE region

7.3.3 Coordination among TSOs

The calculations conducted within this study show that the cross-border possibilities of a border and a direction of power exchange may be significantly different depending on the side of a border evaluated.

According to the ENTSO-E methodology for cross-border transmission capacity assessments, the security criterion (criteria) has to be satisfied on both sides of a border and in third parties transmission systems if they are significantly influenced by power exchanges related to the observed border. If related NTC values are different, TSOs usually agree that the lower one is the final NTC value related to evaluated border and direction of power exchange.

If we observe two areas and calculate related the NTC values, evaluating the security criteria in the transmission network in Area 1 (related NTC may be defined as NTC_{area1}) and then evaluating the same for Area 2 (NTC_{area2}), the final values of the NTC will be:

$NTC = \min (NTC_{area1}, NTC_{area2})$

If network limitation element is a tie-line between two areas the following will be valid:

$NTC_{area1} = NTC_{area2} = NTC$ (assuming that tie-line transmission capacity is the same on both sides of a border)

Differences between NTC_{area1} and NTC_{area2} may be caused by the following:

1. TSOs apply different security criteria on their side of a border,
2. TSOs monitor different voltage levels of possible network limitations,
3. In the transmission system of one TSO, or both of them, there are significant internal network limitations that decrease the NTC value for observed border.

Concerning the first item, obvious recommendation follows:

1. Adjacent TSOs should use the same or very similar criteria for network security evaluation.

If one TSO evaluates NTC values with a contingency list that includes single element outages only, while other TSO uses a contingency list with double-circuit line outages or bus-bar outages, there may be significantly different NTC values for the same border, resulting in lower a NTC value defined as the final value for this border.

The same conclusion is true in relation to monitored elements during the NTC values calculations. Significantly different values may be expected if one TSO observes 400 and 220 kV network elements only, while the other TSO includes 110 kV network into its considerations.

2. Adjacent TSOs should monitor the same voltage levels during network security calculations, only exceptionally including critical 110 kV lines if their loading is significantly influenced by cross-border power exchanges.

The most important recommendation concerning this topic is the following one:

3. Close cooperation between adjacent TSOs is of utmost importance to internal network investments that are planned in order to increase the NTC value for common border.

If the NTC_{area1} value is significantly lower than the NTC_{area2} value, internal network reinforcements conducted in Area 2, in order to increase the final NTC value for a common border, have no importance and will not lead to higher NTC values for evaluated border. This is because limitations will still exist, due to internal network limitations in Area 1 that limit the final NTC value for a common border. Coordination between TSOs would mean that both TSOs will be mutually informed about network limiting elements in both areas and share common knowledge about the most critical network elements in both transmission networks. Transmission development plans will have to be coordinated. Internal network investments should be planned in order to achieve the maximum positive influence on the NTC values for their common border. A TSO in Area 1 will have to plan its internal network reinforcements first, followed by the second TSO of Area 2.

NTC calculations conducted within this study indicate that significantly different NTC values may occur at the following borders and directions of power exchanges (PSS/E model for 2012):

With 400 kV, 220 kV and 110 kV networks monitored in both countries that share a border (surrounding countries are not included – Italy, Austria, Hungary, Ukraine and Greece):

Albania/Kosovo border	(AL>RS direction)	NTC_{AL} = 641 MW	NTC_{RS} = 178 MW
Albania/Montenegro border	(AL>ME direction)	NTC_{AL} = 291 MW	NTC_{ME} = 439 MW
BiH/Montenegro border	(ME>BA direction)	NTC_{BA} = 789 MW	NTC_{ME} = 1088 MW
BiH/Croatia border	(BA>HR direction)	NTC_{BA} = 650 MW	NTC_{HR} = 380 MW
BiH/Croatia border	(HR>BA direction)	NTC_{HR} = 1076 MW	NTC_{BA} = 775 MW
BiH/Serbia border	(BA>RS direction)	NTC_{BA} = 494 MW	NTC_{RS} = 0 MW
BiH/Serbia border	(RS>BA direction)	NTC_{BA} = 473 MW	NTC_{RS} = 791 MW
Bulgaria/Macedonia border	(BG>MK direction)	NTC_{BG} = 267 MW	NTC_{MK} = 855 MW
Bulgaria/Romania border	(BG>RO direction)	NTC_{BG} = 0 MW	NTC_{RO} = 855 MW
Bulgaria/Romania border	(RO>BG direction)	NTC_{BG} = 1014 MW	NTC_{RO} = 1220 MW
Bulgaria/Serbia border	(BG>RS direction)	NTC_{BG} = 161 MW	NTC_{RS} = 816 MW
Bulgaria/Serbia border	(RS>BG direction)	NTC_{BG} = 445 MW	NTC_{RS} = 132 MW
Croatia/Serbia border	(HR>RS direction)	NTC_{HR} = 1207 MW	NTC_{RS} = 669 MW
Croatia/Serbia border	(RS>HR direction)	NTC_{HR} = 443 MW	NTC_{RS} = 642 MW
Croatia/Slovenia border	(HR>SI direction)	NTC_{HR} = 1009 MW	NTC_{SI} = 1259 MW
Croatia/Slovenia border	(SI>HR direction)	NTC_{HR} = 344 MW	NTC_{SI} = 594 MW
Macedonia/Kosovo border	(MK>RS direction)	NTC_{MK} = 681 MW	NTC_{RS} = 441 MW
Macedonia/Kosovo border	(RS>MK direction)	NTC_{MK} = 600 MW	NTC_{RS} = 320 MW
Montenegro/RS border	(ME>RS direction)	NTC_{ME} = 788 MW	NTC_{RS} = 311 MW
Montenegro/RS border	(RS>ME direction)	NTC_{ME} = 583 MW	NTC_{RS} = 303 MW
Serbia/Romania border	(RS>RO direction)	NTC_{RS} = 474 MW	NTC_{RO} = 1266 MW

With 400 kV and 220 kV networks monitored in both countries that share a border (surrounding countries are not included – Italy, Austria, Hungary, Ukraine and Greece):

Albania/Kosovo border	(AL>RS direction)	NTC_{AL} = 671 MW	NTC_{RS} = 178 MW
Albania/Montenegro border	(ME>AL direction)	NTC_{AL} = 291 MW	NTC_{ME} = 439 MW
BiH/Montenegro border	(ME>BA direction)	NTC_{BA} = 789 MW	NTC_{ME} = 1088 MW
BiH/Croatia border	(BA>HR direction)	NTC_{BA} = 650 MW	NTC_{HR} = 491 MW
BiH/Croatia border	(HR>BA direction)	NTC_{HR} = 1076 MW	NTC_{BA} = 775 MW
BiH/Serbia border	(BA>RS direction)	NTC_{BA} = 731 MW	NTC_{RS} = 0 MW
BiH/Serbia border	(RS>BA direction)	NTC_{BA} = 473 MW	NTC_{RS} = 1278 MW
Bulgaria/Macedonia border	(BG>MK direction)	NTC_{BG} = 523 MW	NTC_{MK} = 1074 MW
Bulgaria/Macedonia border	(MK>BG direction)	NTC_{BG} = 282 MW	NTC_{MK} = 412 MW
Bulgaria/Romania border	(BG>RO direction)	NTC_{BG} = 0 MW	NTC_{RO} = 855 MW
Bulgaria/Romania border	(RO>BG direction)	NTC_{BG} = 1014 MW	NTC_{RO} = 1220 MW
Bulgaria/Serbia border	(BG>RS direction)	NTC_{BG} = 386 MW	NTC_{RS} = 816 MW
Bulgaria/Serbia border	(RS>BG direction)	NTC_{BG} = 445 MW	NTC_{RS} = 745 MW
Croatia/Serbia border	(HR>RS direction)	NTC_{HR} = 1738 MW	NTC_{RS} = 669 MW
Croatia/Serbia border	(RS>HR direction)	NTC_{HR} = 830 MW	NTC_{RS} = 1004 MW
Croatia/Slovenia border	(SI>HR direction)	NTC_{HR} = 487 MW	NTC_{SI} = 631 MW
Macedonia/Kosovo border	(MK>RS direction)	NTC_{MK} = 681 MW	NTC_{RS} = 441 MW
Montenegro/RS border	(ME>RS direction)	NTC_{ME} = 788 MW	NTC_{RS} = 311 MW
Serbia/Romania border	(RS>RO direction)	NTC_{RS} = 999 MW	NTC_{RO} = 1542 MW

7.3.4 Interconnection lines investments

TSOs often state that it is necessary to construct new interconnection lines in the region, in order to increase cross-border trading possibilities and volumes of market transactions in the region. Their responses on the questionnaire provided in this study are in line with such statements (Annex 2).

Observing the 2015 and 2020 SECI PSS/E models, there are a lot of new 400 kV interconnection lines that TSOs have planned to be operational in the short, mid and long-time frame.

There are 11 new interconnection projects that are foreseen to be operational till 2020, presented in the following figure (Figure 7.2):

OHL 400 kV Elbassan (Albania) – Ohrid (Macedonia)
OHL 400 kV Štip (Macedonia) – Vranje (Serbia)
OHL 400 kV Bajina Bašta (Serbia) – Pljevlja (Montenegro)
OHL 400 kV Tirana (Albania) – Kosovo B (Kosovo)
OHL 2x400 kV Cirkovce (Slovenia) – Heviz (Hungary) / Žerjavinec (Croatia)
HVDC 1000 MW Lastva (Montenegro) – Villanova (Italy)
OHL 400 kV Banja Luka (Bosnia and Herzegovina) – Lika (Croatia)
OHL 400 kV Višegrad (Bosnia and Herzegovina) – Bajina Bašta (Serbia)
OHL 400 kV Maritsa East (Bulgaria) – N. Santa (Greece)
OHL 2x400 kV Resica (Romania) – Pančevo/Vršac (Serbia)
OHL 2x400 kV Okroglo (Slovenia) – Udine (Italy)

Interconnection projects are often expensive and time consuming, while the volumes of market transactions in the region will have to be increased soon (2015 is the expected year of market establishment on the retail level). The authors of this study suggest that TSOs consider all recommendations provided in this report, in order to increase NTC values in a short period of time.

The final suggestion for the SEE TSOs is to activate all potential measures listed in this study, apply the least-cost principle and prioritize transmission investments relevant for the NTC values increase, and then reinforce internal transmission systems after coordination with neighboring TSOs concerning internal limiting transmission elements on both sides of a border.

Preparation of the new interconnection projects should be based on adjacent TSOs interests, their feasibility and economic justification.

Figure 7.2 Existing and future tie-lines 400 kV and 220 kV in the SEE region

8. POSSIBLE IMPACT OF THE NTC VALUES ON THE FUTURE REGIONAL BALANCING MARKET

The SECI TSP study, "Preparation for large scale wind integration in South East European power system," has shown that the regional approach to balancing WPP would decrease the total reserves needed to balance intermittent the WPP by a range of -2,600 MW and +2,000 MW. In other words, a regional approach would decrease the system reserve requirements for balancing WPPs to less than half of that required by the existing individual country approach. This is a clear message to policy makers to establish the legal framework for a regional approach to ancillary services and balancing mechanisms.

However, the current practice is still far from the regional balancing market. In March, 2012, the Energy Community Regulatory Board issued an assessment report on electricity balancing models with the following main conclusions:

1. Balancing and reserve markets in SEE are still under development
2. Usually, the incumbent company is responsible for ancillary services (AS) and balancing procurement
3. Imbalance settlement lacks efficiency, thus providing the wrong signals to balance responsible parties and balance energy providers

The Energy Community Secretariat launched "The study on the Development of Best Practice Recommendations for Imbalance Settlement", LDK, January 2013. Based on this study the very basic assumptions for establishing the regional balancing market assume:

1. Adoption of the common definitions of ancillary services and balancing energy
2. Adjustment of the ENTSO-E Operation Handbook requirements related to the necessary reserve capacities in close cooperation of regulators, TSOs and ENTSO-E to enable contracting of reserve capacities for tertiary control in wider areas than Control Areas. Control Blocks or larger areas could be an appropriate solution.
3. Apply "Revised Guidelines of Good Practice (GGP) for Electricity Balancing Markets Integration", ERGEG 2009
4. Establish a regional balancing scheme that would increase transparency and decrease costs in line with ERGEG GGP.
5. Before a regional mechanism is established, either throughout the whole region or in parts of it, all the countries that would like to participate in the mechanism need to establish national balancing mechanisms.

One of the most important aspects of the regional balancing mechanism is the treatment of cross-border capacities as a part of the NTC issues analyzed in this study. Cross-border balancing energy trade will be possible and efficient only with the following assumptions:

1. Reservation of cross border transmission capacity for reserves exchanging to be possible only if it is associated with social benefit
2. Merit order reservation of cross-border capacity to be done for reserves exchanging
3. Cost-benefit analysis for the calculation of the social welfare increase should be based on ex-ante calculations, initially utilizing assumptions for the wholesale prices
4. Alternatively, the cost-benefit analysis could be based on the capacity auctions methodology proposed by ENTSO-E

5. Transmission reliability margin (TRM) should be utilized by TSOs close to real time only for Frequency Control Reserve exchange
6. TSOs should commonly develop a detailed methodology on TRM calculation based on the principles and approach set by the ENTSO-E CACM Network Code
7. Corresponding methodology should allow for TRM and ATC recalculation on a day-ahead and intra-day basis and shall be approved by ECRB
8. For the exchange of reserves, the bilateral reserve trading model is proposed with the aim to move to the harmonized multilateral reserve trading model
9. For the exchange of balancing energy, the TSO-TSO without common merit order list is proposed as a transitional step towards the implementation of the TSO-TSO with common merit order list (first come- first served).

These are the main messages that could be drawn at this moment from the cross-border capacity perspective to the future regional balancing market.

However, besides cross-border capacity issues, there are three other areas that need to be developed and harmonized in order to establish regional balancing mechanism:

1. Measuring of AS and balancing
2. Regulatory monitoring
3. Allocation of balancing costs

Measuring of AS and balancing includes the following suggestions:

1. Separate the reserve products being offered/ tendered
2. Set clear limits on the volume of capacity being purchased based on an agreed common calculation method e.g. ENTSO-E methodology
3. Separate the capacity being offered/tendered into blocks e.g. no more than 50 MW in a block for 3rd reserve and 5 MW for 2nd reserve
4. Separate the timescales over which the products are required (e.g. annual and seasonal or possibly even monthly)
5. Require prices for the reservation and utilization of energy portions
6. Centralize and harmonize data collection, data analysis and the results reported under ECRB's management
7. Adopt regulations for collecting, analyzing and publicizing data related to wholesale electricity markets operations

Regulatory monitoring issues include the following suggestions:

1. Establishment of technical (software access restrictions) and organizational (restricted national regulatory agencies (NRA) staff) measures to maintain confidentiality of sensitive data
2. NRAs to closely monitor whether TSOs/MOs apply the transparency requirements as set by ACER and ENTSO-E
3. Central monitoring of declared availabilities based on comparisons with international statistical data on maintenance periods, forced outages and major damages of the types and technologies of the units in the area.

4. Data analysis of balancing and reserves procurement should be performed by NRAs
5. RES should be included in the process of balancing and monitoring reserves
6. Central monitoring of cross border exchanges of reserves and balancing energy involving: quantities and prices of balancing energy exchanges; the volume of unshared bids/offers; the volume of reserves exchanged without reservation of cross-border capacity; the volume, duration and price of cross-border capacity reserved for contracted reserves exchanges and its utilization; ex-post benefits realized.

Allocation of balancing costs should have the following characteristics:

1. Gross model for energy imbalance settlement (whole mechanism is TSO's liability)
2. Single Imbalance price
3. Average price of accepted bids in system imbalance direction but long term aim to move to a marginal price
4. Weight activated reserve bids by reservation fee
5. Remove Transmission constraint resolving bids and make the TSO pay for them
6. RES to be exposed to imbalance settlement on an equal basis to other system users

Finally, it is recommended to prepare the next step: cost-benefit analysis that could be based on the capacity auctions methodology proposed by ENTSO-E.

9. CONCLUSIONS

The NTC values are an indication of cross-border transmission capacities which may be used by the market participants in order to perform different electricity transactions over two or more areas (countries). A matter of TSOs' concern is that cross-border transmission capacities are generally restricted due to tie-lines transmission capacities and security of supply issues. The main task of this report is to analyze the NTC values in the Southeast Europe region, identify critical network elements and identify recommendations in order to increase cross-border trading possibilities in the SEE region.

Analyses conducted within this study were mainly based on the 2012 SECI PSS/E regional transmission system models. The 2012 PSS/E model represents a snapshot of real operating conditions on January 14, 2012 at 12:40 pm.

The NTC values for the SEE countries, published on the ENTSO-E website, relate to the indicative annual NTC values for specific borders and direction of power exchanges, month-ahead NTC values and day-ahead NTC values. The published NTC values show that market trading possibilities at the wholesale level are currently quite restricted in the region. One of the main reasons for this is that a number of borders have low NTC values, especially concerning indicative annual values. Low volumes of electricity trading in the region, large congestion revenues collected by the SEE TSOs and the existence of market power of national electricity producers are all direct consequences of this issue. The possibility of an economically efficient electricity market is also disturbed by the existence of a large number of TSOs and national borders in the region. Indicative annual NTC values do not show the market trading possibilities during the year. They only show the NTC values that are applicable to any topology and therefore, could be transacted in a yearly auction (Transelectrica remark).

The NTC values were computed for all SEE borders using the ENTSO-E methodology that defines procedures for cross-border transmission capacities assessments. The calculated NTC values in this study could not be considered exact indicators of cross-border trading possibilities in the region since only one operational condition has been analyzed. However, they should be considered indicative values used to define specific recommendations to the TSOs on possible actions in order to increase cross-border trading possibilities in the near future.

Transelectrica remark: NTC values calculated in this study could not be considered as precise indicators of cross-border trading possibilities also because interdependence of NTCs on bilateral borders was not considered.

According to the questionnaire filled out by the TSOs involved in this study (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Kosovo, Macedonia, Montenegro, Romania, Serbia, Slovenia and Turkey), their expectations related to the NTC value increases are directed mainly to the new interconnection lines construction. There are 36 400 kV tie-lines and 18 tie-lines in the region today which make the regional transmission system extremely well-meshed compared to other European regions. Because of that, the authors of this report believe that the real challenge is how to increase cross-border transmission capacities immediately, without waiting for the new interconnection lines to be constructed. Recommendations concerning this topic are explained in more details in Chapter 7 of this report. Recommendations are divided into three main categories:

1. General recommendations:
   - concerning the NTC computation methodology,
   - concerning the transmission reliability margin,
   - concerning the security criteria,
   - concerning the list of contingences and monitored network elements.

2. Remedial and dispatching actions:

- concerning existing critical network elements and possible dispatching actions,
- concerning the tie-lines transmission capacity coordination.

3. Investments:
    - low-cost investments,
    - internal network investments,
    - coordination among TSOs,
    - interconnection lines.

Specific recommendations are as follows (for more detail explanations please refer to Chapter 7):

- Composite NTC calculations are more convenient for the SEE region than simple calculations (including power exchanges between two transmission systems only).
- Flow-based methods are more suitable for the SEE region than programmed exchange methods.
- Coordinated flow-based approach seems to be the most suitable methodology for calculating NTC values in the SEE region.
- Realistic base cases should be used.
- The time-frame for computation should be short (day-ahead, week-ahead, month-ahead).
- Annual NTC values should be defined according to computed day-ahead values (for example: minimum day-ahead NTC value from previous time period).
- A merit order list for generation shift definition is preferable (more realistic, unrealistic overloading is avoided).
- Generation pattern should be defined realistically.
- Technical data of generators should be accurate (especially P_{max} and P_{min}).
- Transmission Reliability Margin should be determined according to past experience and realistic operational situations.
- Unintentional deviations should be minimized (balancing energy, ancillary services).
- TSOs should consider the probabilities of simultaneous events that influence cross-border flows deviations.
- One value of TRM should be defined and then allocated to different borders.
- TSOs should consider taking into account the probabilities of line outages while calculating NTC.
- TSOs should consider taking into account the probabilities of different simultaneous events (for example simultaneous forced line outage and planned line outage due to maintenance activities (N-1-1) for a studied period.
- TSOs should consider taking into account the effects of individual contingences (for example, minor overloading may be neglected).
- TSOs should take into account possible dispatching actions (remedial actions).
- A clear understanding of mutual influence between cross-border exchanges, individual contingences and consequences is important.
- TSOs should not observe contingences and their consequences which are not directly and significantly influenced by cross-border transactions.
- TSOs should mainly observe the 400 kV and 220 kV network. It is mostly influenced by cross-border transactions.
- The 110 (154) kV network should be observed exceptionally (if some element is directly and significantly influenced by cross-border transactions and consequences of overloading are serious).

- Transmission lines thermal ratings (transmission capacity) should be defined more accurately (at least seasonal values).
- TSOs should consider the possibility of allowing temporary higher loading of a line than its thermal limit, especially if dispatching actions are possible to relieve a line.
- In order to increase the NTC values in the region, SEE TSOs should more strictly apply UCTE OH suggestions concerning remedial actions and possible mitigation of critical network elements overloading.
- If a TSO practices remedial dispatching actions, in order to efficiently relieve critical network element overloading, especially on regular basis and without any serious consequences on a system security, this critical element should be neglected during the NTC calculations.
- TSOs involved should coordinate to define tie-line ratings and equalize to a unique value if the tie-line has the same technical characteristics for both sides of a border and if there are no other limitations which may influence a tie-line rating on one side of a border.
- Low-cost investments should have the highest priority (replacements of current-measuring transformers, 110 kV network reinforcements etc.).
- Close cooperation between adjacent TSOs is of utmost importance related to internal network investments which are planned in order to increase the NTC value for common border.
- If a TSO considers the 110 kV network as a limiting part of a transmission system concerning the NTC values, it should plan actions or investments to remove the limitations there.
- TSOs should primarily plan internal transmission networks investments in order to increase the NTC values. Such investments are lower cost than interconnection line investments, need a shorter time period for realization, and regulatory approval is more probable.
- Internal network investments have to be conducted before new interconnection lines are constructed
- Some TSOs should reevaluate the significance of the 220 kV interconnection lines and consider the operational practices related to them.
- Adjacent TSOs should use the same or very similar criteria for network security evaluation.
- Adjacent TSOs should monitor the same voltage levels during network security calculations, only exceptionally including critical 110 kV lines if their loading is significantly influenced by cross-border power exchanges.
- The final suggestion for the SEE TSOs is to activate all potential measures listed in this study, apply the least-cost principle and prioritize transmission investments relevant for the NTC values increase, and then reinforce internal transmission systems after coordination with neighboring TSOs concerning internal limiting transmission elements on both sides of a border. The preparation of the new interconnection projects should be based on adjacent TSOs' interests, their feasibility and economic justification.

In order to apply previously described recommendations and increase the NTC values for the SEE region in the short-time period, thus allowing increased volumes of market transactions in the region without waiting for the new interconnection projects to be realized (which are time consuming and expensive), regulation agencies should be more actively involved, by controlling congestion management revenues usage and directing TSOs to low-cost measures and investments. The first step may be the initiation and establishment of an internal dialog between SEE regulation agencies and TSOs in the region, possibly under the umbrella of the Energy Community Secretariat, in order to coordinate common activities with the main goal of increasing cross-border exchange possibilities in the region.

10. LITERATURE

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11. APPENDICES

APPENDIX 1: TERMS OF REFERENCE

APPENDIX 2: QUESTIONNAIRE

APPENDIX 1: TERMS OF REFERENCE

TERMS OF REFERENCE

In the context of the electricity market opening there has been an increasing need from market parties to have a clear understanding of the indicative values for the possible cross border exchanges. Published twice a year on the ENTSO-E website it aims to provide cross border values in to/from each country that allows the interested parties to have a clearer and user-friendlier vision of the energy trading possibilities throughout the grids of the European countries, including those in SEE.

Furthermore, Transmission System Operators have to keep sufficient level of operational security, once when network is going to be subjected to different power flow patterns because of market activities.

The first value to be defined is Total Transfer Capacity (TTC) as the maximum exchange program between two areas compatible, on a given technical profile, with operational security standards applicable at each system if future network conditions, generation and load patterns were perfectly known in advance.

Also, Transmission Reliability Margin (TRM) is defined as the reserve cross-border transmission capacity maintained in case of possible emergency events and due to uncertainty as to the accuracy of data used in determining of TTC value. It is very important to clarify and harmonize the way how TRM value is defined. It will be done within this study.

So, Net Transfer Capacity (NTC) was introduced as the maximum value of generation that can be wheeled through the interface between the two systems without leading to network constraints in either system, taking into account technical uncertainties about future network conditions. It is calculated as:

$$NTC = TTC - TRM$$

Clearly, it is forecasted value.

On the other side, Already Allocated Capacity (AAC) is the total amount of allocated transmission rights i.e. transmission capacity reserved by virtue of historical long-term contracts and the previously held transmission capacity reservation auctions.

Available Transfer Capacity (ATC) is the transmission capacity that remains available, after allocation procedure, to be used under the physical conditions of the transmission system. ATC value is defined as:

$$ATC = NTC - AAC$$

The figure below represents the technical volumes of the cross-border exchange transmission capacity.

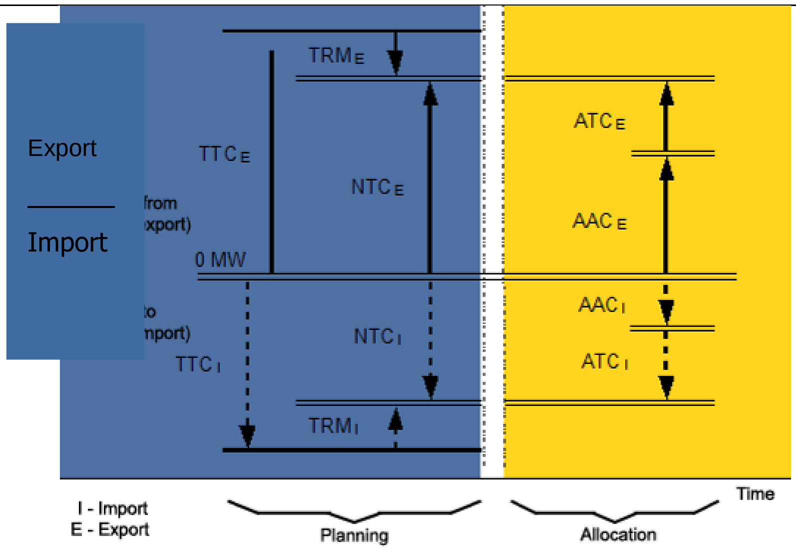

Figure 1 Technical volumes of the cross-border exchange transmission capacity

Revenues resulting from the allocation of interconnection capacity should be used for:

1) Guaranteeing the actual availability of the allocated capacity
2) Network investment
3) As an income to be taken into account for network tariffs reduction

Current status in SEE

There a lot of activities in the framework of ENTSO-E Market Committee, especially in Congestion Management and Market Integration Workgroup. Also, certain activities are taken within the project of establishing regional Coordination Auction Office. All these activities will be listed within this study.

This analysis could result with more efficient usage of existing transmission capacities, especially for cross-border exchanges.

In current practice on the regional and pan-European level the NTC calculation does not take into account bottlenecks in 110 kV network. Regional TSOs naturally take it into account, since actual NTC values are often limited due to internal network congestions (usually located at 110 kV voltage level), not because of insufficient interconnection capacities. It seems unreasonable to invest in a new interconnection capacity while existing ones are not fully used and power transfers are limited due to internal network bottlenecks. Reinforcement of critical internal network bottlenecks may increase some NTC values with minimum investment costs. Accordingly, this study should help regional TSOs, regulators, financial institutions, donors to identify internal bottlenecks that are currently limiting larger cross-border power exchange. In other words, the study should find out which parts of internal networks are having regional importance and thus should get easier approval and financing from the relevant institutions.

Generally, the SEE regional power system is having the following characteristics:

- it consists of ten mostly small mutually very well connected power systems, with the exception of Romania and Turkey as larger power systems, resulting with large number of NTC values and cross border issues that is limiting power exchange,

- NTC values are significantly lower than installed interconnection capacities,
- most of power systems are having significant import needs, with the exception of BiH, Romania and Bulgaria,
- electric market is existing on the wholesale level, while in most of the countries retail electricity market is still in early opening phase,
- import prices were largely fluctuating in the last few years in this region, having large impact on the system operational cost
- through the power system of Montenegro SEE region is going to be strongly connected (1000 MW link) to the largest European electricity importer - Italy.

At the same time, actual net cross-border transmission capacities (NTCs) are limited, practically being a barrier for larger power trade in the region, as shown on the following figure.

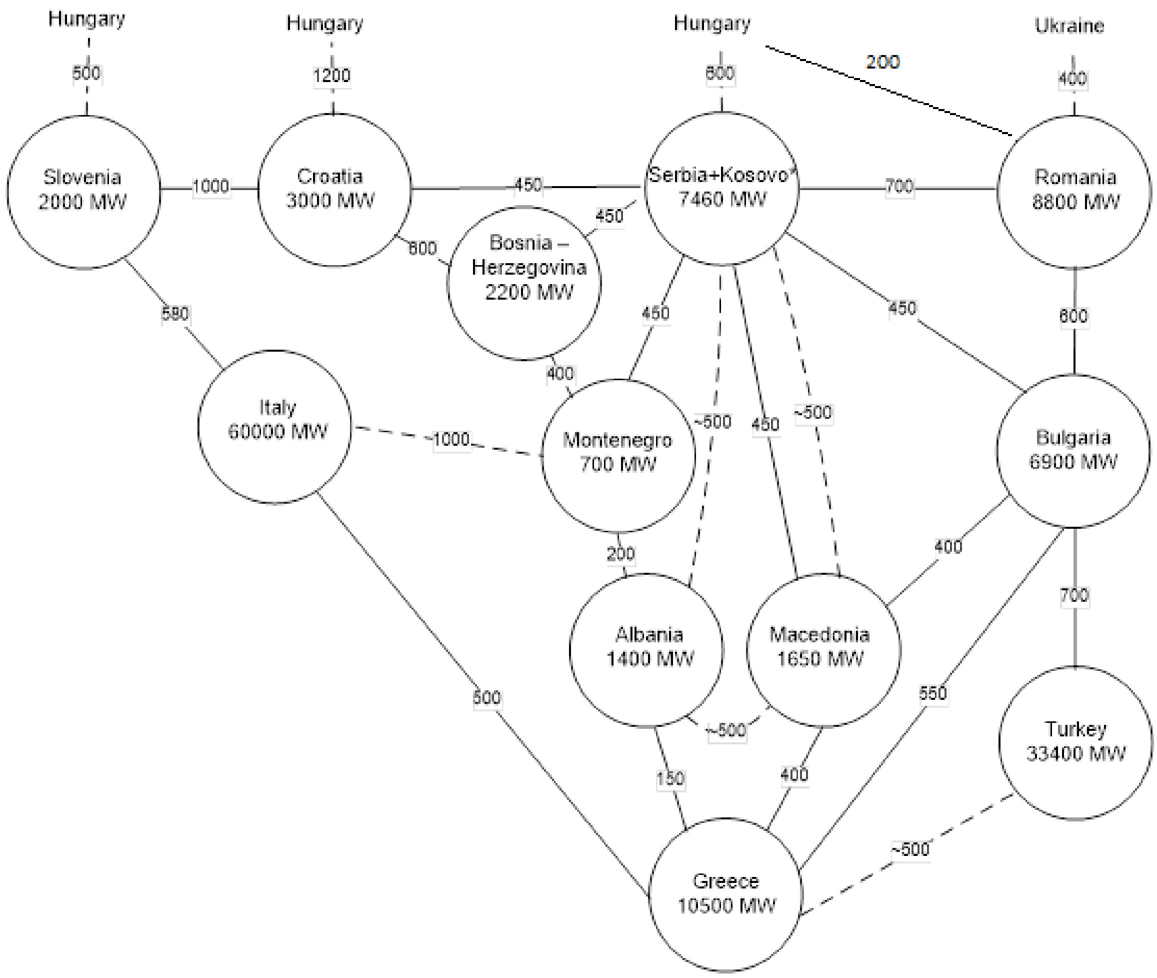

Figure 2 Current system peak loads and net transfer capacities for winter in between SEE countries (MW) (new transmission projects are given in dashed lines) (Source: ENTSO-E)

Clearly, there is a large potential for additional electricity market activities in this region. From one side, wholesale market prices were significantly changing in the last few years. If we add large projects currently under development, this region will face significant changes and additional uncertainties in the electricity market that would need larger NTC values.

On the other side, new power infrastructure investments (HVDC submarine link to Italy, large generation expansion plans...) will have large impact on the regional power balance and power trade, as well as the market positioning of different players.

Finally, improved utilization of existing interconnection capacities and identification of network elements critical for increasing of NTC values will be important issue for this region in the future.

Scope of the Work

The scope of work within this study includes PSS/E scenario analyses on the critical network elements that are limiting NTCs and suggesting dispatching or planning actions to release these limitations. It will be done on the updated existing network model (2012 updated with new network elements currently under construction) to avoid debates on the future network uncertainties. Accordingly, it is of utmost importance to have the base case model for the current power system topology (2012 or 2013) as the reference for the calculation. It is understood that in the planning models for 2015 and 2020 there are lot of new transmission projects that will not be realized in given time frame. Regardless, these new projects will have large impact on the NTC values and the study results. Consequently, the study target is to identify existing network upgrades needed for enlargement of the future NTC values and to compare it with official network development plans.

The study will require strong support from the SECI TSP working group support, especially on the possibility and feasibility of suggested dispatching actions in all given scenarios. EIHP will prepare the questionnaire on the NTC values calculation, allocation and revenue distribution that will be distributed to the TSOs to complete.

Finally, one of the important future activities in the region is common balancing market. NTC values and larger cross border trade is necessary to facilitate future regional balancing market. Possible impact of NTC values on the future regional balancing market will be commented in the study as well.

This final report should include the following chapters:

1. Introduction

2. Current principles of NTC value calculation, allocation and revenue distribution
    2.1. European and global experience
    2.2. Regional specifics

3. Relevant ENTSO-E activities
    3.1. ENSTO-E approach, methodology and GTC values

4. Regional transmission network in the future
    4.1. Actual power system model for 2012
    4.2. Short term future model - 2015
    4.3. Expected development in the mid-term - 2020 and basic assumptions of ENTSO-E Ten Year Network Development Plan

5. Power system calculation of NTC values using load flow and N-1 analyses

6. Critical parts of SEE transmission network with respect to NTC values

7. Identification of network upgrades and dispatching or planning actions needed to increase NTC values

8. Possible impact of the NTC values on the future regional balancing market

9. Conclusions

The analyses will take into account existing operational rules and relevant international experience.

Analyses will be performed under the umbrella of USAID & USEA, using PSS/E software. The main precondition is to have full, verified base case PSS/E model for the current power system topology (2012 or 2013). Input data will be collected from the regional TSO's and other relevant institutions and projects. Workshop for relevant sub-regional experts may be organized in order to present study methodology and study findings, as well as to initiate discussion between relevant representatives and experts.

APPENDIX 2: QUESTIONNAIRE

ALBANIA

1. Do you calculate NTC values?

☒ Yes
☐ No

2. How often do you calculate NTC values now?

☒ Once a year
☒ Twice a year (summer and winter)
☒ Monthly
☐ Other (specify:__________________)

3. What is the methodology you use for NTC calculation?

☒ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☐ Other (specify:____)

5. Did you find ENTSO-E methodology inappropriate for your system?

☐ Yes
☒ No

If yes, please describe why:____
____
____

6. What are the limitations for NTC values increasing in your system?

☒ Limited interconnection capacity

Limiting element: 400 kV Tirana– Podgorica outage: 400 kV Zemblak– Kardia;
Limiting element: 400 kV Zemblak– Kardia outage: 400 kV Tirana– Podgorica
Limiting element: 220 kV Prizren – Fierza outage: 400 kV Zemblak – Kardia.
Limiting element: 220 kV V.Dejes – Podgorica outage: 400 kV Zemblak – Kardia.

☐ limited local 400 kV network capacity
(specify limiting network elements:____)

☐ limited local 220 kV network capacity
(specify limiting network elements:____)

☐ limited local 110 kV network capacity
(specify limiting network elements:____)

☒ Other (specify:____)

- *discrepancies between calculated and nominated values of NTC,*
- *inappropriate limitation of overcurrent protection on some tie-lines.*

7. What's technically and economically the best way to increase NTC values for your system?

☒ New interconnection lines construction
(specify which ones: corridor North-South and East-West)

☐ New internal lines construction
(specify which ones:____)

8. Have NTC values been changed in the last 5 years ?

☒ Yes
☐ No

9. If yes, what is the reason for NTC values changes ?

☒ new/upgraded interconnection capacity
☒ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☐ Other (specify:____)

10. Do you have any detailed analyses on the actions to increase NTC values?

☐ Yes
☒ No

11. If yes, what are the most important study conclusions and recommendations ?

Specify:____

12. What is the average annual TSO revenue from the cross-border congestions ?

Specify:9.840 (million €) (for year 2012)

13. How do you usually spend this revenue?

☒ Construction of new network elements needed for NTC increasing
☒ Upgrading of existing network elements needed for NTC increasing
☒ Construction/upgrading of network elements needed for other system needs
☒ Other (specify: *the price of electricity*)

BOSNIA AND HERZEGOVINA

1. Do you calculate NTC values?

■ Yes
☐ No

2. How often do you calculate NTC values now?

☐ Once a year
☐ Twice a year (summer and winter)
■ Monthly
☐ Other (specify:_________________)

3. What is the methodology you use for NTC calculation?

■ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☐ Other (specify:____)

5. Did you find ENTSO-E methodology inappropriate for your system?

☐ Yes
■ No

If yes, please describe why:____
____
____

6. What are the limitations for NTC values increasing in your system?

■ limited interconnection capacity
(specify limiting network elements: (220 kV OHL Mostar 4-Zakucac, 220 kV OHL Trebinje-Perucica, 220 kV OHL Sarajevo 20-Piva, 220 kV OHL Visegrad-Pozega)

☐ limited local 400 kV network capacity
(specify limiting network elements:____)

■ limited local 220 kV network capacity
(specify limiting network elements: (220 kV OHL RP Jablanica- RP Mostar 3, 220 kV OHL HE Salakovac- RP Mostar 3, 220 kV OHL TE Kakanj V- TS Zenica 2)

☐ limited local 110 kV network capacity
(specify limiting network elements:____)

☐ Other (specify:____)

7. What's technically and economically the best way to increase NTC values for your system?

■ New interconnection lines construction
(specify which ones: (<u>Increase of part of network capacities, specified in Section 6.)</u>

■ New internal lines construction
(specify which ones: (<u>Increase of part of network capacities, specified in Section 6.</u>)

8. Have NTC values been changed in the last 5 years ?

☐ Yes
■ No

9. If yes, what is the reason for NTC values changes ?

☐ new/upgraded interconnection capacity
☐ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☐ Other (specify:____)

10. Do you have any detailed analyses on the actions to increase NTC values?

☐ Yes
■ No

11. If yes, what are the most important study conclusions and recommendations ?

Specify:____

12. What is the average annual TSO revenue from the cross-border congestions ?

Specify:<u>   3.450.000,00   (€)</u>

13. How do you usually spend this revenue?

☐ Construction of new network elements needed for NTC increasing
☐ Upgrading of existing network elements needed for NTC increasing
☐ Construction/upgrading of network elements needed for other system needs
■ Other (specify: <u>Transmission Company in B&H, not ISO B&H</u>)

MACEDONIA

1. Do you calculate NTC values?

☒ Yes
☐ No

2. How often do you calculate NTC values now?

☐ Once a year
☐ Twice a year (summer and winter)
☒ Monthly
☐ Other (specify:_________________)

3. What is the methodology you use for NTC calculation?

☒ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☐ Other (specify:____)

5. Did you find ENTSO-E methodology inappropriate for your system?

☐ Yes
☒ No

If yes, please describe why:____
____
____

6. What are the limitations for NTC values increasing in your system?

☒ limited interconnection capacity
(specify limiting network elements: The limits are the interconnection lines between Macedonia and Serbia/Greece/Macedonia, because of the only one connection with this countries. Also we have with Turkey limits according to ENTSO-E decisions during the trail operation period.____)

☐ limited local 400 kV network capacity
(specify limiting network elements:____)

☐ limited local 220 kV network capacity
(specify limiting network elements:____)

☒ limited local 110 kV network capacity
(specify limiting network elements: We have limits in the NTC with Romania because some OHL 110 kV in Nord-east part of Macedonia are overloaded when we have a big energy transit thought Macedonia.____)

☐ Other (specify:____)

7. What's technically and economically the best way to increase NTC values for your system?

☒ New interconnection lines construction
(specify which ones:_ Between Macedonia and Serbia/Macedonia/Greece_________________________)

☐ New internal lines construction
(specify which ones:____)

8. Have NTC values been changed in the last 5 years ?

☒ Yes
☐ No

9. If yes, what is the reason for NTC values changes ?

☒ new/upgraded interconnection capacity
☐ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☐ Other (specify:____)

10. Do you have any detailed analyses on the actions to increase NTC values?

☒ Yes
☐ No

11. If yes, what are the most important study conclusions and recommendations ?

Specify: Building new interconnection lines between Macedonia and Serbia/Macedonia/Greece.

12. What is the average annual TSO revenue from the cross-border congestions ?

Specify:25 million (€)

13. How do you usually spend this revenue?

☒ Construction of new network elements needed for NTC increasing
☐ Upgrading of existing network elements needed for NTC increasing
☐ Construction/upgrading of network elements needed for other system needs
☐ Other (specify:____)

CROATIA

1. Do you calculate NTC values?

☒ Yes
☐ No

2. How often do you calculate NTC values now?

☐ Once a year
☐ Twice a year (summer and winter)
☒ Monthly
☐ Other (specify:_________________)

3. What is the methodology you use for NTC calculation?

☒ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☒ Other (specify:_ENTSO OH P4)

5. Did you find ENTSO-E methodology inappropriate for your system?

☒ Yes
☐ No

If yes, please describe why: It does not reflect interdependency of various borders, we calculate border by border but in reality exchange is going simultaneously on all borders. This method is good for big systems; for example between France and Spain. It is difficult to calculate bilateral NTC in meshed networks. The results depend also on base case model.

On the other side this is the best method which we have.

6. What are the limitations for NTC values increasing in your system?

☒ limited interconnection capacity
(specify limiting network elements:____)

☒ limited local 400 kV network capacity
(specify limiting network elements:____)

☒ limited local 220 kV network capacity
(specify limiting network elements:____)

☒ limited local 110 kV network capacity
(specify limiting network elements:____)

☐ Other (specify:____)

Limiting equipment depends on direction, border, disconnections in the grid, etc…

7. What's technically and economically the best way to increase NTC values for your system?

☐ New interconnection lines construction
(specify which ones:____)

☒ New internal lines construction
(specify which ones:____)

8. Have NTC values been changed in the last 5 years ?

☒ Yes
☐ No

9. If yes, what is the reason for NTC values changes ?

☒ new/upgraded interconnection capacity
☐ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☒ Other (specify: TSOs agreed on higher values)

10. Do you have any detailed analyses on the actions to increase NTC values?

☐ Yes
☒ No

11. If yes, what are the most important study conclusions and recommendations ?

Specify:____

12. What is the average annual TSO revenue from the cross-border congestions ?

Specify:__________________(€)

13. How do you usually spend this revenue?

☐ Construction of new network elements needed for NTC increasing
☐ Upgrading of existing network elements needed for NTC increasing
☐ Construction/upgrading of network elements needed for other system needs
☐ Other (specify:____)

KOSOVO

1. Do you calculate NTC values?

☒ Yes
☐ No

2. How often do you calculate NTC values now?

☒ Once a year
☐ Twice a year (summer and winter)
☐ Monthly
☐ Other (specify: Only for internal analysis, EMS still allocate KOSTT interconnection capacities________________)

3. What is the methodology you use for NTC calculation?

☒ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☐ Other (specify:____)

5. Did you find ENTSO-E methodology inappropriate for your system?

☐ Yes
☒ No

If yes, please describe why:

6. What are the limitations for NTC values increasing in your system?

☒ Limited interconnection capacity
(Specify limiting network elements:
Limiting element: 220 kV Prizren – Fierza outage: 400 kV Zemblak – Kardia.
Limiting Element: 220kV Prizren – Fierza outage: 220kV Drenas (Glogovc)- Prizreni 2

☐ Limited local 400 kV network capacity
(specify limiting network elements)

☐ limited local 220 kV network capacity
(specify limiting network elements:____)

☐ limited local 110 kV network capacity
(specify limiting network elements:____)

☒ Other (specify):
- <u>Different value settings of overload protection at both ends of an interconnector</u>
- <u>TRM values are too high</u>
- <u>No transparency</u>
- <u>Discrepancies between calculated and nominated values of NTC,</u>

7. What's technically and economically the best way to increase NTC values for your system?

☒ New interconnection lines construction
(specify which ones: corridor North-South and East-West)

☐ New internal lines construction
(specify which ones:___400 kV ring SS Ferizaj 2 – SS Prizren 2- SG Gjakova-

8. Have NTC values been changed in the last 5 years?

☒ Yes
☐ No

9. If yes, what is the reason for NTC values changes?

☒ new/upgraded interconnection capacity
☒ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☐ Other (specify political reasons)

10. Do you have any detailed analyses on the actions to increase NTC values?

☐ Yes
☒ No

11. If yes, what are the most important study conclusions and recommendations?

12. What is the average annual TSO revenue from the cross-border congestions?

Specify: We assume to be around 1,14 m€ based on our analyses. We do not have access to cross border compensation mechanism

13. How do you usually spend this revenue?

☐ Construction of new network elements needed for NTC increasing
☐ Upgrading of existing network elements needed for NTC increasing
☐ Construction/upgrading of network elements needed for other system needs
☒ Other (specify: EMS collect this revenue)

MACEDONIA

1. Do you calculate NTC values?

☒ Yes
☐ No

2. How often do you calculate NTC values now?

☐ Once a year
☐ Twice a year (summer and winter)
☒ Monthly
☐ Other (specify:_________________)

3. What is the methodology you use for NTC calculation?

☒ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☐ Other (specify:____)

5. Did you find ENTSO-E methodology inappropriate for your system?

☐ Yes
☒ No

If yes, please describe why: methodology is generally defined. MEPSO use composite flow based approach for definition of source/ sink areas. All TSOs that form composite border should use the same approach of calculation. In reality some TSOs use bilateral or program approach for calculation of NTC, which lead to different result for the same product on same border.

6. What are the limitations for NTC values increasing in your system?

☒ Limited interconnection capacity
(Specify limiting network elements:
Limiting element: 400 kV Skopje – (Ferizaj) – Kosovo outage: 400 kV Zemblak– Kardia;
Limiting element: 400 kV Shtip – Chervena Mogila outage: 400 kV Blagoevgrad – Solun;
Limiting element: 220 kV Prizren – Fierza outage: 400 kV Zemblak – Kardia.

☐ Limited local 400 kV network capacity
(specify limiting network elements)

☐ limited local 220 kV network capacity
(specify limiting network elements:____)

☐ limited local 110 kV network capacity
(specify limiting network elements:____)

☒ Other (specify):

- political and money oriented nomination of NTC values,
- discrepancies between calculated and nominated values of NTC,
- methodology for calculation of TRM values,
- inappropriate limitation of overcurrent protection on some tie-lines.

7. What's technically and economically the best way to increase NTC values for your system?

☒ New interconnection lines construction
(specify which ones: corridor North-South and East-West)

☐ New internal lines construction
(specify which ones:____)

8. Have NTC values been changed in the last 5 years?

☒ Yes
☐ No

9. If yes, what is the reason for NTC values changes?

☒ new/upgraded interconnection capacity
☒ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☐ Other (specify political reasons)

10. Do you have any detailed analyses on the actions to increase NTC values?

☐ Yes
☒ No

11. If yes, what are the most important study conclusions and recommendations?

12. What is the average annual TSO revenue from the cross-border congestions?

Specify: 7.274 (million €)

13. How do you usually spend this revenue?

☒ Construction of new network elements needed for NTC increasing
☒ Upgrading of existing network elements needed for NTC increasing
☒ Construction/upgrading of network elements needed for other system needs
☒ Other (specify: for non-core business needs)

MONTENEGRO

1. Do you calculate NTC values?

☒ Yes
☐ No

2. How often do you calculate NTC values now?

☐ Once a year
☐ Twice a year (summer and winter)
☒ Monthly
☐ Other (specify:_________________)

3. What is the methodology you use for NTC calculation?

☒ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☐ Other (specify:____)

5. Did you find ENTSO-E methodology inappropriate for your system?

☐ Yes
☒ No

If yes, please describe why:____
____
____

6. What are the limitations for NTC values increasing in your system?

☒ limited interconnection capacity
(specify limiting network elements: DV220kVPljevlja-Požega,DV220KVPljevlja-Bajina Bašta and DV110kV H. Novi - Trebinje

☐ limited local 400 kV network capacity
(specify limiting network elements:____)

☐ limited local 220 kV network capacity
(specify limiting network elements:____)

☒ limited local 110 kV network capacity
(specify limiting network elements:________DV110kVBudva-Tivat and DV110kV Perućica-Podgorica

☐ Other (specify:____)

7. What's technically and economically the best way to increase NTC values for your system?

☒ New interconnection lines construction
(specify which ones:____)

☐ New internal lines construction
(specify which ones:____)

8. Have NTC values been changed in the last 5 years ?

☒ Yes
☐ No

9. If yes, what is the reason for NTC values changes ?

☒ new/upgraded interconnection capacity
☐ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☐ Other (specify:____)

10. Do you have any detailed analyses on the actions to increase NTC values?

☒ Yes
☐ No

11. If yes, what are the most important study conclusions and recommendations ?

Specify: New interconnection lines were considered

12. What is the average annual TSO revenue from the cross-border congestions ?

Specify:_______4580000_____________(€)

13. How do you usually spend this revenue?

☒ Construction of new network elements needed for NTC increasing
☒ Upgrading of existing network elements needed for NTC increasing
☒ Construction/upgrading of network elements needed for other system needs
☐ Other (specify:____)

ROMANIA

1. Do you calculate NTC values?

☒ Yes
☐ No

Comment: NTC values are calculated at the National Dispatching Center

2. How often do you calculate NTC values now?

☒ Once a year - *firm ATC values for yearly auctions, determined in Y-1;*
☒ Twice a year (summer and winter) - *maximum seasonal indicative NTC values;*
☒ Monthly - *firm monthly NTC profiles with resolution down to week and day (depending on simultaneous & successive monthly maintenance programs) .*
☒ Other : *NTC values updated for specific periods due to changes in maintenance programs .*

3. What is the methodology you use for NTC calculation?

☒ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☐ Other :

Comment : *A methodology was developed at the National Dispatching Center, based on ENTSO-E Procedures, specifying in greater detail the calculation of NTCs for bilateral borders which are interdependent; to insure that bilateral NTCs are aggregable in the RO interconnection interface and other multilateral interfaces, there are scenarios for calculation of composite NTCs, considering simultaneous exchanges with /between several interconnection partners through common multilateral interfaces.*

5. Did you find ENTSO-E methodology inappropriate for your system?

☐ Yes
☒ No , *but it should treat in more detail the matter of interdependent bilateral NTCs*

If yes, please describe why:____

6. What are the limitations for NTC values increasing in your system?

☒ limited interconnection capacity
(specify limiting network elements: *400kV OHL Portile de Fier-Djerdap*)

☒ limited local 400 kV network capacity
(specify limiting network elements: *400/220kV Transformer Rosiori*)

☒ limited local 220 kV network capacity
(specify limiting network elements: *220kV OHLs Portile de Fier-Resita 1,2*)

☒ limited local 110 kV network capacity
(specify limiting network elements: *only in incomplete topologies in specific areas requiring meshing of 110kV network*)

☒ Other (*very large generation/load in specific areas of RO EPS, lines & transformers in neighbor EPSs*)

7. What's technically and economically the best way to increase NTC values for your system?

☒ New interconnection lines construction
(specify which ones: *400kV OHL Resita-Pancevo (RO-RS))*

☒ New internal lines construction
(specify which ones*: 400kV axis Portile de Fier-Arad, 400kV OHL Nadab-Oradea)*

8. Have NTC values been changed in the last 5 years ?

☒ Yes
☐ No

9. If yes, what is the reason for NTC values changes ?

☒ new/upgraded interconnection capacity
☒ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☒ Other (*increase of wind generation in S-E area of the RO EPS and better distribution of flows on interconnections, new/upgraded 400kV OHLs including tie-lines in SEE, increase of overload protection settings on neighbor internal 400kV OHLs)*

10. Do you have any detailed analyses on the actions to increase NTC values?

☒ Yes : some comparative analyses on the effect of items in TN development plan on NTC values
☐ No

11. If yes, what are the most important study conclusions and recommendations ?

Specify: *Construction of interconnection and internal lines specified in item 7 will increase significantly export & import NTCs through RO interface (+1000 MW export NTC).*

12. What is the average annual TSO revenue from the cross-border congestions ?

Specify:______________________(€)

13. How do you usually spend this revenue?

☒ Construction of new network elements needed for NTC increasing
☒ Upgrading of existing network elements needed for NTC increasing
☐ Construction/upgrading of network elements needed for other system needs
☒ Other (specify*: price of electric energy transport*)

SERBIA

1. Do you calculate NTC values?

☒ Yes
☐ No

2. How often do you calculate NTC values now?

☐ Once a year
☐ Twice a year (summer and winter)
☒ Monthly
☐ Other (specify:_________________)

3. What is the methodology you use for NTC calculation?

☒ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☐ Other (specify:____)

5. Did you find ENTSO-E methodology inappropriate for your system?

☐ Yes
☒ No

If yes, please describe why:____
____
____

6. What are the limitations for NTC values increasing in your system?

☒ limited interconnection capacity
(specify limiting network elements: Interconnection 220 kV OHL RS-ME, RS-AL, RS-BA)

☐ limited local 400 kV network capacity
(specify limiting network elements:____)

☒ limited local 220 kV network capacity
(specify limiting network elements: 220 kV network in Western Serbia)

☐ limited local 110 kV network capacity
(specify limiting network elements:____)

☐ Other (specify:____)

7. What's technically and economically the best way to increase NTC values for your system?

☒ New interconnection lines construction
(specify which ones: 400 kV OHL Bajina Basta (RS) – Visegrad (BA), 400 kV OHL Bajina Basta (RS) – Pljevlja (ME))

☒ New internal lines construction
(specify which ones: Planned 400 kV upgrade in Western Serbia)

8. Have NTC values been changed in the last 5 years ?

☒ Yes
☐ No

9. If yes, what is the reason for NTC values changes ?

☒ new/upgraded interconnection capacity
☒ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☐ Other (specify:____)

10. Do you have any detailed analyses on the actions to increase NTC values?

☐ Yes
☒ No

11. If yes, what are the most important study conclusions and recommendations ?

Specify:____

12. What is the average annual TSO revenue from the cross-border congestions ?

Specify: approx. 22 mil. €______________________(€)

13. How do you usually spend this revenue?

☒ Construction of new network elements needed for NTC increasing
☒ Upgrading of existing network elements needed for NTC increasing
☐ Construction/upgrading of network elements needed for other system needs
☐ Other (specify:____)

SLOVENIA

1. Do you calculate NTC values?

☒ Yes
☐ No

2. How often do you calculate NTC values now?

☐ Once a year
☒ Twice a year (summer and winter)
☐ Monthly
☐ Other (specify:_________________)

3. What is the methodology you use for NTC calculation?

☒ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☐ Other (specify:____)

5. Did you find ENTSO-E methodology inappropriate for your system?

☒ Yes
☐ No

If yes, please describe why: It is old and not updated. The ENTSO should prepare new version.

6. What are the limitations for NTC values increasing in your system?

☐ limited interconnection capacity
(specify limiting network elements:____)

☐ limited local 400 kV network capacity
(specify limiting network elements:____)

☐ limited local 220 kV network capacity
(specify limiting network elements:____)

☐ limited local 110 kV network capacity
(specify limiting network elements:____)

☒ Other (specify: There is no limitation in our system congestions are in neighboring countries)

7. What's technically and economically the best way to increase NTC values for your system?

☒ New interconnection lines construction
(specify which ones:____)

☐ New internal lines construction
(specify which ones:____)

8. Have NTC values been changed in the last 5 years ?

☒ Yes
☐ No

9. If yes, what is the reason for NTC values changes ?

☐ new/upgraded interconnection capacity
☐ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☒ Other (specify:_PST installation, upgrades in neighboring countries)

10. Do you have any detailed analyses on the actions to increase NTC values?

☒ Yes
☐ No

11. If yes, what are the most important study conclusions and recommendations ?

Specify:/____

12. What is the average annual TSO revenue from the cross-border congestions ?

Specify:/____________________(€)

13. How do you usually spend this revenue?

☒ Construction of new network elements needed for NTC increasing
☒ Upgrading of existing network elements needed for NTC increasing
☐ Construction/upgrading of network elements needed for other system needs
☒ Other (specify: Redispatching)

TURKEY

1. Do you calculate NTC values?

☒ Yes
☐ No

2. How often do you calculate NTC values now?

☐ Once a year
☐ Twice a year (summer and winter)
☒ Monthly
☐ Other (specify:________________)

3. What is the methodology you use for NTC calculation?

☒ ENTSO-E Procedures for Cross-Border Transmission Capacity Assessment, 2001
☐ Other (specify:____)

5. Did you find ENTSO-E methodology inappropriate for your system?

☐ Yes
☒ No

If yes, please describe why:____
____
____

6. What are the limitations for NTC values increasing in your system?

☐ Limited interconnection capacity

☐ limited local 400 kV network capacity
(specify limiting network elements:____)

☐ limited local 220 kV network capacity
(specify limiting network elements:____)

☐ limited local 110 kV network capacity
(specify limiting network elements:____)

☒ Other (specify:____)

- Limitation comes from Turkey's trial parallel operation with ENTSO-E.

7. What's technically and economically the best way to increase NTC values for your system?

☐ New interconnection lines construction
(specify which ones:____)

☒ New internal lines construction
(Specify which ones: Internal lines should be constructed to the Marmara Region of Turkish System and the internal lines should be constructed to Balkan System which cause congestions to the interconnection lines.)

8. Have NTC values been changed in the last 5 years?

☒ Yes
☐ No

9. If yes, what is the reason for NTC values changes?

☐ new/upgraded interconnection capacity
☐ new/upgraded local 400 kV network capacity
☐ new/upgraded local 220 kV network capacity
☐ new/upgraded local 110 kV network capacity
☒ Other (specify: The ENTSO-E Plenary Group monitored Turkish System's performance and after the some improvements observed on Turkish network, NTC values was increased.)

10. Do you have any detailed analyses on the actions to increase NTC values?

☒ Yes
☐ No

11. If yes, what are the most important study conclusions and recommendations ?

Specify: The studies for permanent ENTSO-E membership of Turkish Electricity Interconnection System is at the third phase. The criteria of success progress are defined and after improvement of Turkish network performance which monitored by PG "Turkey Connection", the NTC values were increased. The additional function at the SPS which is installed at Hamitabat SS would be evolved.

12. What is the average annual TSO revenue from the cross-border congestions ?

Specify:10,243 (million €)(for year 2012)

13. How do you usually spend this revenue?

☒ Construction of new network elements needed for NTC increasing
☒ Upgrading of existing network elements needed for NTC increasing
☐ Construction/upgrading of network elements needed for other system needs
☐ Other (specify:)

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